IEEE SA
STANDARDS
ASSOCIATION

STANDARDS

IEEE Standard for
Local and metropolitan area networks—

Bridges and Bridged Networks

IEEE Computer Society

Developed by the
LAN/MAN Standards Committee

IEEE Std 802.1Q™-2022
(Revision of IEEE Std 802.1Q-2018)

IEEE

IEEE Std 802.1Q™-2022
(Revision of IEEE Std 802.1Q-2018)

IEEE Standard for Local and metropolitan area networks—

Bridges and Bridged Networks

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 21 September 2022

IEEE SA Standards Board

Abstract: This standard specifies how the Media Access Control (MAC) Service is supported by Bridged Networks, the principles of operation of those networks, and the operation of MAC Bridges and VLAN Bridges, including management, protocols, and algorithms.

Keywords: Bridged Network, IEEE 802.1Q™, LAN, local area network, MAC Bridge, metropolitan area network, MSTP, Multiple Spanning Tree Protocol, PBN, Provider Bridged Network, Rapid Spanning Tree Protocol, RSTP, Shortest Path Bridging Protocol, SPB Protocol, Time-Sensitive Networking, TSN, Virtual Bridged Network, virtual LAN, VLAN Bridge

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

PDF: ISBN 978-1-5044-9188-4 STD25783
Print: ISBN 978-1-5044-9189-1 STDPD25783

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (https://standards.ieee.org/ipr/disclaimers.html), appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning IEEE Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents are developed within IEEE Societies and subcommittees of IEEE Standards Association (IEEE SA) Board of Governors. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity, nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE is the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group. Statements made by volunteers may not represent the formal position of their employer(s) or affiliation(s).

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, consulting information, or advice pertaining to IEEE Standards documents**.

Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its Societies and subcommittees of the IEEE SA Board of Governors are not able to provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile & Interests area of the IEEE SA myProject system.[1] An IEEE Account is needed to access the application.

Comments on standards should be submitted using the Contact Us form.[2]

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

---

[1] Available at: https://development.standards.ieee.org/myproject-web/public/view.html#landing.

[2] Available at: https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400; https://www.copyright.com/. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit IEEE Xplore or contact IEEE.[3] For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE SA Website.[4] Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in IEEE Xplore. Users are encouraged to periodically check for errata.

Patents

IEEE Standards are developed in compliance with the IEEE SA Patent Policy.[5]

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has

[3] Available at: https://ieeexplore.ieee.org/browse/standards/collection/ieee.

[4] Available at: https://standards.ieee.org/standard/index.html.

[5] Available at: https://standards.ieee.org/about/sasb/patcom/materials.html.

filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE SA Website at https://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

IMPORTANT NOTICE

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. IEEE Standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

Participants

At the time this standard was submitted to the IEEE-SA Standards Board for approval, the IEEE 802.1 Working Group had the following membership:

Glenn Parsons, *Chair*
Jessy V. Rouyer, *Vice Chair*
John Messenger, *Editor*
Mick Seaman, *Editor*

Astrit Ademaj
Venkat Arunarthi
Ralf Assmann
Huajie Bao
Rudy Belliardi
Christian Boiger
Paul Bottorff
Radhakrishna Canchi
Feng Chen
Abhijit Choudhury
Paul Congdon
Rodney Cummings
Josef Dorr
Hesham M. Elbakoury
Anna Engelmann
Thomas Enzinger
János Farkas
Donald W. Fedyk
Norman Finn
Geoffrey Garner
Amrit Gopal
Craig Gunther
Marina Gutierrez
Stephen Haddock
Mark Hantel
Jerome Henry
Marc Holness
Daniel Hopf
Woojung Huh
Satoko Itaya
Yoshihiro Ito
Michael Karl
Stephan Kehrer
Randy Kelsey
Marcel Kiessling
Gavin Lai
Joao Lopes
Lily Lv
Christophe Mangin
Scott Mansfield
Olaf Mater
David McCall
Larry McMillan
Hiroki Nakano
Don Pannell
Razvan Petre
Michael Potts
Dieter Proell
Karen Randall
Maximilian Riegel
Silvana Rodrigues
Atsushi Sato
Frank Schewe
Maik Seewald
Ramesh Sivakolundu
Johannes Specht
Marius Stanica
Guenter Steindl
Nemanja Stamenic
Karim Traore
Max Turner
Balazs Varga
Ganesh Venkatesan
Xinyuan Wang
Tongtong Wang
Karl Weber
Leon Wessels
Ludwig Winkel
Jordon Woods
Takahiro Yamaura
Yue Yin
Uwe Zeier
Nader Zein
William Zhao
Helge Zinner

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Robert Aiello
Thomas Alexander
Harry Bims
Christian Boiger
Rich Boyer
Vern Brethour
William Byrd
Paul Cardinal
Juan Carreon
Pin Chang
Diego Chiozzi
Paul Congdon
Michael Cowan
János Farkas
Avraham Freedman
Craig Gunther
Stephen Haddock
Mark Hantel
Jerome Henry
Marco Hernandez
Werner Hoelzl
Oliver Holland
Marc Holness
Yoshihiro Ito
Raj Jain
Pranav Jha
Lokesh Kabra
Piotr Karocki
Stephan Kehrer
Randy Kelsey
Stuart Kerry
Evgeny Khorov
Yongbum Kim
Jeff Koftinoff
Gavin Lai
Hyeong Ho Lee
James Lepp
Joseph Levy
Christophe Mangin
Scott Mansfield
Roger Marks
Stephen McCann
Jonathon Mclendon
Satoshi Obara
Glenn Parsons
Arumugam Paventhan
Clinton Powell
Dieter Proell
R. K. Rannow
Alon Regev
Maximilian Riegel
Jessy V. Rouyer
Peter Saunderson
Frank Schewe
Mick Seaman
Johannes Specht
Guenter Steindl
Eugene Stoudenmire
Walter Struppler
Mitsutoshi Sugawara
Bo Sun
David Tepen
David Tremblay
Max Turner
John Vergis
Stephen Webb
Karl Weber
Scott Willy
Andreas Wolf
Dayin Xu
Yu Yuan
Oren Yuen

When the IEEE SA Standards Board approved this standard on 21 September 2022, it had the following membership:

David J. Law, *Chair*
Ted Burse, *Vice Chair*
Gary Hoffman, *Past Chair*
Konstantinos Karachalios, *Secretary*

Edward A. Addy
Ramy Ahmed Fathy
J. Travis Griffith
Guido R. Hiertz
Yousef Kimiagar
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick
Johnny Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Andrew Myles
Damir Novosel
Annette D. Reilly
Robby Robson
Jon Walter Rosdahl
Mark Siira
Dorothy V. Stanley
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Philip B. Winston
Daidi Zhong

*Member Emeritus

Historical participants

Since the initial publication, many IEEE standards have added functionality or provided updates to material included in this standard. The following is a historical list of participants who have dedicated their valuable time, energy, and knowledge to the creation of this material:

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Ballot
IEEE Std 802.1Q-1998	8 December 1998	**William P. Lidinsky**, *Chair* **Mick Seaman**, *Chair, Interworking Task Group* **Tony Jeffree**, *Coordinating Editor* **Anil Rijsinghani, Richard Hausmann, Michele Wright, Paul Langille, P. J. Singh**, *Editorial Team*
IEEE Std 802.1u-2001	17 March 2001	**Tony Jeffree**, *Chair* **Neil Jarvis**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group*
IEEE Std 802.1v-2001	17 March 2001	**Tony Jeffree**, *Chair* **Neil Jarvis**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group* **David Delany**, *Editor* **Andrew Smith**, *Editor*
IEEE Std 802.1s-2002	11 December 2002	**Tony Jeffree**, *Chair* **Neil Jarvis**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group* **Norman W. Finn**, *Editor*
IEEE Std 802.1ad-2005	28 March 2005	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group* **Stephen R. Haddock**, *Editor*
IEEE Std 802.1Q-2005	7 December 2005	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group*
IEEE Std 802.1ak-2007	22 March 2007	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group*
IEEE Std 802.1ag-2007	27 September 2007	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **Norman W. Finn**, *Editor-in-Chief* **David V. Elie-Dit-Cosaque**, **Dinesh Mohan**, **Oscar Rodriguez**, **Ali Sajassi,** *Assistant Editors*

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Ballot
IEEE Std 802.1ah-2008	12 June 2008	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **Paul Bottorff, Stephen Haddock,** and **Muneyoshi Suzuki,** *Editors*
IEEE Std 802.1Q-2005/Cor-1-2008	26 September 2008	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group*
IEEE Std 802.1ap-2008	10 December 2008	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **Glenn Parsons**, *Editor* **David Levi,** *Assistant Editor*
IEEE Std 802.1Qaw-2009	17 June 2009	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **Linda Dunbar,** *Editor*
IEEE Std 802.1Qay-2009	17 June 2009	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **Panagiotis Saltsidis,** *Editor*
IEEE Std 802.1aj-2009	9 December 2009	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen R. Haddock**, *Chair, Interworking Task Group* **John Messenger**, *Editor* **Brian Hassink**, *MIB Editor*
IEEE Std 802.1Qav-2009	9 November 2009	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Michael Johas Teener**, *Chair, Audio Video Bridging Task Group*
IEEE Std 802.1Qau-2010	25 March 2010	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Patricia Thaler**, *Chair, Data Center Bridging Task Group* **Norman W. Finn**, *Editor*
IEEE Std 802.1Qat-2010	30 September 2010	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Michael Johas Teener**, *Chair, Audio Video Bridging Task Group* **Craig Gunther**, *Editor*

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Ballot
IEEE Std 802.1Q-2011	16 May 2011	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group*
IEEE Std 802.1Qbe-2011	16 June 2011	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group* **Norman Finn**, *Editor*
IEEE Std 802.1Qbc-2011	16 June 2011	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group* **Thomas Mack-Crane**, *Editor*
IEEE Std 802.1Qbb-2011	16 June 2011	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Patricia Thaler**, *Chair, Data Center Bridging Task Group* **Claudio DeSanti**, *Editor*
IEEE Std 802.1Qaz-2011	16 June 2011	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Patricia Thaler**, *Chair, Data Center Bridging Task Group* **Craig W. Carlson**, *Editor*
IEEE Std 802.1Qbf-2011	7 December 2011	**Tony Jeffree**, *Chair* **Paul Congdon**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group* **Robert Sultan**, *Editor*
IEEE Std 802.1aq-2012	29 March 2012	**Tony Jeffree**, *Chair* **Glenn Parsons**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group* **Donald Fedyk**, **Mick Seaman**, *Editors*
IEEE Std 802.1Qbg-2012	14 May 2012	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Patricia Thaler**, *Chair, Data Center Bridging Task Group* **Paul Bottorff**, *Editor, Clauses 12 and 17*
IEEE Std 802.1Q-2011/Cor-2-2012	19 October 2012	**Tony Jeffree**, *Chair and Editor* **Glenn Parsons**, *Vice Chair and Chair, Maintenance Task Group*
IEEE Std 802.1Qbp-2014	27 March 2014	**Tony Jeffree**, *Chair* **Glenn Parsons**, *Vice Chair* **Stephen Haddock**, *Chair, Interworking Task Group* **Ben Mack-Crane**, *Editor*

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Ballot
IEEE Std 802.1D-2004	9 February 2004	**Tony Jeffree**, *Chair and Editor* **Paul Congdon**, *Vice Chair* **Mick Seaman**, *Chair, Interworking Task Group and Editor*
IEEE Std 802.1D-2004	3 November 2014	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **Tony Jeffree**, *Editor* **Stephen Haddock**, *Chair, Interworking Task Group*
IEEE Std 802.1Qcd-2015	16 February 2015	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* **Patricia Thaler**, *Chair, Data Center Bridging Task Group* **Eric Multanen**, *Editor*
IEEE Std 802.1Qca-2015	3 September 2015	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **János Farkas**, *Editor* **Stephen Haddock**, *Chair, Interworking Task Group*
IEEE Std 802.1Q-2014/Cor 1-2015	5 December 2015	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair and Chair, Maintenance Task Group* **Tony Jeffree**, *Editor*
IEEE Std 802.1Qbv-2015	5 December 2015	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **Michael Johas Teener**, *Chair, Time-Sensitive Networking Task Group* **Tony Jeffree**, *Editor*
IEEE Std 802.1Qbu-2016	30 June 2016	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **Michael Johas Teener**, *Chair, Time-Sensitive Networking Task Group* **Tony Jeffree**, *Editor*
IEEE Std 802.1Qbz-2016	30 June 2016	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **Michael Johas Teener**, *Chair, Time-Sensitive Networking Task Group* **Norm Finn**, *Editor*
IEEE Std 802.1Qci-2017	14 February 2017	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Tony Jeffree**, *Editor*
IEEE Std 802.1Qch-2017	15 May 2017	**Glenn Parsons**, *Chair* **John Messenger**, *Vice-Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Tony Jeffree**, *Editor*

IEEE 802.1Q Standard	Date approved by IEEE	Officers at the time of Working Group Ballot
IEEE Std 802.1Qcc-2018	14 June 2018	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* and *Acting Chair* **Jessy V. Rouyer**, *Acting Vice Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Rodney Cummings**, *Editor*
IEEE Std 802.1Qcp-2018	14 June 2018	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* and *Acting Chair* **Jessy V. Rouyer**, *Acting Vice Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Marc Holness**, *Editor*
IEEE Std 802.1Qcy-2019	21 March 2019	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* and *Acting Chair* **Jessy V. Rouyer**, *Acting Vice Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Yizhou Li**, *Editor* **Paul Bottorff**, *Editor*
IEEE Std 802.1Qcx-2020	4 June 2020	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Marc Holness**, Editor
IEEE Std 802.1Qcr-2020	24 September 2020	**Glenn Parsons**, *Chair* **John Messenger**, *Vice Chair* **Jessy V. Rouyer**, *Secretary* **János Farkas**, *Chair, Time-Sensitive Networking Task Group* **Craig Gunther**, *Vice Chair, Time-Sensitive Networking Task Group* **Johannes Specht**, *Editor*

Osama Aboul-Magd
Steve Adams
Stephen Ades
Fumio Akashi
Zehavit Alon
Ken Alonge
Ann Ambler
Paul D. Amer
Yafan An
Ting Ao
Charles Arnold
Peter Ashwood-Smith
Siamack Ayandeh
Floyd Backes
Ann Ballard
Richard Bantel
John Bartlett
Sy Bederman
Alexei Beliaev
Les Bell
Amatzia Ben-Artzi
Avner Ben-Dor
Michael Berger
Caitlin Bestler
Jan Bialkowski
James S. Binder
Robert Bledsoe
Rob Boatright
Kwami Boakaye
Christian Boiger
Brad Booth
Jean-Michel Bonnamy
Mike Borza
Paul Bottorff
David Brady
Rudolf Brandner
Martin Brewer
Frank Bruns
Juan Bulnes
Bill Bunch
Jim Burns
Peter Carbone
Bob Cardinal
Craig W. Carlson
Paul Carroll
Marco Carugi
Jeffrey Catlin
Dennis Cave
Dirceu Cavendish
Alan Chambers
Steve Chan
David W. Chang
Xin Chang
Frank Chao
Ken Chapman
Alice Chen
David Chen
Feng Chen
Weiying Cheng
Rao Cherukuri
Taesik Cheung
Jade Chien
Hon Wah Chin
Chi Chong
Jin-Seek Choi
Chris Christ
Marc Cochran
Paul Congdon
Glenn Connery
Alex Conta
Jim Corrigan
Diego Crupnicoff
David Cullerot
Rodney Cummings
Uri Cummings
Ted Davies
Andy Davis
Peter Dawe
Stan Degen
Arjan de Heer
Frank Deignan
David Delaney
Prakash Desai
Claudio DeSanti
Ron Dhondy
Patrick Diamond
Aboubacar Kader Diarra
Jeffrey Dietz
Russell Dietz
Zhemin Ding
Kurt Dobbins
Eiji Doi
Barbara J. Don Carlos
Linda Dunbar
Craig Easley
Donald Eastlake, III
Peter Ecclesine
J. J. Ekstrom
Anush Elangovan
Hesham M. Elbakoury
Walter Eldon
David Elie-Dit-Cosaque
János Farkas
Donald W. Fedyk
Eldon D. Feist
Felix Feifei Feng
Norman Finn
Len Fishler
Kevin Flanagan
Yishai Fraenkel
Paul Frantz
David Frattura
Robert Frazier
Lars Henrik Frederiksen
Andre Fredette
John Fuller
Ilango Ganga
Geoffrey Garner
Anoop Ghanwani
Franz Goetz
Pat Gonia
Gerrard Goubert
Richard Graham
Mark Gravel
Michael A. Gravel
Eric W. Gray
Karanvir Grewal
John Grinham
Yingjie Gu
Craig Gunther
Mitch Gusat
Stephen Haddock
Sharam Hakimi
Mogens Hansen
Mark Hantel
Harold Harrington
John Hart
Scott Harvell
Mike Harvey
Takashi Hasegawa
Brian Hassink
Wayne Hathaway
Brian Hausauer
Richard Hausman
Hitoshi Hayakawa
Vic Hayes
Asif Hazarika
David Head
Gaby Hecht
Deepak Hegde
Ariel Hendel
Bob Herbst
John Hickey
Jeremy Hitt
David Hollender
Marc Holness
Steve Horowitz
Bob Hott
Michelle Hsiung
Charles Hudson
Jack R. Hung
Rita Hunt
David Husak
Altaf Hussain
Rahil Hussain
Thomas Hytry
Romain Insler
Ran Ish-Shalom
Jay Israel
Atsushi Iwata
Vipin K. Jain
Neil Jarvis
Tony Jeffree
Paul Hongkyu Jeong
Pankaj Jha
Markus Jochim
Michael Johas Teener
Girault Jones
Peter Jones
Shyam Kaluve
Daya Kamath
Abhay Karandikar
Allen Kasey
Prakash Kashyap
Toyayuki Kato
Manu Kaycee
Hal Keen
Srikanth Keesara
Stephan Kehrer

Daniel Kelley
Kevin Ketchum
Keti Kilcrease
Doyeon Kim
Yongbum Kim
Alan Kirby
Kimberly Kirkpatrick
Keith Klamm
Steve Kleiman
Philippe Klein
Oliver Kleinberg
Marcel Kiessling
Yongbum Kim
Philippe Klein
Bruce Kling
Walter Knitl
Mike Ko
Raghu Kondapalli
Jouni Korhonnen
Michael Krause
Dan Krent
James Kristof
Vinod Kumar
Paul Kummer
Bruce Kwan
Paul Lachapelle
Kari Laihonen
Ashvin Lakshmikantha
Bill Lane
Paul Langille
Roger Lapuh
H. Eugene Latham
Loren Larsen
Yannick Le Goff
Marcus Leech
John Lemon
Michael Lerer
Lin Li
Bing Liao
George Lin
William P. Lidinsky
Johann Lindmeyr
Marina Lipshteyn
Gary Littleton
Robert D. Love
Yuanqui Luo
Andy Luque
Jeff Lynch
Gael Mace
Thomas Mack-Crane
Phillip Magnuson
Christophe Mangin
Mahalingam Mani
David Martin
Peter Martini
Riccardo Martinotti
Marco Mascitto
Tom McBeath
Keith McCloghrie
Bruce McClure
Tom McGowan
Alan McGuire
James McIntosh
Martin McNealis
Menucher Menuchery
Milan Merhar
Margaret A. Merrick
John Messenger
Colin Mick
Amol Mitra
Dinesh Mohan
Gabriel Montenegro
Jim Montrose
Matthew Mora
John Morris
Bob Moskowitz
Eric Multanen
Yaron Nachman
Yukihiro Nakagawa
Hiroki Nakano
Krishna Narayanaswamy
Lawrence Ng
Henry Ngai
Paul Nikolich
Kevin Nolish
Bob Noseworthy
Don O'Connor
Karen O'Donoghue
Jerry O'Keefe
Eugene O'Neil
Satoshi Obara
Hiroshi Ohta
David Olsen
Toshio Ooka
Jörg Ottensmeyer
Shlomo Ovadia
Vijoy Pandey
Don Pannell
Luc Pariseau
Glenn Parsons
Richard Patti
Ken Patton
Mark Pearson
Joseph Pelissier
Yonadav Perry
David Peterson
Roger Pfister
Thomas L. Phinney
John Pickens
Walter Pienciak
Daniel Pitt
Hayim Porat
Gideon Prat
Kirk Preiss
Ron L. G. Prince
Max Pritikin
Ray Qiu
Rene Raeber
Ananda Rajagopal
Steve Ramberg
Nigel Ramsden
Karen Randall
Shlomo Reches
Frank Reichstein
Dick Reohr
Trudy Reusser
James Richmond
Maximilian Riegel
Anil Rijsinghani
Robert Roden
Edouard Rocher
Guenter Roeck
John J. Roese
Josef Roese
Derek J. Rohde
Allyn Romanow
Dan Romascanu
Paul Rosenblum
Moran Roth
Jessy V. Rouyer
Doug Ruby
Eric Ryu
Jonathan Sadler
Ali Sajassi
Dolors Sala
Joseph Salowey
John Salter
Panagiotis Saltsidis
Sam Sambasivan
Ray Samora
Behcet Sarikaya
Alan Sarsby
Satish Sathe
John M. Sauer
Ayman Sayed
Susan Schanning
Ted Schroeder
Benjamin Schultz
Mick Seaman
Gerry Segal
Rich Seifert
Lee Sendelbach
Koichiro Seto
Daniel Sexton
Himanshu Shah
Rakesh Sharma
Ravi Shenoy
Howard Sherry
K. Karl Shimada
Fred Shu
Wu-Shi Shung
Taeshi Shimizu
Phil Simmons
Curtis Simonson
Paramjeet Singh
Rosemary V. Slager
Alexander Smith
Andrew Smith
Michel Soerensen
M. Soha
Stuart Soloway
Johannes Specht
Nurit Sprecher
Kevin B. Stanton
Larry Stefani
Wilfried Steiner
Dan Stokesberry
Sundar Subramaniam
Robert Sultan

Muneyoshi Suzuki
Yoshihiro Suzuki
George Swallow
Lennart Swartz
Richard Sweatt
Vahid Tabatabaee
Attila Takacs
Kenta Takumi
Francois Tallet
Robin Tasker
Angus Telfer
John Terry
Patricia A. Thaler
Jonathan Thatcher
Dave Thompson
Geoff Thompson
David Thornburg
Oliver Thorp
Michel Thorsen
Fouad Tobagi
Nathan Tobol
Jeremy Touve
Naoki Tsukutari
Fred Tuck
Chait Tumuluri
Wendell Turner
Paul Unbehagen
Dhadesugoor Vaman
Steve Van Seters
Dono van-Mierop
Peter Videcranz
John Viega
Maarten Vissers
Dennis Volpano
Manoj Wadekar
Paul Wainwright
Scott Wasson
Daniel Watts
Yuehua Wei
John Wakerly
Peter Wang
Philip Wang
Y. C. Wang
Yan Wang
Trevor Warwick
Bob Watson
Karl Weber
Yuehua Wei
Brian Weis
Alan Weissberger
Glenn Wenig
Martin White
Bert Wijnen
Deborah Wilbert
Keith Willette
Robert Williams
Val Wilson
Ludwig Winkel
Robert Winter
Michael Witkowski
Edward Wong
Jordon Woods
Michael D. Wright
Michele Wright
Chien-Hsien Wu
Min Xiao
Ken Young
Allen Yu
Wayne Zakowski
Igor Zhovnirovsky
Carolyn Zimmer
Helge Zinner
Glen Zorn
Nick Zucchero
Juan-Carlos Zuniga

Introduction

This introduction is not part of IEEE Std 802.1Q™-2022, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks.

IEEE Std 802.1Q™-2022 incorporates the text of the following amendments into IEEE Std 802.1Q™-2018.

IEEE Std 802.1Qcc™-2018	Stream Reservation Protocol (SRP) Enhancements and Performance Improvements
IEEE Std 802.1Qcp™-2018	YANG Data Model
IEEE Std 802.1Qcy™-2019	Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP) Extension to Support Network Virtualization Overlays Over Layer 3 (NVO3)
IEEE Std 802.1Qcx™-2020	YANG Data Model for Connectivity Fault Management
IEEE Std 802.1Qcr™-2020	Asynchronous Traffic Shaping

The 2018 revision of this standard incorporated the text of the following amendments into IEEE Std 802.1Q-2014.

IEEE Std 802.1Qcd™-2015	Application Virtual Local Area Network (VLAN) Type, Length, Value (TLV)
IEEE Std 802.1Qca™-2015	Path Control and Reservation
IEEE Std 802.1Q-2014 Cor 1-2015	Technical and editorial corrections
IEEE Std 802.1Qbv™-2015	Enhancements for scheduled traffic
IEEE Std 802.1Qbu™-2016	Frame preemption
IEEE Std 802.1Qbz™-2016	Enhancements to Bridging of IEEE 802.11 Media
IEEE Std 802.1Qci™-2017	Per-Stream Filtering and Policing
IEEE Std 802.1Qch™-2017	Cyclic Queuing and Forwarding

The 2014 revision of this standard incorporated the text of the following amendments into IEEE Std 802.1Q-2011.

IEEE Std 802.1Qbe™-2011	Multiple I-SID Registration Protocol
IEEE Std 802.1Qbc™-2011	Provider Bridging—Remote Customer Service Interfaces
IEEE Std 802.1Qbb™-2011	Priority-based Flow Control
IEEE Std 802.1Qaz™-2011	Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes
IEEE Std 802.1Qbf™-2011	PBB-TE Infrastructure Segment Protection
IEEE Std 802.1Qbg™-2012	Edge Virtual Bridging
IEEE Std 802.1aq™-2012	Shortest Path Bridging
IEEE Std 802.1Q-2011/Cor 2-2012	Technical and editorial corrections
IEEE Std 802.1Qbp™-2014	Equal Cost Multiple Paths (ECMP)

The 2011 revision of this standard incorporated the text of the following amendments into IEEE Std 802.1Q-2005.

IEEE Std 802.1ad™-2005	Provider Bridges
IEEE Std 802.1ak™-2007	Multiple Registration Protocol
IEEE Std 802.1ag™-2007	Connectivity Fault Management
IEEE Std 802.1ah™-2008	Provider Backbone Bridges
IEEE Std 802-1Q-2005/Cor-1-2008	Corrections to the Multiple Registration Protocol

IEEE Std 802.1ap™-2008	Management Information Base (MIB) Definitions for VLAN Bridges
IEEE Std 802.1Qaw™-2009	Management of Data Driven and Data Dependent Connectivity Faults
IEEE Std 802.1Qay™-2009	Provider Backbone Bridge Traffic Engineering
IEEE Std 802.1aj™-2009	Two-Port Media Access Control (MAC) Relay
IEEE Std 802.1Qav™-2009	Forwarding and Queuing Enhancements for Time-Sensitive Streams
IEEE Std 802.1Qau™-2010	Congestion Notification
IEEE Std 802.1Qat™-2010	Stream Reservation Protocol

Clause 13 of IEEE Std 802.1Q-2011 was also revised to include an updated specification of the Rapid Spanning Tree Algorithm and Protocol (RSTP), superseding references to IEEE Std 802.1D™-2004 [B12].[6]

The 2005 revision of this standard incorporated the text of the following amendments into IEEE Std 802.1Q-1998.

IEEE Std 802.1u™-2001	Technical and Editorial Corrections
IEEE Std 802.1v™-2001	VLAN Classification by Protocol and Port
IEEE Std 802.1s™-2002	Multiple Spanning Trees

This standard was first published as IEEE Std 802.1Q-1998, making use of the concepts and mechanisms of LAN Bridging that were introduced by IEEE Std 802.1D and defining additional mechanisms to allow the implementation of Virtual Bridged Networks.

For an introduction to this standard that details each of the provisions introduced by amendments and revisions throughout its development, refer to 1.3.

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802 standards may be obtained from

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

[6] The numbers in brackets correspond to those of the bibliography in Annex W.

Contents

Figures

Tables

IEEE Standard for
Local and metropolitan area networks—

Bridges and Bridged Networks

1. Overview

IEEE 802® Local Area Networks (LANs, 3.110)[7] of all types can be connected together with Media Access Control (MAC) Bridges (3.150) or Virtual Local Area Network (VLAN) Bridges (3.296), collectively known as Bridges (3.24). This standard defines the operation of Bridges and Bridged Networks. VLANs facilitate the administration of logical groups of stations. Stations in the same VLAN communicate as if they were on the same LAN, while traffic between VLANs is restricted. Management of VLAN Bridges and stations allows stations to be added to, removed from, or moved between VLANs.

This standard further extends the specification of VLAN Bridges to enable a service provider organization to use a common infrastructure of Bridges and LANs to offer the equivalent of separate LANs, Bridged, or Virtual Bridged Networks to independent customer organizations.

This standard specifies protocols and protocol entities within the architecture of Bridges that provide capabilities for detecting, verifying, and isolating connectivity failures in Bridged Networks. These capabilities can be used in networks operated by multiple independent organizations, each with restricted management access to each other's equipment.

1.1 Scope

This standard specifies Bridges that interconnect individual LANs, each supporting the IEEE 802 MAC Service using a different or identical media access control method, to provide Bridged Networks and VLANs.

1.2 Purpose

Bridges, as specified by this standard, allow the compatible interconnection of information technology equipment attached to separate individual LANs.

[7] IEEE and IEEE 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

1.3 Introduction

For the purpose of compatible interconnection of information technology equipment using the IEEE 802 MAC Service supported by interconnected IEEE 802 standard LANs using different or identical media access control methods, this standard specifies the operation of MAC Bridges and VLAN Bridges. To this end, it:

a) Positions the support of VLANs within an architectural description of the MAC Sublayer.
b) Defines the principles of operation of the MAC Bridge and VLAN Bridge in terms of the support and preservation of the MAC Service, and the maintenance of quality of service (QoS).
c) Specifies an Enhanced Internal Sublayer Service (EISS) provided to the Media Access-Independent functions that provide frame relay in a VLAN Bridge.
d) Establishes the principles and a model of Virtual Bridged Network operation.
e) Identifies the functions to be performed by Bridges, and provides an architectural model of the operation of a Bridge in terms of processes and entities that provide those functions.
f) Specifies a frame format that allows a VLAN Identifier (VID) and priority information to be carried by VLAN-tagged user data frames.
g) Specifies the rules that govern the addition or removal of VLAN tags to and from user data frames.
h) Establishes the requirements for automatic configuration of VLAN topology.
i) Establishes the requirements for VLAN Bridge Management in a Virtual Bridged Network, identifying managed objects and defining management operations.
j) Defines SMIv2 (IETF STD 58)[8] Management Information Based (MIB) modules for the management of VLAN Bridge capabilities including spanning tree protocols and Provider Bridges.
k) Define YANG configuration and operational state models (Clause 48) in support of Two-Port MAC Relays, Customer VLAN Bridges, and Provider Bridges, including Connectivity Fault Management (CFM) for those Bridges.
l) Defines the operation of the Multiple Spanning Tree Algorithm and Protocol (MSTP).
m) Describes the protocols and procedures necessary to support interoperation between Multiple Spanning Tree (MST) and Single Spanning Tree (SST) Bridges in the same Virtual Bridged Networks.
n) Specifies the requirements to be satisfied by equipment claiming conformance to this standard.

To enable a service provider to use a Virtual Bridged Network to provide separate instances of the IEEE 802 MAC Service, MAC Internal Sublayer Service (ISS), and EISS to multiple independent customers, in a manner that does not require cooperation among the customers and that requires a minimum of cooperation between the customers and the provider of the MAC Service, this standard further specifies the operation of Provider Bridges. To this end, it:

o) Differentiates Customer VLANs (C-VLANs) that are under the administrative control of a single customer of a service provider, from the Service VLANs (S-VLANs) that are used by a service provider to support different customers.
p) Specifies VLAN tag formats for both C-VLANs and S-VLANs, allowing each to be distinguished and separately applied and administered by customers and by a service provider.
q) Specifies the functionality of a generic VLAN Bridge component within a system and the specific requirements of derived C-VLAN and S-VLAN components.
r) Specifies a C-VLAN Bridge as comprising a single C-VLAN component, and a Provider Bridge as encompassing Bridges that comprise a single S-VLAN component and no C-VLAN components (S-VLAN Bridge) or a single S-VLAN component and one or more C-VLAN components (Provider Edge Bridge).

[8] Information on references can be found in Clause 2.

s) Specifies parameters and mappings that allow the EISS to support traffic classes that comprise distinct aggregate flows supporting different QoS characteristics and provide independent guarantees to different customers, through support of priority and drop precedence marking.

t) Specifies the incorporation of flow metering, transmission queue management, and transmission selection algorithms within the forwarding process of a Bridge.

u) Positions the support of S-VLANs within the architectural description of the MAC Sublayer and specifies their relationship to media access method-dependent functions and to the media-independent functions used by customers to administer their networks, including the support of C-VLANs.

v) Allocates the reserved multicast addresses to media access method-dependent, provider network, and customer network functions, specifying the filtering to be applied in each type of VLAN Bridge component.

w) Defines the principles of network operation in terms of the support and preservation of the MAC Service, and the maintenance of QoS for each service instance, including the segregation of data belonging to different organizations.

x) Specifies customer interfaces to a Provider Bridged Network (PBN) in terms of the operation and configuration of the VLAN Bridge components of Provider Bridges, including interfaces that:
   1) Provide access to a single service instance through a Bridge Port.
   2) Allow a customer to select among and identify service instances by Customer VLAN Identifier (C-VID).
   3) Allow a customer to select among and identify service instances by Service VLAN Identifier (S-VID).
   4) Support customer signaling of priority information on a frame by frame basis.
   5) Multiplex service instances over LANs that provide access to a provider network.
   6) Support fault tolerance through redundant provision of access LANs and equipment.

y) Describes the functions to be performed within the PBN in order to support and maintain the connectivity provided to customer service instances.

z) Establishes the requirements for Bridge Management in the PBN, identifying the managed objects and defining the management operations.

aa) Specifies performance requirements, and recommends default values and applicable ranges for the operational parameters of a Provider Bridge.

This standard specifies protocols, procedures, and managed objects to support Connectivity Fault Management (CFM). These allow discovery and verification of the path, through Bridges and LANs, taken for frames addressed to and from specified network users, and support detection and isolation of a connectivity fault to a specific Bridge or LAN. To this end, it:

ab) Defines Maintenance Domains, Maintenance Associations (MAs), their constituent Maintenance Points (MPs), and the managed objects required to create and administer them.

ac) Describes the protocols and procedures used by MPs to detect and diagnose connectivity faults within a Maintenance Domain.

This standard specifies protocols, procedures, and managed objects to allow support of provisioning systems that explicitly select traffic engineered paths within Provider Backbone Bridged Networks (PBBNs) by allowing a network operator to disable unknown destination address forwarding, source address learning and spanning tree protocols for administratively selected VIDs, while allowing other network control protocols to dynamically determine active topologies for other services. These interoperable capabilities are supported by management of individual Bridges by Simple Network Management Protocol (SNMP) using an SMIv2 MIB, by extensions to the other control protocols specified in this standard, by the use of CFM with the addresses and VIDs that specify traffic engineered connections, and by 1:1 path protection switching capable of load sharing. To this end, it:

ad) Enables construction of active topologies by an external agent that is responsible for setting up Ethernet Switched Paths (ESPs) by splitting the B-VID space between distributed spanning tree protocols and provisioned control.

ae) Supports discard of frames with unknown destination addresses for B-VIDs under provisioned control.

af) Supports the operation of Continuity Check, Loopback, and Linktrace protocols on provisioned traffic engineered paths.

ag) Supports 1:1 protection switching capable of load sharing for Traffic Engineering service instances (TESIs).

ah) Supports protection of a group of TESIs that traverses a sequence of LANs and intervening Bridges using a method that does not require the modification of data or control frames.

ai) Provides required extension to SNMP management by SMIv2 MIB modules.

This standard does not specify operation of ESPs through multiple Provider Backbone Bridge Traffic Engineering (PBB-TE) Regions. All the Backbone Edge Bridges (BEBs) specified for use in a PBB-TE Region are combined I type and B type Backbone Edge Bridges (IB-BEBs).

This standard specifies protocols, procedures, and managed objects to support the Multiple Registration Protocol (MRP). MRP allows participants in an MRP Application to register attributes with other participants in a Bridged Network. Four applications are defined—one to register VIDs [Multiple VLAN Registration Protocol (MVRP)], one to register MAC addresses [Multiple MAC Registration Protocol (MMRP)], one to register Streams and configure associated network resources [Multiple Stream Registration Protocol (MSRP)], and one that provides the ability to flush learned MAC Address Entries held in the Filtering Database (FDB) of an I-component on a per-I-SID basis [Multiple I-SID Registration Protocol (MIRP)]. MVRP will furthermore provide for the rapid healing of network failures without interrupting services to unaffected VLANs. To this end, it specifies the following:

aj) MRP and the operation of MRP entities.[9]

ak) The generic frame formats used in MRP exchanges.

al) The MMRP application of MRP, and the frame formats that it uses.

am) The MVRP application of MRP, and the frame formats that it uses.

To allow scaling of Provider Networks to at least 2^{24} S-VLANs, this standard further specifies the operation of Provider Backbone Bridges (PBBs) by means of an architecture and Bridge protocols compatible and interoperable with PBN protocols and equipment, allowing interconnection of multiple PBNs. To this end, it:

an) Introduces BEBs that, by exchanging backbone frames that encapsulate the addresses, VLAN tags, and data of customer frames, support the virtual, media-independent equivalent of a number of independent instances of the service provided by media-dependent frame transmission procedures.

ao) Extends the parameters of the ISS and EISS to include a connection identifier, capable of referencing the backbone addresses and other parameters, used to convey customer frames from one BEB to all, or one of, the other BEBs supporting a particular backbone service instance.

ap) Specifies the format of the Backbone Service Instance tag (I-TAG) that encapsulates the customer addresses, and introduces a Backbone Service Instance Identifier (I-SID) that allows each BEB to support a number of backbone service instances and permits the unambiguous identification of up to 2^{24} backbone service instances within a single PBBN.

aq) Provides a model of BEB operation in terms of VLAN Bridge components that allows the use of Provider Bridges as Backbone Core Bridges (BCBs), with PBBN traffic carried as frames

[9] MRP replaces the Generic Attribute Registration Protocol (GARP), defined in IEEE Std 802.1D™-2004 [B12], that was used to support GVRP and GMRP in earlier revisions of IEEE Std 802.1Q. Similarly, GVRP and GMRP are replaced by MVRP and MMRP, respectively.

containing I-TAGs on particular Backbone VLANs (B-VLANs) potentially coexisting with PBN traffic carried as frames without I-TAGs on other B-VLANs.

ar) Specifies the interfaces that a PBBN can provide to transport service frames. These comprise a Port-based service interface that assigns all received untagged and priority-tagged frames to a single S-VLAN transported over a single backbone service instance, an S-tagged service interface capable of mapping individual S-VLANs to different backbone service instances, and an I-tagged service interface capable of mapping frames from one set of backbone service instances to another.

as) Describes the use of redundant Bridges and access LANs to protect backbone service access against failure of any of those systems or components.

at) Specifies the management of BEBs in terms of the model of operation [item ap) above], making use of defined management objects for the individual VLAN Bridge components, and adding managed objects to facilitate service creation.

au) Describes the use of CFM to detect and isolate faults in the connectivity provided to individual S-VLANs across the PBBN, in the connectivity provided to the group of S-VLANs supported by a single backbone service instance (identified by an I-SID), and in the connectivity provided to individual B-VLANs within the backbone itself.

av) Specifies extensions to MSTP to allow network administrators to protect against loops through peered PBBNs without requiring coupling of spanning trees that operate independently for each PBBN.

This standard specifies CFM protocols, procedures, and managed objects that provide confirmation of successful transmission of frames conveying specified data. This capability supports diagnosis of faults sensitive to, or caused by, particular data patterns, and their isolation to part of the transmission path. Connectivity verification can be carried out from any single point with bridged connectivity to MPs on the path, can isolate failures to communicate in a specific direction, and can be carried out while service is being provided to other users of the data path. To this end, it:

aw) Defines the extensions to CFM capabilities defined by Clause 18 through Clause 22 to facilitate diagnosis and isolation of faults sensitive to, or caused by, particular data patterns in frames transmitted by a service user.

ax) Describes the protocols and procedures for data-driven and data-dependent connectivity fault management (DDCFM).

This standard specifies the function of a Two-Port MAC Relay (TPMR), along with protocols and procedures that support its operation. A TPMR is a type of Bridge that has only two externally accessible Bridge Ports, and supports a subset of the functionality of a MAC Bridge. A TPMR is transparent to all frame-based media-independent protocols, except those explicitly addressed to it and those that are destined for reserved MAC addresses that the relay function of the TPMR is defined not to forward. It is remotely manageable through at least one of its external MACs, and signals a failure of either MAC's LAN through the other MAC. A TPMR should only be attached to point-to-point LANs. The conformance requirements for a TPMR are stated in 5.13 and 5.15.

This standard allows Bridges to provide performance guarantees for time-sensitive (i.e., bounded latency and latency variation) loss-sensitive real-time audio/video (AV) data stream transmission (AV traffic). It specifies priority regeneration and controlled bandwidth queue draining algorithms. VLAN tag encoded priority values are allocated, in aggregate, to segregate frames among queues that support AV traffic and queues that support non-AV traffic, allowing simultaneous support of both AV traffic and other bridged traffic over and between wired and wireless Local Area Networks (LANs). To this end, it:

ay) Defines status parameters that allow the boundaries of a Stream Reservation Protocol (SRP—see Clause 35) domain (35.1.4) to be identified and maintained.

az) Specifies how the priority information in frames received at SRP domain boundary ports is regenerated.

NOTE 1—The priorities in frames transmitted from outside an SRP domain to a Bridge inside an SRP domain are remapped in order to ensure that traffic that is not associated with a reservation does not disrupt traffic that is associated with a reservation. Hence, traffic entering an SRP domain that uses Priority Code Point values associated with reserved traffic classes will be remapped to Priority Code Point values that are not associated with reserved traffic classes.[10]

ba) Specifies how priority information is used to determine the traffic classes to be used for time-sensitive streams.

bb) Defines a credit-based shaper algorithm to shape traffic in accordance with stream reservations.

NOTE 2—The credit-based shaper algorithm operates on the outbound queues; the mechanisms specified for the support of time-sensitive AV traffic do not involve any form of ingress metering or policing.

This standard specifies protocols, procedures, and managed objects to support congestion notification. These allow a Virtual Bridged Network or a portion thereof, with a limited bandwidth-delay product, to transfer long-lived data flows with a significantly reduced chance of frame loss compared to a network without congestion notification. To this end, it:

bc) Defines a means for VLAN Bridges that support congestion notification to form Congestion Managed Domains within a Virtual Bridged Network.

bd) Defines a means for detecting congested queues in end stations and VLAN Bridges, for signaling such congestion to the end stations sourcing the frames causing the congestion, and for those end stations to control the rate of transmission of those frames.

To enable the end-to-end management of resource reservation for QoS guaranteed streams, this standard further specifies protocols, procedures, and managed objects, usable by existing higher layer mechanisms, that allow network resources to be reserved for specific traffic streams traversing a Bridged Network. To this end, it:

be) Specifies the use of Dynamic Reservation Entries (8.8.7) in the FDB to control the forwarding of frames associated with a particular Stream.

bf) Specifies a Stream Reservation Protocol (SRP). SRP facilitates the registration, deregistration, and maintenance of stream reservation information in relevant Bridges to establish end-to-end stream paths.

This standard specifies protocols, procedures, and managed objects to support topology change signaling to alter the binding (held in an I-Component) of Customer addresses to backbone addresses on a per-I-SID basis. This is accomplished by extending the use of MRP. To this end, it specifies the MIRP application of MRP and the frame formats that it uses.

NOTE 3—MIRP can only trigger the flushing of learned MAC address information; it does not propagate the registration of I-SIDs. The name Multiple I-SID Registration Protocol is chosen because MIRP is a Multiple Registration Protocol (MRP) application and can be extended to perform I-SID registrations.

This standard allows an S-tagged service interface connecting two independently administered PBNs to be used to handle traffic (identified by a single S-VID) for a given customer attached to one PBN as if the customer were directly attached to the other PBN using a Port-based or C-tagged service interface. To this end, it:

bg) Specifies the use of a Port-mapping S-VLAN component to associate selected S-VIDs registered on an external port with distinct internal ports, each of which supports a separate service interface.

This standard specifies protocols, procedures, and managed objects to support Priority-based Flow Control (PFC). These allow a Virtual Bridged Network, or a portion thereof, to enable flow control per traffic class on IEEE 802 point-to-point full-duplex links. To this end, it:

[10] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

bh) Defines a means for a system to inhibit transmission of data frames on certain priorities from the remote system on the link.

This standard specifies protocols, procedures, and managed objects for enhancement of transmission selection to support allocation of bandwidth among traffic classes. When the offered load in a traffic class does not use its allocated bandwidth, Enhanced Transmission Selection (ETS) will allow other traffic classes to use the available bandwidth. Bandwidth is used by traffic classes subject to ETS when there are no frames to be transmitted for traffic classes subject to strict priority or credit-based shaper algorithms. It defines the Data Center Bridging eXchange protocol (DCBX), which controls the application of ETS and PFC.

This standard specifies Shortest Path Bridging (SPB) of unicast and multicast frames, specifying protocols to calculate multiple active topologies that can share learned station information, and support of a VLAN by multiple, per-topology, Shortest Path VLAN Identifiers (SPVIDs). To this end, it:

bi) Describes the use of shortest paths to increase throughput and minimize transit delay, while introducing a negligible rate of frame misordering.

bj) Requires that active topologies calculated by spanning tree protocols and Shortest Path Tree (SPT) protocols be stable, predictable, and reproducible to maintain the characteristics of the MAC Service provided.

bk) Requires, except in the case of SPB using Equal Cost Multiple Paths (ECMP), active topologies that are reverse path congruent and unicast-multicast congruent to permit learning of station location from the source addresses of all frames and simplify the detection and management of faults.

NOTE 4—ECMP operation does not provide (nor does this standard attempt to define for ECMP VLANs) reverse path congruence and unicast-multicast congruence as these concepts cease to have utility in an ECMP context.

bl) Specifies the calculation of symmetric sets of SPTs, each rooted at a Bridge within an SPT Region comprising Bridges operating compatible protocols and configurations.

bm) Specifies the use of Bridge Protocol Data Units (BPDUs) to identify and bound SPT Regions and to ensure loop-free interoperability with regions using the Rapid Spanning Tree Algorithm and Protocol (RSTP) and MSTP.

bn) Specifies both Shortest Path Bridging VID (SPBV) and Shortest Path Bridging MAC (SPBM) modes:
  1) for SPBV, identifying each SPT by SPVID and locating end stations by source MAC address learning.
  2) for SPBM, identifying each SPT by VID and source MAC address and distributing end station location information explicitly.

bo) Supports management selection of the Common Spanning Tree (CST), a Multiple Spanning Tree Instance (MSTI), or SPB for support of any given VLAN within an SPT Region.

bp) Specifies a protocol that automatically assigns SPVIDs for each VLAN supported by SPBV.

bq) Supports load sharing by Equal Cost Trees (ECTs) through the calculation of multiple SPT Sets, with each shortest path VLAN being assigned to one SPT Set.

br) Specifies Intermediate System to Intermediate System Protocol for Shortest Path Bridging (ISIS-SPB): the use of and extensions to the Intermediate System to Intermediate System (IS-IS) Protocol to calculate SPTs for both SPBV and SPBM.

bs) Describes the addressing of ISIS-SPB entities and specifies the group MAC addresses they use.

bt) Specifies the use of loop prevention (for SPBV and for multicast frames for SPBM) and loop mitigation (for unicast frames for SPBM).

bu) Specifies an Agreement Protocol that prevents loops, specifying the necessary state information and computation as part of ISIS-SPB and communicating agreement information for the CIST and (as a compact Digest) for SPTs in each BPDU.

This standard specifies protocols, procedures, and managed objects that:

bv) Provide for the discovery, configuration, and control of a pair of direct-attached Port-mapping S-VLAN components to extend the operation of a Customer Bridge to remote ports and enable coexistence of multiple services on station-resident ports (e.g., embedded bridging).

bw) Provide for discovery, configuration, and operation of reflective relay (8.6.1) for a Bridge Port.

bx) Provide for discovery of, and coordinated configuration of, edge relays (ERs) and other devices that utilize the reflective relay service.

by) Provide for dynamic profile-driven port configuration.

bz) Specifies load spreading by distributing unicast traffic over the set of available equal cost paths and assigning multicast traffic flows to a variety of trees.

ca) Specifies a flow filtering tag (F-TAG) containing a flow hash used in unicast ECMP traffic distribution and a TTL (time-to-live) field used to mitigate the effects of traffic loops resulting from transient conditions or control software errors or faults.

This standard also specifies further protocol extensions, procedures, and managed objects to IS-IS for providing capabilities beyond Shortest Path Bridging (SPB) for Bridged Networks. These extensions involve explicit path control, bandwidth reservation, and redundancy (protection, restoration) for data flows. Thus, this standard specifies bridging on explicit paths for unicast and multicast frames, specifying protocols to determine multiple active topologies. To this end, it:

cb) Describes the use of explicit trees, e.g., to improve resiliency and decrease the probability of congestion.

cc) Requires that active topologies calculated by one or multiple entities external to the routing protocol are such that the characteristics of the MAC Service are provided.

cd) Supports management selection of explicit trees for support of any given VLAN within an SPT Region.

ce) Specifies Intermediate System to Intermediate System Path Control and Reservation (ISIS-PCR): the use of and extensions to the Intermediate System to Intermediate System (IS-IS) protocol to establish explicit trees.

cf) Specifies the use of ISIS-PCR for recording bandwidth assignments.

cg) Specifies redundancy for ISIS-SPB and ISIS-PCR.

This standard also:

ch) Provides for the use of IEEE 802.11™ media as links internal to, as well as links providing access to, a Bridged Network or Virtual Bridged Network.

ci) Defines enhancements for scheduled traffic to allow transmissions scheduled relative to a known timescale.

cj) Defines frame preemption to interrupt transmission of preemptable frames by express frames.

This standard specifies protocols, procedures, and managed objects that:

ck) Allow for the filtering and policing of individual traffic streams.

cl) Allow for Asynchronous Traffic Shaping (ATS) over full-duplex links with constant bit data rates.

This standard specifies enhancements to protocols, procedures, and managed objects for the configuration of network resources for time-sensitive (i.e., bounded latency) applications. The enhancements address Time-Sensitive Networking (TSN) application requirements beyond audio/video (AV) traffic. To this end, it:

cl) Specifies a software interface between the user (i.e., time-sensitive application) and network components, such that the user provides Stream requirements (e.g., for bounded latency), and the network configures resources from Talker to Listeners to meet those requirements. This user/network interface (UNI) is specified as an information model that can be applied to any protocol.

cm) Specifies three models for the UNI: fully distributed, centralized network/distributed user, and fully centralized.

cn) Specifies enhancements to the Stream Reservation Protocol (SRP), using a new application version, MSRPv1. MSRPv1 integrates the UNI TLVs for the benefits of enhanced configuration. For compatibility, MSRPv1 translates to the previous version (MSRPv0).

co) Specifies enhancements to the managed objects for forwarding and queuing enhancements for time-sensitive streams (FQTSS).

cp) Specifies enhancements to the managed objects for SRP.

cq) Specifies managed objects for configuration of Bridges by a Centralized Network Configuration (CNC) component.

This standard specifies protocols, procedures, and managed objects that:

cr) Provide for Network Virtualization Overlays over Layer 3 (NVO3)-related port configuration.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.159, American National Standards for Information Systems—Programming Language—C.[11]

IEEE Std 802®, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.[12, 13]

IEEE Std 802d™-2017, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture—Amendment 1: Allocation of Uniform Resource Name (URN) Values in IEEE 802® Standards.

IEEE Std 802.1AB™, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

IEEE Std 802.1AC™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE™, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Security.

IEEE Std 802.1AS™, IEEE Standard for Local and metropolitan area networks—Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.

IEEE Std 802.1AX™, IEEE Standard for Local and metropolitan area networks—Link Aggregation.

IEEE Std 802.1BR™, IEEE Standard for Local and metropolitan area networks—Virtual Bridged Local Area Networks—Bridge Port Extension.

IEEE Std 802.1CB™, IEEE Standard for Local and metropolitan area networks—Frame Replication and Elimination for Reliability.

IEEE Std 802.1X™, IEEE Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.

IEEE Std 802.3™, IEEE Standard for Ethernet.

IEEE Std 802.11™, Standard for Information Technology—Telecommunications and Information Exchange between Systems—Local and Metropolitan Area Networks—Specific Requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

IEEE Std 802.20™, IEEE Standard for Local and metropolitan area networks—Part 20: Air Interface for Mobile Broadband Wireless Access Systems Supporting Vehicular Mobility—Physical and Media Access Control Layer Specification.

IETF RFC 1035 (STD 13), Domain Names—Implementation and Specification, November 1987.[14]

[11] ANSI publications are available from the IHS Standards Store (https://global.ihs.com/).
[12] The IEEE standards or products referred to in Clause 2 are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.
[13] IEEE publications are available from The Institute of Electrical and Electronics Engineers (https://standards.ieee.org/).
[14] IETF RFCs are available from the Internet Engineering Task Force (https://www.ietf.org/).

IETF RFC 1042, A Standard for the Transmission of IP Datagrams over IEEE 802 Networks, February 1988.

IETF RFC 1390 (STD 36), Transmission of IP and ARP over FDDI Networks, January 1993.

IETF RFC 2104, HMAC: Keyed-Hashing for Message Authentication, February 1997.

IETF RFC 2119 (BCP 14), Key words for use in RFCs to Indicate Requirement Levels, March 1997.

IETF RFC 2205, Resource ReSerVation Protocol (RSVP)—Version 1 Functional Specification, September 1997.

IETF RFC 2271, An Architecture for Describing SNMP Management Frameworks, January 1998.

IETF RFC 2474, Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers, December 1998.

IETF RFC 2578 (STD 58), Structure of Management Information Version 2 (SMIv2), April 1999.

IETF RFC 2579 (STD 58), Textual Conventions for SMIv2, April 1999.

IETF RFC 2580 (STD 58), Conformance Statements for SMIv2, April 1999.

IETF RFC 2685, Virtual Private Networks Identifier, September 1999.

IETF RFC 2737, Entity MIB (Version 2), December 1999.

IETF RFC 2750, RSVP Extensions for Policy Control, January 2001.

IETF RFC 2863, The Interfaces Group MIB, June 2000.

IETF RFC 3046, DHCP Relay Agent Information Option, January 2000.

IETF RFC 3410, Introduction and Applicability Statements for Internet Standard Management Framework, December 2002.

IETF RFC 3411, An Architecture for Describing Simple Network Management Protocol (SNMP) Management Frameworks, December 2002.

IETF RFC 3413 (STD 62), Simple Network Management Protocol (SNMP) Applications, December 2002.

IETF RFC 3414 (STD 62), User-based Security Model (USM) for version 3 of the Simple Network Management Protocol (SNMPv3), December 2002.

IETF RFC 3415 (STD 62), View-based Access Control Model (VACM) for the Simple Network Management Protocol (SNMP), December 2002.

IETF RFC 3417 (STD 62), Transport Mappings for the Simple Network Management Protocol (SNMP), December 2002.

IETF RFC 3418 (STD 62), Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), December 2002.

IETF RFC 3419, Textual Conventions for Transport Addresses, December 2002.

IETF RFC 4122, A Universally Unique IDentifier (UUID) URN Namespace, July 2005.

IETF RFC 4188, Definitions of Managed Objects for Bridges, September 2005.

IETF RFC 4291, IP Version 6 Addressing Architecture, February 2006.

IETF RFC 4318, Definitions of Managed Objects for Bridges with Rapid Spanning Tree Protocol, December 2005.

IETF RFC 4363, Definitions of Managed Objects for Bridges with Traffic Classes, Multicast Filtering, and Virtual LAN Extensions, January 2006.

IETF RFC 4789, Simple Network Management Protocol (SNMP) over IEEE 802 Networks, November 2006.

IETF RFC 5120, M-ISIS: Multi Topology (MT) Routing in Intermediate System to Intermediate Systems (IS-ISs), February 2008.

IETF RFC 5303, Three-Way Handshake for IS-IS Point-to-Point Adjacencies, October 2008.

IETF RFC 5305, IS-IS Extensions for Traffic Engineering, October 2008.

IETF RFC 5307, IS-IS Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS), October 2008.

IETF RFC 6165, Extensions to IS-IS for Layer-2 Systems, April 2011.

IETF RFC 7365, Framework for Data Center (DC) Network Virtualization, October 2014.

IETF RFC 7810, IS-IS Traffic Engineering (TE) Metric Extensions, May 2016.

IETF RFC 7811, An Algorithm for Computing IP/LDP Fast Reroute Using Maximally Redundant Trees (MRT-FRR) , June 2016.

IETF RFC 7950, The YANG 1.1 Data Modeling Language, August 2016.

IETF RFC 8343, A YANG Data Model for Interface Management, March 2018.

IETF RFC 8394, Split Network Virtualization Edge (Split-NVE) Control-Plane Requirements, May 2018.

ISO/IEC 7498-1, Information technology—Open Systems Interconnection—Basic Reference Model: The Basic Model.[15]

ISO/IEC 8802-2, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 2: Logical link control.

ISO/IEC 8802-11, Telecommunications and information exchange between systems—Specific requirements for local and metropolitan area networks—Part 11: Wireless LAN medium access control (MAC) and physical layer (PHY) specifications.

[15] ISO/IEC publications are available from the International Organization for Standardization (https://www.iso.org/) and the International Electrotechnical Commission (https://www.iec.ch/). ISO/IEC publications are also available from the American National Standards Institute (https://www.ansi.org/).

ISO/IEC TR 9577:1999, Information technology—Protocol identification in the network layer.

ISO/IEC 10589:2002, Information technology—Telecommunications and information exchange between systems—Intermediate System to Intermediate System intra-domain routeing information exchange protocol for use in conjunction with the protocol for providing the connectionless-mode network service (ISO 8473).

ISO/IEC TR 11802-5:1997, Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Technical reports and guidelines—Part 5: Media Access Control (MAC) Bridging of Ethernet V2.0 in Local Area Networks.

ITU-T Recommendation X.690 (2002), Information technology—ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER).[16]

ITU-T Recommendation G.8013/Y.1731, Operation, administration and maintenance (OAM) functions and mechanisms for Ethernet-based networks.

MEF Technical Specification 10.3 (MEF 10.3), Ethernet Services Attributes Phase 3, October 2013.[17]

[16] ITU-T publications are available from the International Telecommunications Union (https://www.itu.int/).
[17] MEF publications are available from the MEF Forum (https://www.mef.net/).

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[18]

This standard makes use of the following terms defined in IEEE Std 802:

— end station
— station

The following terms are specific to this standard:

3.1 Active Segment: The Infrastructure Segment, either the Working Segment or the Protection Segment, that is currently carrying traffic of Traffic Engineering service instances (TESIs) associated with the Infrastructure Protection Group (IPG).

3.2 Active Service Access Point [SAP] (Active SAP): The SAP, bounding a Maintenance Point (MP), that is on the side of the MP toward the monitored Maintenance Association (MA).

3.3 Adjacency: A neighbor in Intermediate System to Intermediate System (IS-IS) Protocol. From section 3.6 of ISO/IEC 10589:2002.

3.4 Agreement Protocol: A protocol that uses control plane synchronization between adjacent Bridges to guarantee loop prevention, so enabling rapid transition to forwarding after network topology changes.

NOTE—See 13.16 and 13.17.

3.5 Almost Directed Acyclic Graph (ADAG): A directed graph that can be transformed into a Directed Acyclic Graph (DAG) by removing all arcs incoming to the ADAG Root.

3.6 audio/video (AV) traffic: Traffic associated with audio and/or video applications that is sensitive to transmission latency and latency variation, and, for some applications, packet loss.

3.7 B-component (B-Comp): A Service Virtual Local Area Network (S-VLAN) component with one or more Customer Backbone Ports (CBPs).

3.8 B-DEI field: A field of a Backbone Virtual Local Area Network (B-VLAN) tag (B-TAG) that identifies the drop eligibility of the frame.

3.9 B-PCP field: A field of a Backbone Virtual Local Area Network (B-VLAN) tag (B-TAG) that indicates the B-VLAN priority of the frame.

3.10 Backbone Core Bridge (BCB): A Service Virtual Local Area Network (S-VLAN) Bridge used within the core of a Provider Backbone Bridged Network (PBBN).

3.11 Backbone Edge Bridge (BEB): A system that encapsulates customer frames for transmission across a Provider Backbone Bridged Network (PBBN).

3.12 Backbone Media Access Control (B-MAC) address: An individual Media Access Control (MAC) address associated with a Provider Instance Port (PIP) and used in creating the MAC header of I-tagged frames transmitted across a Provider Backbone Bridged Network (PBBN).

[18] *IEEE Standards Dictionary Online* is available at https://dictionary.ieee.org.

3.13 Backbone Media Access Control (B-MAC) Frame: A local area network (LAN) frame addressed with B-MAC addresses.

3.14 backbone service instance: An instance of the Media Access Control (MAC) Service in a Provider Backbone Bridged Network (PBBN), provided between two or more Virtual Instance Ports (VIPs) in Backbone Edge Bridges (BEBs).

3.15 Backbone Service Instance tag (I-TAG): A tag with an EtherType value allocated for "IEEE 802.1Q Backbone Service Instance Tag EtherType."

3.16 Backbone Virtual Local Area Network (B-VLAN): A Virtual Local Area Network (VLAN) identified by a B-VLAN Identifier (B-VID).

3.17 Backbone Virtual Local Area Network [B -VLAN] Identifier (B-VID): A Virtual Local Area Network (VLAN) Identifier (VID) conveyed in a B-VLAN tag (B-TAG).

3.18 Backbone Virtual Local Area Network [B -VLAN] tag (B-TAG): An Service Virtual Local Area Network (S-VLAN) tag (S-TAG) used in conjunction with Backbone Media Access Control (B-MAC) addresses.

3.19 Backbone Virtual Local Area Network (B-VLAN) tagged frames: Frames that contain a B-VLAN tag (B-TAG) immediately following the Source MAC Address field.

3.20 base time: A time from which future cycles of gate close and open events are calculated.

3.21 Base Virtual Local Area Network [VLAN] Identifier [VID] (Base VID): The identifier of a VLAN in management operations in both Shortest Path Bridging VID (SPBV) mode and Shortest Path Bridging Media Access Control (MAC) (SPBM) mode.

3.22 bit time: The duration of one bit as transferred to and from the Media Access Control (MAC).

3.23 Boundary Port: A Bridge Port attaching a Multiple Spanning Tree (MST) Bridge to a Local Area Network (LAN) that is not in the same region.

3.24 Bridge: A system that includes Media Access Control (MAC) Bridge or Virtual Local Area Network (VLAN) Bridge component functionality.

3.25 Bridge Local Computation Engine (BLCE): A computation engine in a Bridge that performs path and routing computations. The BLCE implements, e.g., Shortest Path First (SPF), Constrained Shortest Path First (CSPF), or the Maximally Redundant Trees Algorithm (IETF RFC 7811).

3.26 Bridge Port: A Service Access Point (SAP) that provides the Enhanced Internal Sublayer Service (EISS) to the Media Access Control (MAC) Relay Entity of a Virtual Local Area Network (VLAN) Bridge component, or that provides the Internal Sublayer Service (ISS) to the MAC Relay Entity of a MAC Bridge, and the interface stack that supports that SAP.

NOTE—See 6.1, 8.5, and IEEE Std 802.1AC.

3.27 Bridged Network: A concatenation of individual IEEE 802 Local Area Networks (LANs) interconnected by Bridges.

3.28 Centralized Network Configuration (CNC): A centralized component that configures network resources on behalf of TSN applications (users).

3.29 Centralized User Configuration (CUC): A centralized entity that discovers end stations, retrieves end station capabilities and user requirements, and configures TSN features in end stations.

3.30 C-tagged service interface: The interface provided by a Provider Edge Bridge (PEB) to allow the attached customer to select between and identify service instances using the C-VID associated with transmitted and received frames.

3.31 candidate Protection Segment: In the case of M:1 Infrastructure Protection Switching (IPS), an Infrastructure Segment that can assume the role of Protection Segment.

3.32 Common and Internal Spanning Tree (CIST): The single spanning tree calculated by the Rapid Spanning Tree Algorithm and Protocol (RSTP) and the logical continuation of that connectivity through Multiple Spanning Tree (MST) Bridges and Regions, calculated by the Multiple Spanning Tree Algorithm and Protocol (MSTP) to ensure that all Local Area Networks (LANs) in the Bridged Network are simply and fully connected.

3.33 Common Spanning Tree (CST): The single spanning tree calculated by the Rapid Spanning Tree Algorithm and Protocol (RSTP) and Multiple Spanning Tree Algorithm and Protocol (MSTP) to connect Multiple Spanning Tree (MST) Regions.

3.34 congestion-aware system: A Bridge component or end station that is capable of detecting congestion and sending congestion notifications.

3.35 Congestion Controlled Flow (CCF): A sequence of frames with the same priority, that the transmitting end station treats as belonging to a single flow, using a single Reaction Point (RP) to control the transmission rate of all those frames.

3.36 Congestion Notification Domain (CND): A connected subset of the end stations and Virtual Local Area Network (VLAN) Bridges in a Virtual Bridged Network that are compatibly configured to support a Congestion Notification Priority Value (CNPV).

3.37 Congestion Notification Message (CNM): A message transmitted by a Congestion Point (CP) to a Reaction Point (RP), in response to a frame received from that RP, conveying congestion information used by the RP to reduce its transmission rate.

3.38 Congestion Notification Priority Value (CNPV): A value of the priority parameter that a congestion-aware system uses to support congestion notification.

3.39 Congestion Notification Tag (CN-TAG): A tag that conveys a Flow Identifier (ID), that a Reaction Point (RP) can add to transmitted Congestion Controlled Flow (CCF) frames, and that a Congestion Point (CP) includes in a Congestion Notification Message (CNM).

3.40 Congestion Point (CP): A Virtual Local Area Network (VLAN) Bridge or end station Port function that monitors a single queue serving one or more Congestion Notification Priority Values (CNPVs), can generate Congestion Notification Messages (CNMs), and can remove Congestion Notification Tags (CN-TAGs).

NOTE—See 31.1.1.

3.41 congruent: (A) An adjective to describe two or more paths that coincide at all points when superimposed. (B) An adjective to describe a set of trees specifying paths that coincide at all points when superimposed, for all Virtual Local Area Networks (VLAN**s).** *See also:* **reverse path congruent**, **unicast multicast congruent**, **downstream congruent**, and **symmetric**.

3.42 Connectivity Fault Management (CFM): Management capabilities for detecting, verifying, and isolating connectivity failures in Virtual Bridged Networks.

3.43 constrained routing (CR): Shortest path routing on a topology pruned to only contain the links meeting a given constraint.

3.44 Constrained Shortest Path First (CSPF): The phrase for the Dijkstra Shortest Path First Algorithm when it is run after pruning the links not meeting a given constraint.

3.45 constrained tree: A tree meeting a certain constraint, e.g., providing a minimal available bandwidth.

3.46 Continuity Check Message (CCM): A multicast Connectivity Fault Management (CFM) protocol data unit (PDU) transmitted periodically by a Maintenance Association (MA) Endpoint (MEP) in order to ensure continuity over the MA to which the transmitting MEP belongs.

3.47 current Protection Segment: In the case of M:1 Infrastructure Protection Switching (IPS), the candidate Protection Segment that is currently assuming the role of Protection Segment.

3.48 customer: The purchaser of a service instance from a service provider.

NOTE—Certain terms in this standard, including customer and service provider, reflect common business relationships that exist among the users of equipment implemented in conformance with this standard. The use of these terms does not imply or impose any requirement on such business relationships. A customer is often a business.

3.49 Customer Backbone Port (CBP): A Backbone Edge Bridge (BEB) Port that can receive and transmit I-tagged frames for multiple customers and can assign Backbone Virtual Local Area Network (B-VLAN) Identifiers (B-VIDs) and translate Backbone Service Instance Identifier (I-SID) on the basis of the received I-SID.

3.50 Customer Bridge: A Media Access Control (MAC) Bridge or a Customer Virtual Local Area Network (C-VLAN) Bridge.

3.51 Customer Bridged Network (CBN): A network of Customer Bridges.

3.52 Customer Edge Port (CEP): A Customer Virtual Local Area Network (C-VLAN) component Port on a Provider Edge Bridge (PEB) that is connected to customer-owned equipment and receives and transmits frames for a single customer.

3.53 customer equipment: The physical embodiment of one or more customer systems.

3.54 Customer Media Access Control (C-MAC) address: A Media Access Control (MAC) address within a Customer Bridged Network (CBN) or Provider Bridged Network (PBN). C-MAC addresses are carried within an Backbone Service Instance tag (I-TAG) in a Provider Backbone Bridged Network (PBBN).

3.55 Customer Network Port (CNP): A Service Virtual Local Area Network (S-VLAN) component Port on a Provider Bridge or within a Provider Edge Bridge (PEB) that receives and transmits frames for a single customer.

3.56 customer system: A system attached to a Provider Bridged Network (PBN) but not intended by the service provider to be under the control of the service provider.

3.57 Customer Virtual Local Area Network (C-VLAN): A Virtual Local Area Network (VLAN) identified by a C-VID (C-VLAN Identifier).

3.58 Customer Virtual Local Area Network (C-VLAN) Bridge: A system comprising a single C-VLAN component.

3.59 Customer Virtual Local Area Network (C-VLAN) component: A Virtual Local Area Network (VLAN) Bridge component with each Port supported by an instance of the Enhanced Internal Sublayer Service (EISS) that can recognize, insert, and remove C-VLAN tags (C-TAGs).

3.60 Customer Virtual Local Area Network [C-VLAN] Identifier (C-VID): A Virtual Local Area Network (VLAN) Identifier (VID) conveyed in a C-VLAN tag (C-TAG).

3.61 Customer Virtual Local Area Network [C-VLAN] tag (C-TAG): A Virtual Local Area Network (VLAN) tag with a Tag Protocol Identification value allocated for "802.1Q Tag Protocol EtherType."

3.62 cut-bridge: A Bridge whose removal partitions the network.

3.63 cut-link: A link whose removal partitions the network.

3.64 Data Center Bridging (DCB): A set of protocols and capabilities for use in a data center environment.

3.65 data-driven and data-dependent connectivity fault management (DDCFM): Connectivity Fault Management (CFM) capabilities that facilitate detecting and isolating data-driven and data-dependent faults (DDFs) in Virtual Bridged Networks.

3.66 data-driven and data-dependent fault (DDF): A fault that is sensitive to, or caused by, particular data patterns in frames transmitted by a service user.

3.67 Decapsulator Responder (DR): An entity for decapsulating Send Frame Messages (SFMs) and sending the decapsulated frames toward destinations specified by their own destination_address field.

3.68 Designated Multiple Stream Registration Protocol [MSRP] Node (DMN): A single station on a shared medium (e.g., IEEE 802.11 or a Coordinated Shared Network (CSN)) that controls MSRP access for all other stations on that shared medium.

3.69 Directed Acyclic Graph (DAG): A directed graph containing no directed cycle.

3.70 Domain Service Access Point (DoSAP): A member of a set of Service Access Points (SAPs) at which a Maintenance Domain is capable of offering connectivity to systems outside the Maintenance Domain. Each DoSAP provides access to an instance either of the Enhanced Internal Sublayer Service (EISS) or of the Internal Sublayer Service (ISS).

3.71 Down Maintenance Association [MA] Endpoint [MEP] (Down MEP): A MEP residing in a Bridge that receives Connectivity Fault Management (CFM) protocol data units (PDUs) from, and transmits them toward, the direction of the Local Area Network (LAN).

3.72 Down Maintenance Point [MP] (Down MP): A Maintenance Association (MA) Endpoint (MEP) or a Maintenance Domain Intermediate Point (MIP) Half Function (MHF) residing in a Bridge that receives Connectivity Fault Management (CFM) protocol data units (PDUs) from, and transmits them toward, the direction of the Local Area Network (LAN).

3.73 downlink relay port (DRP): A port of an edge relay (ER) that is capable of supporting at least one Virtual Station Interface (VSI). For NVO3 a port of a tNVE that is capable of supporting at least one NVO3 Tenant Station Interface (TSI) (see IETF RFC 8394).

3.74 downstream congruent: A phrase to describe the path for a given frame relayed by a first Bridge when that path passes through a second Bridge and is thereafter the same as the path for any other frame (assigned to the same Virtual Local Area Network (VLAN) and destined to the same station) relayed by the second Bridge.

3.75 Edge Control Protocol (ECP): A protocol that provides reliable delivery of control service data units (SDUs).

3.76 edge relay (ER): A Bridge supporting the transfer of frames between one or more downlink relay ports (DRPs) and one uplink relay port (URP).

3.77 Edge Virtual Bridging (EVB): The set of functions supporting Virtual Station Interfaces (VSIs) in Bridges and attached end stations.

3.78 Edge Virtual Bridging (EVB) Bridge: A Customer Virtual Local Area Network (C-VLAN) Bridge that supports the Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP).

3.79 Edge Virtual Bridging (EVB) station: An end station containing one or more edge relays (ERs).

3.80 Enhanced Internal Sublayer Service [EISS] Service Access Point [SAP] (EISS-SAP): An instance of the EISS.

NOTE—See 6.8.

3.81 Equal Cost Multiple Paths (ECMP): The use of multiple possible next hop choices for frames within a single service in Shortest Path Bridging Media Access Control (MAC) (SPBM) mode networks.

3.82 Equal Cost Multiple Paths [ECMP] path Maintenance Association [MA] (ECMP path MA): An MA that monitors a set, which can be complete, of equal connectivity paths between two specific endpoints as constructed by ECMP.

3.83 Equal Cost Tree (ECT): One of the shortest path trees from the root Bridge selected from alternatives with the same path costs.

3.84 Equal Cost Tree (ECT) Algorithm: A Shortest Path Tree (SPT) algorithm yielding a consistent result for a given root Bridge when run by all Bridges within an SPT Region.

3.85 Ethernet: A term that is used to refer either to the IEEE 802.3 media access method or to the IEEE 802.3 frame format.

NOTE—In many places, “Ethernet” is also used as part of a reserved term with its own specific meaning.

3.86 Ethernet Switched Path (ESP): A provisioned traffic engineered unidirectional connectivity path among two or more Customer Backbone Ports (CBPs) that extends over a Provider Backbone Bridged Network (PBBN). The path is identified by a 3-tuple <ESP-DA, ESP-SA, ESP-VID>, where ESP-DA and ESP-SA are Media Access Control (MAC) addresses and ESP-VID is a Virtual Local Area Network (VLAN) Identifier (VID) allocated to Traffic Engineering Multiple Spanning Tree Instance Identifier (TE-MSTID).

NOTE—The use of “Ethernet” in this definition does not imply that an ESP is limited to use in conjunction with IEEE Std 802.3™.

3.87 Ethernet Switched Path [ESP] Virtual Local Area Network [VLAN] Identifier [VID] (ESP-VID): A VLAN Identifier (VID) associated with a special (Traffic Engineering) value of the Multiple Spanning Tree Instance Identifier (MSTID) in the Multiple Spanning Tree (MST) Configuration Table, the TE-MSTID, indicating that the VID is under the control of an external agent responsible for setting up ESPs and that learning is disabled and forwarding is enabled.

3.88 Expedited traffic: Traffic that requires preferential treatment as a consequence of jitter, latency, or throughput constraints or as a consequence of management policy.

3.89 Explicit Tree (ET): An explicitly defined tree, which is specified by its Edge Bridges and the paths among the Edge Bridges. If only the Edge Bridges are specified but the paths are not, then it is a loose explicit tree. If the paths are also specified, then it is a strict explicit tree.

3.90 Explicit Tree Database (ETDB): A database storing explicit trees.

3.91 Fault Alarm: An out-of-band signal, which can be a Simple Network Management Protocol (SNMP) Notification, that notifies a system administrator of a connectivity failure.

3.92 flow filtering tag (F-TAG): A tag with a Tag Protocol Identification value allocated for "IEEE 802.1Q Flow Filtering Tag EtherType."

3.93 flow hash: An arbitrary value that serves to distinguish flows that may be subject to different treatment in a bridged network, for example, flows subject to independent treatment by Equal Cost Multiple Paths (ECMP).

3.94 Flow Identifier [ID] (Flow ID): An ID assigned by a congestion-aware end station, unique within the scope of one or more of the source Media Access Control (MAC) addresses used by that system to transmit Congestion Controlled Flow (CCF) frames.

3.95 forced switch (FS): An administrative command to force the backbone service instances assigned to a Traffic Engineering (TE) protection group to be carried by this group's protection entity.

3.96 forward path test (FPT): A test to determine whether a data frame that matches the specified filter condition can reach a specific location within a network.

3.97 Frame: A unit of data transmission on an IEEE 802 Local Area Network (LAN) that conveys a Media Access Control (MAC) Protocol Data Unit (MPDU).

3.98 Frame relay: Forwarding of frames between the Ports of a Bridge.

3.99 gate-close event: An event that occurs when the transmission gate associated with a queue transitions from the Open state to the Closed state, disconnecting the transmission selection function of the forwarding process from the queue and preventing it from selecting frames from that queue.

3.100 gate-open event: An event that occurs when the transmission gate associated with a queue transitions from the Closed state to the Open state, connecting the transmission selection function of the forwarding process to a queue and allowing it to select frames from that queue.

3.101 gating cycle: The period of time over which the sequence of operations in a gate control list repeats.

3.102 Generalized Almost Directed Acyclic Graph (GADAG): A directed graph that has only Almost Directed Acyclic Graphs (ADAGs) as all of its topology blocks.

3.103 Group: An association of

a) A group Media Access Control (MAC) address
b) A set of properties that define membership characteristics
c) A set of properties that define the forwarding/filtering behavior of a Bridge with respect to frames destined for members of that group MAC address

with a set of end stations that all wish to receive information destined for that group MAC address.

NOTE—An example of the information that Group members might wish to receive is a multicast video data stream.

3.104 GroupID: A service instance identifier used in Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP).

3.105 I-component (I-Comp): A Service Virtual Local Area Network (S-VLAN) component with one or more Provider Instance Ports (PIPs).

3.106 I-DEI field: A field of the Backbone Service Instance tag (I-TAG) that indicates the drop eligibility of a frame in a backbone service instance.

3.107 I-PCP field: A field of the Backbone Service Instance tag (I-TAG) that indicates the priority of a frame in a backbone service instance.

3.108 I-SID field: A field of the Backbone Service Instance tag (I-TAG) that identifies the backbone service instance of a frame.

3.109 I-tagged frame: A frame that contains a Backbone Service Instance tag (I-TAG) immediately following the Source MAC Address field.

3.110 IEEE 802 Local Area Network [LAN] (IEEE 802 LAN): LAN technologies that provide a Media Access Control (MAC) Service equivalent to the MAC Service defined in IEEE Std 802.1AC. IEEE 802 LANs include IEEE 802.3 (Ethernet) and IEEE 802.11 (Wireless) LANs.

NOTE—The term “Local Area Network” and the abbreviation LAN are used exclusively to refer to an individual LAN specified by a MAC technology, without the inclusion of Bridges. This precise use of terminology within this specification allows a Bridged Network to be distinguished from an individual LAN that has been bridged to other LANs in the network (a bridged LAN). In more general usage, such precise terminology is not required, as it is an explicit goal of IEEE Std 802.1Q that Bridges are transparent to the users of the MAC Service.

3.111 Independent Virtual Local Area Network [VLAN] Learning (IVL): Configuration and operation of the Learning Process and the Filtering Database (FDB) such that, for a given set of VLAN Identifiers (VIDs), if a given individual Media Access Control (MAC) Address is learned in association with one VID, that learned information is not used in forwarding decisions taken for that address relative to any other VID in the given set.

NOTE—In a Bridge that supports only IVL operation, the “given set of VIDs” is the set of all VIDs.

3.112 Independent Virtual Local Area Network [VLAN] Learning [IVL] Bridge (IVL Bridge): A Bridge that supports only IVL.

3.113 Infrastructure Protection Group (IPG): In the case of 1:1 Infrastructure Protection Switching (IPS), a set comprising a Working Segment and a Protection Segment or, in the case of M:1 IPS, a set comprising a Working Segment and one or more Protection Segments.

3.114 Infrastructure Protection Switching (IPS): The switching of a selected group of Traffic Engineering service instances (TESIs) from a Working Segment to a Protection Segment or from a Protection Segment to a Working Segment due to failure of connectivity, restoration of connectivity, or administrative command.

3.115 Infrastructure Segment: A sequence of Provider Network Ports (PNPs) and the intervening Local Area Networks (LANs) and Bridge relay entities.

3.116 Intermediate Service Access Point (ISAP): A Service Access Point (SAP), interior to a Maintenance Domain, through which frames can pass in transit from Domain Service Access Point (DoSAP) to DoSAP.

3.117 Intermediate System to Intermediate System (IS-IS) Path Control and Reservation (ISIS-PCR): IS-IS with the Path Control and Reservation extensions specified by Clause 45 of IEEE Std 802.1Q-2022.

3.118 Internal Spanning Tree (IST): The connectivity provided by the Common and Internal Spanning Tree (CIST) within a Multiple Spanning Tree (MST) Region.

3.119 Internal Sublayer Service (ISS) Service Access Point (ISS-SAP): An instance of the ISS.

NOTE—See IEEE Std 802.1AC.

3.120 latency: The delay experienced by a frame in the course of its propagation between two points in a network, measured from the time that a known reference point in the frame passes the first point to the time that the reference point in the frame passes the second point.

NOTE—Latency is sometimes referred to as *frame delay*.

3.121 Layer Management Interface (LMI): An interface used for carrying management controls, counters, status parameters, or event indications that are not communicated to an entity's peers.

NOTE—This is not one of the Service Access Points (SAPs) defined in this standard.

3.122 Legacy region: A set of Local Area Networks (LANs) connected such that there is physical connectivity between any pair of LANs using only Media Access Control (MAC) Bridges.

NOTE—If, in a Bridged Network containing both MAC Bridges and Virtual Local Area Network (VLAN) Bridges, all VLAN Bridges were to be removed, the result would be one or more Bridged Networks, each with its own distinct spanning tree. Each of those networks is a legacy region.

3.123 Link status notification: Notification of the status of a Local Area Network (LAN) by transmitting a frame conveying information about the MAC_Operational parameter associated with the LAN.

3.124 Linktrace Message (LTM): A Connectivity Fault Management (CFM) protocol data unit (PDU) initiated by a Maintenance Association (MA) Endpoint (MEP) to trace a path to a target Media Access Control (MAC) address, forwarded from Maintenance Domain (MD) Intermediate Point (MIP) to MIP, up to the point at which the LTM reaches its target, a MEP, or can no longer be forwarded.

3.125 Linktrace Output Multiplexer (LOM): A Connectivity Fault Management (CFM) shim that enables the Linktrace Responder to forward Linktrace Messages (LTMs) out of a specific Bridge Port without passing the LTMs through the Frame filtering entity.

3.126 Linktrace Reply (LTR): A unicast Connectivity Fault Management (CFM) protocol data unit (PDU) sent by an Maintenance Point (MP) to a Maintenance Association (MA) Endpoint (MEP), in response to receiving a Linktrace Message (LTM) from that MEP.

3.127 Listener: The end station that is the destination, receiver, or consumer of a stream.

3.128 Loop-Free Alternate (LFA): A loop-free backup path for local repair after a failure event.

3.129 Loopback Message (LBM): A unicast Connectivity Fault Management (CFM) protocol data unit (PDU) transmitted by a Maintenance Association (MA) Endpoint (MEP), addressed to a specific Maintenance Point (MP), in the expectation of receiving a Loopback Reply (LBR).

3.130 Loopback Reply (LBR): A unicast Connectivity Fault Management (CFM) protocol data unit (PDU) transmitted by an Maintenance Point (MP) to a Maintenance Association (MA) Endpoint (MEP), in response to a Loopback Message (LBM) received from that MEP.

3.131 Maintenance Association Identifier (MAID): An identifier for a Maintenance Association (MA), unique over the domain that Connectivity Fault Management (CFM) is to protect against the accidental concatenation of service instances. The MAID has two parts: the Maintenance Domain Name and the Short MA Name.

3.132 Maintenance Association (MA): A set of MA Endpoints (MEPs), each configured with the same Maintenance Association Identifier (MAID) and Maintenance Domain (MD) Level, established to verify the integrity of a single service instance. Equivalently, an MA is the closure of the Maintenance Entities among a set of MEPs so configured.

3.133 Maintenance Association [MA] Endpoint [MEP] Identifier [ID] (MEPID): A small integer, unique over a given MA, identifying a specific MEP.

3.134 Maintenance Association [MA] Endpoint (MEP): An actively managed Connectivity Fault Management (CFM) entity, associated with a specific Domain Service Access Point (DoSAP) of a service instance, which can generate and receive CFM protocol data units (PDUs) and track any responses. It is an endpoint of a single MA and is an endpoint of a separate Maintenance Entity for each of the other MEPs in the same MA.

3.135 Maintenance Association [MA] Endpoint [MEP] Continuity Check Message [CCM] Database (MEP CCM Database): A database, maintained by every MEP, that maintains received information about other MEPs in the MA.

3.136 Maintenance Domain: The network or the part of the network for which faults in connectivity can be managed. The boundary of a Maintenance Domain is defined by a set of Domain Service Access Points (DoSAPs), each of which can become a point of connectivity to a service instance.

3.137 Maintenance Domain Intermediate Point (MIP): A Connectivity Fault Management (CFM) entity consisting of two MIP Half Functions (MHFs).

3.138 Maintenance Domain Intermediate Point [MIP] Continuity Check Message [CCM] Database (MIP CCM Database): A database, maintained optionally by a MIP or Maintenance Association (MA) Endpoint (MEP), that maintains received information about the MEPs in the Maintenance Domain.

3.139 Maintenance Domain Intermediate Point [MIP] Half Function (MHF): A Connectivity Fault Management (CFM) entity, associated with a single Maintenance Domain, and thus with a single Maintenance Domain Level (MD Level) and a set of Virtual Local Area Network (VLAN) Identifiers (VIDs), that can generate CFM protocol data units (PDUs), but only in response to received CFM PDUs.

3.140 Maintenance Domain Level (MD Level): A small integer in a field in a Connectivity Fault Management (CFM) protocol data unit (PDU) that is used, along with the Virtual Local Area Network (VLAN) Identifier (VID) in the VLAN tag, to identify to which Maintenance Domain among those associated with the CFM frame's VID, and thus to which Maintenance Association (MA), a CFM PDU belongs.

3.141 Maintenance Domain Name: The identifier, unique over the domain that Connectivity Fault Management (CFM) is to protect against accidental concatenation of service instances, of a particular Maintenance Domain.

3.142 Maintenance Entity: A point-to-point relationship between two Maintenance Association (MA) Endpoints (MEPs) within a single MA.

3.143 Maintenance Point (MP): One of either a Maintenance Association (MA) Endpoint (MEP) or a Maintenance Domain Intermediate Point (MIP).

3.144 Maintenance Point (MP) Level Demultiplexer: The component of an MP that separates Connectivity Fault Management (CFM) protocol data units (PDUs) at different Maintenance Domain Levels (MD Levels).

3.145 Maintenance Point (MP) Multiplexer: A component of an MP that merges frames from more than one input Service Access Point (SAP), sending them to a single output SAP.

3.146 Maintenance Point (MP) OpCode Demultiplexer: A component of an MP that identifies and separates Connectivity Fault Management (CFM) protocol data units (PDUs) with different values of the OpCode field.

3.147 Maintenance Point (MP) Type Demultiplexer: A component of an MP that identifies and separates Connectivity Fault Management (CFM) protocol data units (PDUs) based on the Length/Type field.

3.148 manual switch: An **ad**ministrative command to move the backbone service instances assigned to a Traffic Engineering (TE) protection group to a specific TE service instance (TESI) associated with this TE protection group in absence of signal failures on both of the entities in the group.

3.149 Maximally Redundant Trees (MRTs): A pair of trees with a common MRT Root where the path from any leaf Bridge to the MRT Root along the first tree (MRT-Blue) and the path from the same leaf Bridge along the second tree (MRT-Red) share the minimum number of Bridges and the minimum number of links.

3.150 Media Access Control (MAC) Bridge: A Bridge that does not recognize Virtual Local Area Network (VLAN) tagged frames.

3.151 Media Access Control (MAC) Bridge component: The media access method-independent functionality supporting an instance of the Internal Sublayer Service (ISS) at each Bridge Port and the functionality that relays frames between Bridge Ports.

3.152 Media Access Control (MAC) Bridged Network: A concatenation of individual IEEE 802 Local Area Networks (LANs) interconnected by MAC Bridges.

3.153 Media Access Control (MAC) status notification: A layer management interaction with an underlying MAC Service to change the status of the MAC_Operational parameter in a Bridge that is a peer user of that service.

3.154 Media Access Control (MAC) status propagation: The process of communicating a MAC_Operational parameter value through one or more Two-Part MAC Relays (TPMRs), using link status notification, MAC status notification, or both.

3.155 MRT-Blue: One of the two Maximally Redundant Trees (MRTs), specifically, the increasing MRT where links in the Generalized Almost Directed Acyclic Graph (GADAG) are taken in the direction from a lower topologically ordered Bridge to a higher one.

3.156 MRT-Red: One of the two Maximally Redundant Trees (MRTs), specifically, the decreasing MRT where links in the Generalized Almost Directed Acyclic Graph (GADAG) are taken in the direction from a higher topologically ordered Bridge to a lower one.

3.157 MRT Root: The common root of the two Maximally Redundant Trees (MRTs), i.e., of MRT-Blue and MRT-Red.

3.158 Multi-Topology (MT): One of a set of independent topologies that the Intermediate System to Intermediate System (IS-IS) Protocol supports within an IS-IS domain.

3.159 Multi-Topology Identifier (MTID): The identifier of an Intermediate System to Intermediate System (IS-IS) Protocol Multi-Topology (MT).

3.160 Multicast:

a) A group Media Access Control (MAC) address (noun).
b) To transmit a frame using a group MAC address as the destination address (verb).
c) Containing a group MAC address as the destination address (adjective).

3.161 Multiple Spanning Tree Instance (MSTI): One of a number of spanning trees calculated by the Multiple Spanning Tree Algorithm and Protocol (MSTP) within a Multiple Spanning Tree (MST) Region.

3.162 Multiple Spanning Tree (MST) Bridge: A Bridge capable of supporting the Common Spanning Tree (CST), and one or more Multiple Spanning Tree Instances (MSTIs), and of selectively mapping frames classified in any given Virtual Local Area Network (VLAN) to the CST or a given MSTI.

3.163 Multiple Spanning Tree [MST] Configuration Identifier (MCID): A name for, revision level, and a summary of a given allocation of Virtual Local Area Networks (VLANs) to spanning trees.

NOTE—Each MST Bridge uses a single MST Configuration Table and Configuration Identifier.

3.164 Multiple Spanning Tree (MST) Configuration Table: A configurable table that allocates each and every possible Virtual Local Area Network (VLAN) Identifier (VID) to the Common Spanning Tree (CST) or a specific Multiple Spanning Tree Instance (MSTI).

3.165 Multiple Spanning Tree (MST) Region: One or more MST Bridges with the same MST Configuration Identifiers (MCIDs), interconnected by and including Local Area Networks (LANs) for which one of those Bridges is the Designated Bridge for the Common and Internal Spanning Tree (CIST) and that have no Bridges attached that cannot receive and transmit Rapid Spanning Tree (RST) Bridge Protocol Data Units (BPDUs).

3.166 Multiple Stream Registration Protocol (MSRP): A protocol designed to provide quality of service (QoS) for streams in bridged networks by reserving resources within each Bridge along the streams' paths.

3.167 Network Virtualization Edge (NVE): A term as defined in IETF RFC 7365.

3.168 Network Virtualization Overlays over Layer 3 (NVO3): A framework conforming to IETF RFC 7365.

3.169 nNVE: Network-side VNE as defined in IETF RFC 8394.

3.170 Operations, Administration, and Maintenance (OAM): A group of network management functions that provide network fault indication, performance information, and data and diagnosis functions.

NOTE—Examples are ATM OAM ITU-T I.610 (02/1999) [B49][19] and IEEE 802.3™ Clause 57 OAM.

3.171 operator: (A) A provider of a single network of Provider Bridges or a single Layer 2 or Layer 3 backbone network to the service provider. (B) An enumeration of a state machine event. (C) A symbol denoting a mathematical operation.

NOTE 1—(A) An operator can, in fact, be identical to, or a part of the same organization as, the service provider, but for the purposes of IEEE Std 802.1Q, the operator and service provider are presumed to be separate organizations.

NOTE 2—(A) Certain terms in this standard, including "customer," "service provider," and "operator," reflect common business relationships that often exist among organizations and individuals that use equipment implemented in accordance with this standard. Terms such as "customer VID" or "operator MD Level" are no more than convenient labels for entities defined here; their use does not imply any requirement upon the business relationships among vendors or users of devices compliant with this standard.

3.172 Owner: A user of a system (and in particular, a Bridge) who has full access to the System Group of the SNMPv2-MIB (IETF RFC 3418).

3.173 packet: A protocol data unit, comprising data, addressing, and protocol identification information, sent by an instance of an identified class of protocol entities and transmitted in one or more frames (e.g., an IPv6 packet).

3.174 Passive Service Access Point [SAP] (Passive SAP): The SAP, bounding an Maintenance Point (MP), that is on the side of the MP away from the monitored Maintenance Association (MA).

3.175 Path Computation Element (PCE): An entity that is capable of computing a path through a network based on a representation of the network's topology (obtained by undefined means external to the PCE). A PCE is a higher layer entity in a Bridge or an end station.

3.176 Path Control Agent (PCA): The agent that is part of the Intermediate System to Intermediate System (IS-IS) Domain and thus can perform IS-IS operations on behalf of a Path Computation Element (PCE), e.g., maintain Link State Database (LSDB) and send Link State protocol data units (PDUs) (LSPs).

3.177 Paused state: A state of a queue in which the transmission selection entity does not select frames from the queue.

3.178 Point of Local Repair (PLR): A Bridge that locally redirects the data traffic to a backup path, e.g., to a loop-free alternate path after a failure event.

3.179 point-to-multipoint Ethernet Switched Path [ESP] (point-to-multipoint ESP): An ESP among one root Customer Backbone Port (CBP) and n leaf CBPs.

3.180 point-to-multipoint Traffic Engineering service instance [TESI] (point-to-multipoint TESI): A TESI supported by a set of Ethernet Switched Paths (ESPs) that comprises one point-to-multipoint ESP from a root to n leaves plus a point-to-point ESP from each of the leaves to the root.

[19] Numbers in brackets correspond to the numbers in the bibliography in Annex W.

3.181 point-to-point Ethernet Switched Path [ESP] (point-to-point ESP): An ESP between two Customer Backbone Ports (CBPs). The ESP-DA and the ESP-SA in the ESP's 3-tuple identifier are the individual Media Access Control (MAC) addresses of the two CBPs.

3.182 point-to-point Traffic Engineering service instance [TESI] (point-to-point TESI): A TESI supported by two point-to-point Ethernet Switched Paths (ESPs) where the ESPs' endpoints have the same Customer Backbone Port (CBP) Media Access Control (MAC) addresses.

3.183 policing: A process of monitoring network traffic and deliberately dropping frames that are in excess of previously defined criteria.

3.184 Port: A Service Access Point (SAP) and the interface stack supporting that SAP.

3.185 Port State: One of a number of possible combinations of forwarding and learning variables, used by a spanning tree protocol or Shortest Path Tree (SPT) protocol for each tree for each Bridge Port, to enforce the active topology of that tree.

3.186 Port-based service interface: The interface provided by a Provider Bridge that associates all customer frames with a single service instance.

3.187 Port-mapping Service Virtual Local Area Network [S-VLAN] component (Primary S-VLAN component): An S-VLAN component with one externally accessible port and one or more additional ports, each connected to another Bridge component via an internal Local Area Network (LAN), and for which each registered S-VLAN Identifier's (S-VID's) member set includes the externally accessible port and exactly one other port.

NOTE—See 6.14.

3.188 preemption: The suspension of the transmission of a preemptable frame to allow one or more express frames to be transmitted before transmission of the preemptable frame is resumed.

3.189 Primary Virtual Local Area Network [VLAN] Identifier [VID] (Primary VID): The VID, among a list of VIDs associated with a service instance, on which all Connectivity Fault Management (CFM) protocol data units (PDUs) generated by Maintenance Points (MPs) except for forwarded Linktrace Messages (LTMs) are to be transmitted.

3.190 Priority-tagged frame: A tagged frame whose tag header carries priority information but carries no Virtual Local Area Network (VLAN) identification information.

3.191 Protection Segment: An Infrastructure Segment associated with an Infrastructure Protection Group (IPG) that can carry Traffic Engineering service instance (TESI) traffic when the Working Segment associated with that IPG has failed or when directed by administrative command.

3.192 protocol group database: Specifies a group of protocols by assigning a unique protocol group identifier to all protocols of the same group.

3.193 protocol group identifier: Designates a group of protocols that are associated together when assigning a Virtual Local Area Network (VLAN) Identifier (VID) to a frame.

3.194 protocol template: A tuple of values that specify a data-link encapsulation format and an identification of the protocol layer above the data-link layer.

3.195 Provider Access Port (PAP): A Port-mapping Service Virtual Local Area Network (S-VLAN) component port within a Provider Edge Bridge (PEB) that receives and transmits frames for a single customer [single S-VLAN Identifier (S-VID)].

3.196 Provider Backbone Bridge (PBB): A Backbone Core Bridge (BCB) or a Backbone Edge Bridge (BEB).

3.197 Provider Backbone Bridge Traffic Engineering (PBB-TE) Region: A contiguous set of combined I type and B type Backbone Edge Bridges (IB-BEBs) and Backbone Core Bridges (BCBs) that implement traffic engineering capabilities.

3.198 Provider Backbone Bridged Network (PBBN): A network using Backbone Edge Bridges (BEBs) and Backbone Core Bridges (BCBs) to interconnect Provider Bridged Networks (PBNs) and other networks.

3.199 Provider Bridge: A Provider Edge Bridge (PEB) or a Service Virtual Local Area Network (S-VLAN) Bridge.

3.200 Provider Bridged Network (PBN): A network using Provider Bridges to offer customer protocol transparent connectivity.

3.201 Provider Edge Bridge (PEB): A system comprising one or more Service Virtual Local Area Network (S-VLAN) components and one or more Customer Virtual Local Area Network (C-VLAN) components.

3.202 Provider Edge Port (PEP): A Customer Virtual Local Area Network (C-VLAN) component Port within a Provider Edge Bridge (PEB) that connects to a Customer Network Port (CNP) and receives and transmits frames for a single customer.

3.203 Provider Instance Port (PIP): The set of Virtual Instance Ports (VIPs) that are supported by a single instance of the Internal Sublayer Service (ISS).

3.204 Provider Network Port (PNP): A Service Virtual Local Area Network (S-VLAN) component Port on a Provider Bridge that can transmit and receive frames for multiple customers.

3.205 Rapid Spanning Tree (RST) Bridge: A Bridge that uses the Rapid Spanning Tree Algorithm and Protocol (RSTP) to calculate a single spanning tree and is only capable of forwarding frames on that tree.

3.206 Reaction Point (RP): An end station port function that controls the transmission rate of frames for one or more Congestion Controlled Flows (CCFs).

NOTE—See 31.2.2.2.

3.207 redundant trees: A pair of trees with a common root where the paths from any leaf Bridge to the root along the first tree and the second tree are disjoint.

3.208 Reflected Frame Message (RFM): A Connectivity Fault Management (CFM) protocol data unit (PDU) transmitted by a Reflection Responder (RR) in order to perform forward path test (FPT).

3.209 Reflection Responder (RR): An entity that encapsulates and reflects selected data frames to a target location and allows a copy of each reflected frame to continue to its destination without encapsulation.

3.210 Reflective relay: A mode of operation of the active topology enforcement function in which a received frame on a port that supports reflective operation can be forwarded on the same port on which it was received.

3.211 Remote Customer Access Port (RCAP): A Port-mapping Service Virtual Local Area Network (S-VLAN) component port on a Provider Edge Bridge (PEB) that is intended to be directly connected to another Provider Bridged Network (PBN) under a different administration, and receives and transmits frames for one or more customers.

3.212 return path test (RPT): A test to determine if a data frame can be sent without error from a specific location within a network to a station specified by the destination_address field of the data frame.

3.213 reverse path congruent: A phrase to describe two paths where a unicast frame traverses exactly the same Bridges and Local Area Networks (LANs) along the path from the source to the destination, but in the reverse order as a frame transmitted from that destination to the source.

3.214 rooted-multipoint: A service instance in which each Service Access Point (SAP) is either a Root or a Leaf, and a Data.Request at a Leaf does not result in a Data.Indication at any other Leaf.

NOTE—See 6.2.1 and F.1.3.2.

3.215 S-channel: A point-to-point Service Virtual Local Area Network (S-VLAN) established between a Port-mapping S-VLAN component in an Edge Virtual Bridging (EVB) Bridge and a Port-mapping S-VLAN component in an EVB station.

3.216 S-channel Access Port (CAP): The Port that terminates an S-channel.

3.217 S-channel Discovery and Configuration Protocol (CDCP): A protocol that is used to configure Service Virtual Local Area Network (S-VLAN) components to create S-channels.

3.218 S-tagged service interface: The interface provided by a Provider Bridge to allow the attached customer to select between and identify service instances using the Service Virtual Local Area Network (S-VLAN) Identifier (S-VID) associated with transmitted and received frames.

3.219 Segment Endpoint Bridge (SEB): A Provider Backbone Bridge (PBB) at the endpoint of an Infrastructure Segment.

3.220 Segment Endpoint Port (SEP): A Provider Network Port (PNP) at the endpoint of an Infrastructure Segment.

3.221 Segment Identifier (SEG-ID): A pair of Segment Monitoring Path Identifiers (SMP-IDs) specifying the identity of an Infrastructure Segment.

3.222 Segment Intermediate Bridge (SIB): A Provider Backbone Bridge (PBB) having an intermediate position within an Infrastructure Segment.

3.223 Segment Intermediate Port (SIP): A Provider Network Port (PNP) having an intermediate position within an Infrastructure Segment.

3.224 Segment Monitoring Path (SMP): A unidirectional path carrying Connectivity Fault Management (CFM) traffic associated with the monitoring of an Infrastructure Segment.

3.225 Segment Monitoring Path Identifier (SMP-ID): A 3-tuple <SMP-DA, SMP-SA, SMP-VID> where the SMP-DA is the Media Access Control (MAC) address of the destination Provider Network Port (PNP) of the Segment Monitoring Path (SMP), the SMP-SA is the MAC address of the origin PNP of the SMP, and SMP-VID is a Virtual Local Area Network (VLAN) Identifier (VID) allocated to the Traffic Engineering Multiple Spanning Tree Instance Identifier (TE-MSTID) and associated with the SMP.

NOTE—See 8.9.

3.226 Send Frame Message (SFM): A Connectivity Fault Management (CFM) protocol data unit (PDU) destined to a Decapsulator Responder (DR) in order to perform return path test (RPT).

3.227 Send Frame Message (SFM) Originator: A function on a Bridge interface, an end station, or a test equipment to send SFM encapsulated data frames.

3.228 Service Access Point (SAP): The point at which a service is offered.

NOTE—In this standard, an instance of either the Internal Sublayer Service (ISS) (IEEE Std 802.1AC) or the Enhanced Internal Sublayer Service (EISS) (6.8). This term is used in place of the awkward "ISS Service Access Point" or "EISS Service Access Point," where no loss of clarity is introduced.

3.229 service frame: A Local Area Network (LAN) frame exchanged between a provider and a customer.

3.230 service instance: A set of Service Access Points (SAPs) such that a Data.Request primitive presented to one SAP can result in a Data.Indication primitive occurring at one or more of the other SAPs in that set.

NOTE—In general, a service provider can use a number of technologies to support a service instance; within this standard, a service instance is supported by a single Service Virtual Local Area Network (S-VLAN).

3.231 service provider: An organization that contracts to provide one or more service instances to a customer.

3.232 Service Virtual Local Area Network (S-VLAN): A Virtual Local Area Network (VLAN) identified by an S-VLAN Identifier (S-VID).

3.233 Service Virtual Local Area Network (S-VLAN) Bridge: A system comprising a single S-VLAN component.

3.234 Service Virtual Local Area Network (S-VLAN) component: A Virtual Local Area Network (VLAN) Bridge component with each Port supported by an instance of the Enhanced Internal Sublayer Service (EISS) that can recognize, insert, and remove S-VLAN tags (S-TAGs).

3.235 Service Virtual Local Area Network [S-VLAN] Identifier (S-VID): A Virtual Local Area Network (VLAN) Identifier (VID) conveyed in an S-VLAN tag (S-TAG).

3.236 Service Virtual Local Area Network [S-VLAN] tag (S-TAG): A Virtual Local Area Network (VLAN) tag with a Tag Protocol Identification value allocated for "802.1Q Service Tag EtherType."

3.237 Shared Risk Link Group (SRLG): A set of links that share a resource whose failure affects each link.

3.238 Shared Virtual Local Area Network [VLAN] Learning (SVL): Configuration and operation of the Learning Process and the Filtering Database (FDB) such that, for a given set of VLANs, if an individual Media Access Control (MAC) Address is learned in one VLAN, that learned information is used in forwarding decisions taken for that address relative to all other VLANs in the given set.

NOTE—In a Bridge that supports only SVL operation, the "given set of VLANs" is the set of all VLANs.

3.239 Shared Virtual Local Area Network [VLAN] Learning [SVL] Bridge (SVL Bridge): A type of Bridge that supports only SVL.

3.240 Shared Virtual Local Area Network [VLAN] Learning [SVL]/Independent VLAN Learning [IVL] Bridge (SVL/IVL Bridge): A type of Bridge that simultaneously supports both SVL and IVL.

3.241 shim: A protocol entity that uses the same service as it provides.

NOTE—Within this standard, shims make use of the Internal Sublayer Service (ISS) or the Enhanced Internal Sublayer Service (EISS).

3.242 Short Maintenance Association [MA] Name (Short MA Name): The part of the Maintenance Association Identifier (MAID) that is unique within the Maintenance Domain and is appended to the Maintenance Domain Name to form the MAID.

3.243 Shortest Path Bridging (SPB): The method of bridging using Shortest Path Trees (SPTs) for forwarding from each Bridge. SPB is used for references that are applicable to all modes of SPB: Shortest Path Bridging Media Access Control (MAC) (SPBM) mode and Shortest Path Bridging Virtual Local Area Network (VLAN) Identifier (VID) (SPBV) mode.

3.244 Shortest Path Bridging (SPB) System Identifier: A unique 6-byte value for each Intermediate System to Intermediate System Protocol for Shortest Path Bridging (ISIS-SPB) capable Bridge and is equivalent to the Intermediate System to Intermediate System (IS-IS) Protocol System Identifier (ID).

NOTE—See 8.13.8.

3.245 Shortest Path Bridging Media Access Control [MAC] [SPBM] mode (SPBM mode): The Shortest Path Bridging (SPB) method where all Shortest Path Trees (SPTs) are rooted at a Backbone Edge Bridge (BEB). In frames with a group destination address, the SPT is identified by a destination MAC address derived from the SPSourceID; in frames with an individual address, the SPT is identified by a MAC address of the source BEB. This method does not use learning.

3.246 Shortest Path Bridging Media Access Control [MAC] [SPBM] mode Maintenance Association [MA] (SPBM MA): An MA for monitoring and diagnosing connectivity associated with a Virtual Local Area Network (VLAN) Identifier (VID) assigned to the SPBM Multiple Spanning Tree Instance Identifier (MSTID). There are three types of SPBM MA—SPBM VID MAs, SPBM path MAs, and SPBM group MAs.

NOTE—See 27.18.1.

3.247 Shortest Path Bridging Media Access Control [MAC] [SPBM] mode Virtual Local Area Network [VLAN] Identifier [VID] (SPBM VID): A VID associated with the SPBM-MSTID value of the Multiple Spanning Tree Instance Identifier (MSTID) in the Multiple Spanning Tree (MST) Configuration Table.

3.248 Shortest Path Bridging Virtual Local Area Network [VLAN] Identifier [VID] [SPBV] mode (SPBV mode): The Shortest Path Bridging (SPB) method where Shortest Path VLAN Identifiers (SPVIDs) are used to identify the Shortest Path Trees (SPTs) for individual and group addresses. This method is learning capable.

3.249 Shortest Path First (SPF): Abbreviation for the Dijkstra Shortest Path First Algorithm that is used in link state protocols such as Intermediate System to Intermediate System (IS-IS) Protocol.

3.250 Shortest Path Source Identifier (SPSourceID): A 20-bit identifier of a Bridge that is unique within a Shortest Path Tree (SPT) Domain. SPSourceID is used to auto-create SPT Domain significant group Media Access Control (MAC) addresses utilizing the local address bit in Shortest Path Bridging MAC (SPBM) mode.

NOTE—See 27.10.

3.251 Shortest Path Tree (SPT) Bridge: A Virtual Local Area Network (VLAN) Bridge capable of operating Shortest Path Bridging (SPB) protocols.

3.252 Shortest Path Tree (SPT) Domain: A set of SPT Bridges that are interconnected by Local Area Networks (LANs) and have the same configured Intermediate System to Intermediate System (IS-IS) Protocol area address. An SPT Domain contains one or more SPT Regions, each comprising some or all of the Bridges in the Domain.

3.253 Shortest Path Tree (SPT) Region: A set of Local Area Networks (LANs) and SPT Bridges interconnected via Ports on those SPT Bridges, where each LAN's Common and Internal Spanning Tree (CIST) Designated Bridge is an SPT Bridge, and each Port is either the Designated Port on one of the LANs or else a non-Designated Port of an SPT Bridge that is connected to one of the LANs, whose Multiple Spanning Tree (MST) Configuration Identifier (MCID) matches exactly the MCID or the Auxiliary MCID of the Designated Bridge of that LAN.

NOTE—See 27.4.1.

3.254 Shortest Path Tree (SPT) Set: A set of SPTs determined by one Equal Cost Tree (ECT) Algorithm and capable of supporting one or more Virtual Local Area Networks (VLANs) within an SPT Region. The set is the union of all the SPTs from all sources to all other Bridges using that single ECT Algorithm. A single SPT Set is created for each ECT Algorithm. Active SPT Sets are identified by their {ECT Algorithm, FID} tuples.

NOTE—See 8.9.4 and 13.6.

3.255 Shortest Path Virtual Local Area Network [VLAN] Identifier (SPVID): The identifier of both the VLAN and the Shortest Path Tree (SPT) that is used for the transmission of a tagged frame in Shortest Path Bridging VLAN Identifier (VID) (SPBV) mode.

3.256 Single Spanning Tree (SST) Bridge: A Bridge capable of supporting only a single spanning tree.

3.257 spanning tree: A simply and fully connected active topology formed from the arbitrary physical topology of connected Bridged Network components by relaying frames through selected Bridge Ports and not through others. The protocol parameters and states used and exchanged to facilitate the calculation of that active topology and to control the Media Access Control (MAC) relay function.

3.258 Station-facing Bridge Port (SBP): A Bridge Port that supports the Edge Virtual Bridging (EVB) status parameters with an EVBMode parameter value of "EVB Bridge". For NVO3 a port of an nNVE that supports VDP.

NOTE—See 40.4.

3.259 Stream: A unidirectional flow of data (e.g., audio and/or video) from a Talker to one or more Listeners.

3.260 Stream Reservation Protocol (SRP) domain boundary port: A Port of a station that is a member of an SRP domain for a given stream reservation (SR) class and that is connected via an individual Local Area Network (LAN) to a Port of a station that either is within a different SRP domain for that SR class or is not part of any SRP domain.

NOTE—The term *SRP domain* is defined in 35.1.4.

3.261 Stream Reservation Protocol (SRP) domain core port: A Port of a station that is a member of an SRP domain for a given stream reservation (SR) class and that is connected, via an individual Local Area Network (LAN) that is part of the active topology, to a Port of a station that is a member of the same SRP domain for that SR class.

3.262 stream reservation (SR) class: A traffic class whose bandwidth can be reserved for time-sensitive streams using the Stream Reservation Protocol (SRP). A priority value is associated with each SR class. SR classes are denoted by consecutive letters of the alphabet, starting with A and continuing for up to seven classes.

3.263 StreamID: A 64-bit field that uniquely identifies a stream.

3.264 symmetric: An adjective to describe paths, trees, or sets of trees. Symmetric algorithms are used to create a set of trees that are *reverse path congruent* with respect to sources and destinations. Symmetric algorithms are used to create a set of trees that are *unicast multicast congruent* with respect to a given source. *See also:* **reverse path congruent** and **unicast multicast congruent**.

3.265 T-component: A Two-Port Media Access Control (MAC) Relay (TPMR) component with one Provider Instance Port (PIP).

3.266 Tag header: A header that allows priority information, and optionally, Virtual Local Area Network (VLAN) identification information, to be associated with a frame.

3.267 Tagged frame: A frame that contains a tag header immediately following the Source MAC Address field of the frame.

3.268 Talker: The end station that is the source or producer of a stream.

3.269 time-aware: An adjective to describe use of time that is synchronized with other stations using a protocol (e.g., IEEE Std 802.1AS).

3.270 time-sensitive stream: A stream of data frames that are required to be delivered with a bounded latency.

3.271 tNVE: Terminal-side NVE as defined in IETF RFC 8394.

3.272 topology block: A maximally two-connected (induced) subgraph, a cut-link with the two Bridges at either end, or an isolated Bridge.

3.273 traffic class: A classification used to expedite transmission of frames generated by critical or time-sensitive services.

3.274 Traffic Engineering Database (TED): A database storing the traffic engineering information propagated by a link state protocol, e.g., Intermediate System to Intermediate System (IS-IS).

3.275 Traffic Engineering service instance (TESI): An instance of the Media Access Control (MAC) Service supported by a set of Ethernet Switched Paths (ESPs) and identified by Traffic Engineering service instance Identifier (TE-SID), forming a bidirectional service. A TESI is point-to-point or point-to-multipoint.

3.276 Traffic Engineering service instance Identifier (TE-SID): An identifier of the Traffic Engineering service instance (TESI) that corresponds to a series of 3-tuples <ESP-DA, ESP-SA, ESP-VID>, each one identifying one of the TESI's Ethernet Switched Paths (ESPs).

NOTE—The TE-SID is not used as a tag parameter.

3.277 Traffic Engineering (TE): The process that controls the placement of traffic demands in a network in order to optimize the resource utilization and to ensure that the quality of service (QoS) objectives for each defined class of service are met.

3.278 Traffic Engineering (TE) protection group: A group of two point-to-point Traffic Engineering service instances (TESIs) between a pair of Customer Backbone Ports (CBPs), which carries an assigned set of backbone service instances and continues to carry these backbone service instances if any one of the TESIs in the group is failed or disabled.

3.279 traffic specification (TSpec): A specification that characterizes the bandwidth that a stream can consume.

3.280 transmission gate: A gate that connects or disconnects the transmission selection function of the forwarding process from the queue, allowing or preventing it from selecting frames from that queue. The gate has two states, Open and Closed.

3.281 Two-connected: A topology that has no cut-bridges. This is a topology that requires at least two Bridges to be removed before it is partitioned.

3.282 Two-Port Media Access Control [MAC] Relay (TPMR): A Bridge that has exactly two externally accessible Ports and supports a subset of the functionality of a MAC Bridge as specified in 5.15 of IEEE Std 802.1Q-2022.

3.283 Two-Port Media Access Control [MAC] Relay (TPMR) component: A MAC Bridge component with two Bridge Ports.

3.284 unicast:

a) An individual Media Access Control (MAC) address (noun).
b) To transmit a frame using an individual MAC address as the destination address (verb).
c) Containing an individual MAC address as the destination address (adjective).

3.285 unicast multicast congruent: A phrase to describe the path taken by a unicast frame to a given destination when that path is the same as the path taken by any multicast frame [assigned to the same Virtual Local Area Network (VLAN)] from that source to the same destination.

3.286 Untagged frame: A frame that does not contain a tag header immediately following the Source MAC Address field of the frame.

3.287 Up Maintenance Association [MA] Endpoint [MEP] (Up MEP): A MEP residing in a Bridge that transmits Connectivity Fault Management (CFM) protocol data units (PDUs) toward, and receives them from, the direction of the Media Access Control (MAC) Relay Entity.

3.288 Up Maintenance Point [MP] (Up MP): A Maintenance Association (MA) Endpoint (MEP) or a Maintenance Domain Intermediate Point (MIP) Half Function (MHF) residing in a Bridge that transmits Connectivity Fault Management (CFM) protocol data units (PDUs) toward, and receives them from, the direction of the Media Access Control (MAC) Relay Entity.

3.289 Uplink Access Port (UAP): A Port on a Port-mapping Service Virtual Local Area Network (S-VLAN) component that connects an Edge Virtual Bridging (EVB) Bridge with an EVB station.

3.290 uplink relay port (URP): A port of an edge relay (ER) that supports the Edge Virtual Bridging (EVB) status parameters with an EVBMode parameter value of “EVB station.”

NOTE—See 40.4.

3.291 Virtual Bridged Network: A concatenation of individual IEEE 802 Local Area Networks (LANs) interconnected by Bridges, including Virtual Local Area Network (VLAN) Bridges.

3.292 virtual edge bridge (VEB): An edge relay (ER) that requires reflective relay service to be disabled on the Station-facing Bridge Port (SBP) of the attached Bridge.

3.293 virtual edge port aggregator (VEPA): An edge relay (ER) that always forwards frames through its uplink relay port (URP) and that can make use of reflective relay service provided by the Station-facing Bridge Port (SBP) of the attached Bridge.

3.294 Virtual Instance Port (VIP): A Bridge Port on an I-component or a T-component in a Backbone Edge Bridge (BEB) that provides access to a single backbone service instance.

3.295 Virtual Local Area Network (VLAN): The closure of a set of Media Access Control (MAC) Service Access Points (MSAPs) such that a data request in one MSAP in the set is expected to result in a data indication in another MSAP in the set.

NOTE—See also 6.2.

3.296 Virtual Local Area Network (VLAN) Bridge: A system comprising a single VLAN Bridge component implemented in accordance with Clause 5 of IEEE Std 802.1Q-2022.

3.297 Virtual Local Area Network (VLAN) Bridge component: The media access method-independent functionality supporting an instance of the Enhanced Internal Sublayer Service (EISS) at each Bridge Port that can recognize, insert, and remove VLAN tags, and the functionality that relays frames between Bridge Ports.

3.298 Virtual Local Area Network (VLAN) Bridged Network: A Virtual Bridged Network.

3.299 Virtual Local Area Network (VLAN) tagged frame: A tagged frame whose tag header carries both VLAN identification and priority information.

3.300 Virtual Network Instance (VNI): A term as defined in IETF RFC 7365.

3.301 Virtual Network Instance Identifier (VNI ID): A 3-octet identifier for a VNI.

3.302 virtual station: An end station instantiated within an Edge Virtual Bridging (EVB) station.

3.303 Virtual Station Interface (VSI): An interface to a virtual station that is attached to a downlink relay port (DRP) of an edge relay (ER). For NVO3 a VSI is equivalent to an NVO3 Tenant Station Interface (TSI) (see IETF RFC 8394).

3.304 Virtual Station Interface [VSI] Discovery and Configuration Protocol (VDP): A protocol that supports the association of a VSI with a Bridge Port.

3.305 Working Segment: The Infrastructure Segment, among the Infrastructure Segments associated with an Infrastructure Protection Group (IPG), on which Traffic Engineering service instance (TESI) traffic is carried when no connectivity failure of that segment has been detected and no administrative command is active.

4. Abbreviations

The following abbreviations are used in this standard:

ACK	acknowledgment
ADAG	Almost Directed Acyclic Graph
AP	Agreement Protocol
ATS	Asynchronous Traffic Shaping
AV	audio/video
AVB	audio/video bridging
B-BEB	B type Backbone Edge Bridge
B-Comp	B-component
B-DA	Backbone Destination MAC address
B-DEI	B-VLAN Drop Eligible Indicator
B-MAC	Backbone Media Access Control
B-PCP	B-VLAN Priority Code Point
B-SA	Backbone Source MAC address
B-TAG	B-VLAN tag
B-VID	Backbone VLAN Identifier
B-VLAN	Backbone Virtual Local Area Network
BCB	Backbone Core Bridge
BEB	Backbone Edge Bridge
BLCE	Bridge Local Computation Engine
BNF	Backus-Naur Form
BPDU	Bridge Protocol Data Unit
BSI	backbone service instance
CBS	committed burst size
C-DA	Customer Destination MAC address
C-MAC	Customer Media Access Control
C-SA	Customer Source MAC address
C-TAG	C-VLAN tag
C-VID	Customer VLAN Identifier
C-VLAN	Customer Virtual Local Area Network
CAP	S-channel Access Port
CBN	Customer Bridged Network
CBP	Customer Backbone Port
CCF	Congestion Controlled Flow
CCM	Continuity Check Message
CCP	Current Congestion Point
CDCP	S-channel Discovery and Configuration Protocol
CE	customer equipment
CEP	Customer Edge Port
CFM	Connectivity Fault Management
CID	Company ID[20]. (See also OUI)
CIST	Common and Internal Spanning Tree
CIST-MSTID	Common and Internal Spanning Tree Multiple Spanning Tree Instance Identifier
CN	congestion notification
CNC	Centralized Network Configuration
CN-TAG	Congestion Notification tag
CND	Congestion Notification Domain
CNM	Congestion Notification Message

[20] See https://standards.ieee.org/develop/regauth/tut/eui.pdf.

CNP	Customer Network Port
CNPV	Congestion Notification Priority Value
CP	Congestion Point
CPID	Congestion Point Identifier
CQF	cyclic queuing and forwarding
CR	constrained routing
CRC	Cyclic Redundancy Check
CSN	Coordinated Shared Network
CSPF	Constrained Shortest Path First
CST	Common Spanning Tree
CUC	Centralized User Configuration
DAG	Directed Acyclic Graph
DCB	Data Center Bridging
DCBX	Data Center Bridging eXchange protocol
DCCP	Datagram Congestion Control Protocol
DCN	data center network
DDCFM	data-driven and data-dependent connectivity fault management
DDF	data-driven and data-dependent fault
DEI	Drop Eligible Indicator
DLSDU	Data Link Service Data Unit
DMN	Designated MSRP Node
DoSAP	Domain Service Access Point
DR	Decapsulator Responder
DRP	downlink relay port
ECMP	Equal Cost Multiple Paths
ECP	Edge Control Protocol
ECPDU	Edge Control Protocol Data Unit
ECT	Equal Cost Tree
EISS	Enhanced Internal Sublayer Service (6.8)
eMAC	express Media Access Control
ER	edge relay
ESP	Ethernet Switched Path
ET	Explicit Tree
ETDB	Explicit Tree Database
ETS	Enhanced Transmission Selection
EUI-48	48-bit Extended Unique Identifier[21]
EVB	Edge Virtual Bridging
F-TAG	flow filtering tag
F_b	Quantized Feedback
FCS	Frame Check Sequence
FDB	Filtering Database
FID	Filtering Identifier (8.8.8, 8.9.3)
FPT	forward path test
FQTSS	Forwarding and Queuing Enhancements for time-sensitive streams
FS	Forced Switch
GADAG	Generalized Almost Directed Acyclic Graph
I-BEB	I type Backbone Edge Bridge
I-Comp	I-component
I-DEI	Backbone Service Instance Drop Eligible Indicator
I-PCP	Backbone Service Instance Priority Code Point
I-TAG	Backbone Service Instance tag
I-SID	Backbone Service Instance Identifier

[21] A tutorial on the structure and use of EUI-48 identifiers can be found at https://standards.ieee.org/develop/regauth/tut/eui.pdf.

IB-BEB	combined I type and B type Backbone Edge Bridge
ID	identifier
IP	Internet Protocol
IPG	Infrastructure Protection Group
IPS	Infrastructure Protection Switching
IPV	internal priority value specification
IPv6	Internet Protocol version 6
ISAP	Intermediate Service Access Point
ISIS-PCR	Intermediate System to Intermediate System with Path Control and Reservation extensions
ISIS-SPB	Intermediate System to Intermediate System Protocol for Shortest Path Bridging
ISS	Internal Sublayer Service (IEEE Std 802.1AC)
IST	Internal Spanning Tree
ITB-BEB	any valid combination of multi-component Backbone Edge Bridge, e.g., IB-BEB
IVL	Independent VLAN Learning (3.111)
LACP	Link Aggregation Control Protocol
LAG	Link Aggregation Group
LAN	Local Area Network (IEEE Std 802)
LBM	Loopback Message
LBR	Loopback Reply
LFA	Loop-Free Alternate
LLC	Logical Link Control (ISO/IEC 8802-2)
LLDP	Link Layer Discovery Protocol
LMI	Layer Management Interface
Local-SID	Local Service Instance Identifier
LOM	Linktrace Output Multiplexer
LoP	Lockout of Protection
LSB	least significant bit
LSDB	Link State Database
LSP	Link State PDU
LT	Loose Tree
LTM	Linktrace Message
LTR	Linktrace Reply
LTS	Loose Tree Set
MA	Maintenance Association
MAC	Medium Access Control (IEEE Std 802)
MAD	MRP Attribute Declaration
MAID	Maintenance Association Identifier
MAP	MRP Attribute Propagation
MCID	MST Configuration Identifier
MD Level	Maintenance Domain Level
MEP	MA Endpoint
MEPID	MA Endpoint Identifier
MHF	MIP Half Function
MIB	Management Information Base (Clause 17)
MIP	Maintenance domain Intermediate Point
MIRP	Multiple I-SID Registration Protocol
MIRPDU	Multiple I-SID Registration Protocol Data Unit
MMRP	Multiple MAC Registration Protocol
MMRPDU	Multiple MAC Registration Protocol Data Unit
MO	Managed Object
MoCA	Multimedia over Coax Alliance
MP	Maintenance Point
MPDU	MAC Protocol Data Unit
MRP	Multiple Registration Protocol

MRPDU	Multiple Registration Protocol Data Unit
MRTs	Maximally Redundant Trees
MS	MAC Service
MSAP	MAC Service Access Point
MSB	most significant bit
MSDU	MAC Service Data Unit (IEEE Std 802.1AC)
MSP	MAC Status Protocol or MAC status propagation
MSPDU	MAC Status Protocol Data Unit
MSPE	MAC Status Propagation Entity
MSRP	Multiple Stream Registration Protocol
MSRPDU	Multiple Stream Registration Protocol Data Unit
MSS	MAC Status Shim
MST	Multiple Spanning Tree
MST BPDU	Multiple Spanning Tree Bridge Protocol Data Unit
MSTI	Multiple Spanning Tree Instance
MSTID	Multiple Spanning Tree Instance Identifier
MSTP	Multiple Spanning Tree Algorithm and Protocol
MT	Multi-Topology (Note that “MT state” is used in Clause 10 for the “Empty state.”)
MTID	Multi-Topology Identifier
MVRP	Multiple VLAN Registration Protocol
MVRPDU	Multiple VLAN Registration Protocol Data Unit
NETCONF	Network Configuration Protocol
NLPID	Network Layer Protocol Identifier
NVE	Network Virtualization Edge
NVO3	Network Virtualization Overlays over Layer 3
OAM	Operations, Administration, and Maintenance
OUI	organizationally unique Identifier
PAE	Port Access Entity
PAP	Provider Access Port
PATHID	Path Identifier
PB	Provider Bridge
PBB	Provider Backbone Bridge
PBB-TE	Provider Backbone Bridge Traffic Engineering
PBBN	Provider Backbone Bridged Network
PBN	Provider Bridged Network
PCA	Path Control Agent
PCE	Path Computation Element
PCP	Priority Code Point
PCR	Path Control and Reservation
PDU	protocol data unit
PFC	Priority-based Flow Control
PICS	Protocol Implementation Conformance Statement (Annex A, Annex B)
PID	Protocol Identifier
PIP	Provider Instance Port
PLR	Point of Local Repair
pMAC	preemptable Media Access Control
PNP	Provider Network Port
PPVID	port and protocol VLAN Identifier
PQoS	Parameterized Quality of Service
PSFP	Per-Stream Filtering and Policing
PTP	IEEE 1588 precision time protocol
PVID	port VLAN Identifier
QCN	Quantized Congestion Notification protocol
QoS	quality of service

RCAP	Remote Customer Access Port
RCSI	Remote Customer Service Interface
RFM	Reflected Frame Message
RP	Reaction Point
RPT	return path test
RR	Reflection Responder
RST	Rapid Spanning Tree
RST BPDU	Rapid Spanning Tree Bridge Protocol Data Unit
RSTP	Rapid Spanning Tree Algorithm and Protocol
RSVP	Resource Reservation Protocol
S-TAG	S-VLAN tag
S-VID	Service VLAN Identifier
S-VLAN	Service Virtual Local Area Network
SAP	Service Access Point
SBP	Station-facing Bridge Port
SCID	S-channel Identifier
SCTP	Stream Control Transmission Protocol
SDU	service data unit
SEB	Segment Endpoint Bridge
SEG-ID	Segment Identifier
SEP	Segment Endpoint Port
SF	Signal Fail
SFM	Send Frame Message
SIB	Segment Intermediate Bridge
SIP	Segment Intermediate Port
SMP	Segment Monitoring Path
SMP-ID	Segment Monitoring Path Identifier
SNAP	Subnetwork Access Protocol
SNM	Status Notification state machine
SNMP	Simple Network Management Protocol
SPB	Shortest Path Bridging
SPBM	Shortest Path Bridging MAC
SPBV	Shortest Path Bridging VID
SPF	Shortest Path First
SPT	Shortest Path Tree
SPVID	Shortest Path VLAN Identifier
SR	stream reservation
SR_PVID	Stream Reservation Port VLAN Identifier
SRLG	Shared Risk Link Group
SRP	Stream Reservation Protocol
SST	Single Spanning Tree
ST	Strict Tree
ST BPDU	Spanning Tree Bridge Protocol Data Unit
STM	Status Transition state machine
STP	Spanning Tree Algorithm and Protocol
SVL	Shared VLAN Learning (3.238)
TAI	Temps Atomic International—International Atomic Time
TC	textual convention
TCI	Tag Control Information (9.3)
TCP	Transmission Control Protocol
TE	Traffic Engineering
TE-MSTID	Traffic Engineering Multiple Spanning Tree Instance Identifier
TE-SID	Traffic Engineering service instance Identifier
TED	Traffic Engineering Database

TESI	Traffic Engineering service instance
TLV	Type, Length, Value
TPID	Tag Protocol Identifier (9.3)
TPMR	Two-Port MAC Relay
TSpec	traffic specification
TSN	Time-Sensitive Networking
TTL	time-to-live
UAP	Uplink Access Port
UDP	User Datagram Protocol
ULP	upper layer protocol
ULPDU	upper layer protocol data unit
UNI	User Network Interface
URP	uplink relay port
UUID	Universally Unique Identifier
VDP	VSI Discovery and Configuration Protocol
VEB	virtual edge bridge
VEPA	virtual edge port aggregator
VID	VLAN Identifier (7.2, 9.3)
VIP	Virtual Instance Port
VLAN	Virtual Local Area Network
VNI	Virtual Network Instance
VNI ID	Virtual Network Instance Identifier
VSI	Virtual Station Interface
VSIID	VSI Instance Identifier
VTID	VSI Type Identifier
YANG	Yet Another Next Generation[22]

[22]YANG is best viewed as a name, not an acronym.

5. Conformance

This clause specifies the mandatory and optional capabilities provided by conformant implementations of this standard. An implementation can:

a) Compose all or part of the functionality of a system.
b) Provide, as specified by this standard, one or more instances of the MAC Service to other functional entities whose specification is outside the scope of this standard.
c) Provide, as specified by this standard, one or more instances of the MAC Internal Sublayer Service (ISS) to other implementations or instances of the same implementation that conform to this standard.

Accordingly, and as detailed in 5.4, this clause specifies conformance requirements for common systems and for functional components within systems, possibly connected to other system components with interfaces that are not otherwise accessible.

5.1 Requirements terminology

For consistency with existing IEEE and IEEE 802.1™ standards, requirements placed upon conformant implementations of this standard are expressed using the following terminology:

a) ***Shall*** is used for mandatory requirements.
b) ***May*** is used to describe implementation or administrative choices ("may" means "is permitted to," and hence, "may" and "may not" mean precisely the same thing).
c) ***Should*** is used for recommended choices (the behaviors described by "should" and "should not" are both permissible but not equally desirable choices).

NOTE—The usage in 17.7 follows the IETF model.

The Protocol Implementation Conformance Statement (PICS) proformas (see Annex A for Bridges and Annex B for end station implementations) reflect the occurrences of the words "shall," "may," and "should" within the standard.

The standard avoids needless repetition and apparent duplication of its formal requirements by using ***is***, ***is not***, ***are***, and ***are not*** for definitions and the logical consequences of conformant behavior. Behavior that is permitted but is neither always required nor directly controlled by an implementer or administrator, or whose conformance requirement is detailed elsewhere, is described by ***can***. Behavior that never occurs in a conformant implementation or system of conformant implementations is described by ***cannot***. The word ***allow*** is used as a replacement for the phrase "Support the ability for," and the word ***capability*** means "can be configured to."

5.2 Conformant components and equipment

This subclause specifies requirements and options for the following core components:

a) VLAN Bridge component (5.4)
b) MAC Bridge component (5.13)

for the following components that use that core functionality:

c) Customer VLAN (C-VLAN) component (5.5)
d) Service VLAN (S-VLAN) component (5.6)
e) I-component (5.7)
f) B-component (5.8)

g) TPMR component (5.15)
h) T-component (5.17)
i) Edge relay (ER) (5.24.1)

and for the following systems that include instances of the above components:

j) C-VLAN Bridge (5.9)
k) S-VLAN Bridge (5.10.1)
l) Provider Edge Bridge (5.10.2)
m) Backbone Edge Bridge (BEB) (5.12)
n) MAC Bridge (5.14)
o) TPMR (5.16)
p) Edge Virtual Bridging (EVB) Bridge (5.23)
q) EVB station (5.24)
r) TSN CNC station (5.29)
s) VDP-NVO3 (5.30)

NOTE—Both S-VLAN Bridges and Provider Edge Bridges are examples of Provider Bridges.

5.3 Protocol Implementation Conformance Statement (PICS)

A claim of conformance specifies implementation of a C-VLAN component, an S-VLAN component, an I-component, a B-component, a VLAN-unaware MAC Bridge component, or a specific system. A component or system can support multiple claims for a range of possible behaviors.

The supplier of an implementation that is claimed to conform to this standard shall provide the information necessary to identify both the supplier and the implementation, and shall complete a copy of the PICS proforma provided in Annex A for that specific Bridge component or system, or Annex B for an end station implementation, together with any further information and completed PICS(s) required to identify subcomponents.

NOTE 1—C-VLAN component and S-VLAN component PICS both require completion of a PICS for a VLAN Bridge component; the VLAN Bridge PICS requires a claim of conformance for a single C-VLAN component; the Provider Edge Bridge requires a claim of conformance for a single S-VLAN component and one or more claims for C-VLAN components.

NOTE 2—The claim of conformance that could be made to this standard for an implementation of a VLAN-aware Bridge is replaced by a claim of conformance to a VLAN Bridge. Although the current and subsequent amendment(s) or revision(s) of this standard have changed the presentation of the information, the technical requirements of conformance remain unchanged.

NOTE 3—I-component and B-component PICS both require completion of a PICS for an S-VLAN component.

5.4 VLAN Bridge component requirements

An implementation of a VLAN Bridge component shall:

a) Conform to the relevant standard for the MAC technology implemented at each Port in support of the MAC ISS, as specified in IEEE Std 802.1AC.
b) Support the MAC Enhanced Internal Sublayer Service (EISS) at each Port, as specified in 6.8 and 6.9.
c) Implement an ISO/IEC 8802-2 conformant Logical Link Control (LLC) class with Type 1 operation as required by 8.2.
d) Relay and filter frames as described in 8.1 and specified in 8.5, 8.6, 8.7, and 8.8.

e) Maintain the information required to support Basic Filtering Services, as described in 6.16 and in 8.1 and specified in 8.5, 8.7, and 8.8.
f) Conform to the provisions for addressing specified in 8.13.
g) Implement Rapid Spanning Tree Algorithm and Protocol (RSTP), as specified in Clause 13.
h) Encode transmitted BPDUs and validate received BPDUs as specified in Clause 14.
i) Specify the following parameters of the implementation:
    1) Filtering Database Size, the maximum number of entries
    2) Permanent Database Size, the maximum number of entries
j) Specify the following performance characteristics of the implementation:
    1) A Guaranteed Port Filtering Rate for each Bridge Port
    2) A Guaranteed Bridge Relaying Rate for the Bridge
    3) The related time intervals T_F and T_R for these parameters as specified in Clause 24
k) Operation of the Bridge within the specified parameters shall not violate any of the other conformance provisions of this standard.
l) On each Port, support at least one of the permissible values for the Acceptable Frame Types parameter, as defined in 6.9.
m) Support the following on each Port that supports untagged and priority-tagged frames:
    1) A Port VLAN Identifier (PVID) value (6.9)
    2) Configuration of at least one VID whose untagged set includes that Port (8.8.2)
    3) Configuration of the PVID value via management operations (12.10)
    4) Configuration of Static Filtering Entries via management operations (12.7)
n) Allow tag headers to be inserted, modified, and removed from relayed frames, as specified in 8.1 and Clause 9, as required by the value(s) of the Acceptable Frame Types parameter supported on each Port, and by the ability of each Port to transmit VLAN-tagged and/or untagged frames.
o) Allow automatic configuration and management of VLAN topology using the Multiple VLAN Registration Protocol (MVRP) (5.4.2, Clause 11) on all Ports.
p) Allow static and dynamic configuration information for at least one VID, by means of Static and Dynamic VLAN Registration Entries in the FDB (8.8).
q) Support at least one Filtering Identifier (FID) (8.8.3, 8.8.8, 8.8.9, and IEEE Std 802.1AC).
r) Allow allocation of at least one VID to each FID that is supported (8.8.3, 8.8.8, 8.8.9, and IEEE Std 802.1AC).

NOTE—Under some circumstances, the ability for VLAN Bridges to successfully interoperate depends on the number of FIDs supported and on the number of VIDs that can be allocated to each FID. These circumstances are discussed in Annex B, along with interoperability implications.

5.4.1 VLAN Bridge component options

An implementation of a VLAN Bridge component may:

a) Support MST operation (5.4.1.1).
b) Support Port-and-Protocol-based VLAN classification (5.4.1.2), including multiple VID values per port, administrative control of the values of the multiple VIDs, and a Protocol Group Database.
c) Support CFM operation (5.4.1.4).
d) Support Shortest Path Bridging (SPB) operation (5.4.5).
e) Support congestion notification (5.4.3).
f) Support Priority-based Flow Control (PFC) (5.11).
g) Support Extended Filtering Services (6.16.5) and the operation of Multiple MAC Registration Protocol (MMRP, 10.9) to support automatic configuration and management of MAC address information on all Ports (5.4.1.3).

h) Allow the FDB to contain Static and Dynamic VLAN Registration Entries (8.8) for more than one VID, up to a maximum of 4094 VIDs.

i) Allow translation of VIDs through support of the VID Translation Table or through support of both the VID Translation Table and Egress VID translation table on one or more Bridge Ports (6.9).

NOTE 1—The maximum number of VIDs that can be supported is 4094 rather than 4096, as the VID values 0 and FFF are reserved, as indicated in Table 9-2. As conformance to this standard is only with regard to externally visible protocol behavior, this limit on the number of VIDs that can be supported does not imply any such limitation with regard to the internal architecture of a Bridge.

j) On each Port, support all of the permissible values for the Acceptable Frame Types parameter, as defined in 6.9, and support configuration of the parameter value via management.

k) Support enabling and disabling of Ingress Filtering (8.6.2).

l) Allow configuration of more than one VID whose untagged set includes that Port (8.8.2).

m) Support the management functionality defined in Clause 12.

n) Support the use of a remote management protocol. Bridges claiming to support remote management shall:

1) State which remote management protocol standard(s) or specification(s) are supported.
2) State which standard(s) or specification(s) for managed object definitions and encodings are supported for use by the remote management protocol.

o) Support multiple Traffic Classes for relaying and filtering frames through one or more outbound Ports, controlling the mapping of the priority of forwarded frames as specified in 6.9.4 and IEEE Std 802.1AC.

p) Support more than one FID (8.8).

q) Allow allocation of more than one VID to each supported FID (8.8, 8.8.8).

r) Allow configuration of fixed VID to FID allocations (8.8.8, 12.10.3).

s) Allow configuration of the Restricted_MAC_Address_Registration parameter (10.12.2.3) for each Port of the Bridge.

t) Support the ability to configure the value of the Restricted_VLAN_Registration parameter (11.2.3.2.3) for each Port of the Bridge.

u) Support Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS) (5.4.1.5).

v) Support SMIv2 MIB modules for the management of VLAN Bridge capabilities (Clause 17).

w) Support YANG modules for the management of VLAN Bridge capabilities (Clause 48);

NOTE 2—In previous versions of this standard, the MIB modules were maintained by IETF (e.g., IETF RFC 4363 for the Q-BRIDGE MIB). For this version of the standard, the relevant set of MIB modules required to manage a Bridge is contained in Clause 17.

x) Support Multiple Stream Registration Protocol (MSRP) (Clause 35).

y) Support the operation of MVRP (5.4.2, 11.2) as a New-Only Participant.

z) Support the MVRP extension MIB module defined in 17.7.15.

aa) Support Enhanced Transmission Selection (ETS) (5.4.1.6).

ab) Support Data Center Bridging eXchange protocol (DCBX) (5.4.1.7).

ac) Support the enhancements for scheduled traffic as specified in 8.6.8.4.

ad) Support the management entities for scheduled traffic as specified in 12.29.

ae) Support frame preemption as specified in 6.7.1, 6.7.2, and 8.6.8.

af) Support Stream reservation remote management (5.4.1.10).

5.4.1.1 Multiple Spanning Tree (MST) operation (optional)

A VLAN Bridge implementation in conformance to the provisions of this standard for an MST Bridge (5.4.1, 8.3, 8.4, 8.6.1, 8.9, 8.10, 11.2, 11.2.3.1, Clause 13, and Clause 14) shall:

a) Support MSTP as specified in Clause 13.

b) Support the Common and Internal Spanning Tree (CIST) plus a stated maximum number of Multiple Spanning Tree Instances (MSTIs), where that number is at least 2 (8.9) and at most 64 (13.14).

NOTE—In other words, a conformant MST Bridge supports a minimum of three spanning tree instances—the CIST and at least two additional MSTIs.

c) Support a stated maximum number of FIDs not less than the number of MSTIs (8.9).

d) Support the ability to associate each FID to a spanning tree (8.9.3).

e) Support the transmission and reception of MST Configuration Identifier (MCID) information (8.9.2).

f) Support a Port State for each Port for each spanning tree instance supported (8.4, 13.38).

g) Support operation of a spanning tree protocol for each spanning tree instance and Port (8.10, Clause 13).

h) Use the Bridge Group Address as specified in 8.13.3.

i) Support the default values for Bridge Forward Delay and Bridge Priority parameters specified in 13.26.

j) Support the operation of MVRP in each supported spanning tree context (11.2.3.1.1, 11.2.3.1.2).

k) Support the Bridge management functions for the Bridge protocol entity for each supported spanning tree, independently (12.8).

l) Support, in particular, management of the Bridge priority parameters, and of the port priority and path cost parameters for every port, independently for each supported spanning tree (12.8.1.1, 12.8.1.3, 13.27).

m) Support VLAN management functions for each supported spanning tree (12.10.1 and 12.11.1).

n) Support management of the MSTI configuration (12.12).

A VLAN Bridge implementation in conformance to the provisions of this standard for an MST Bridge (5.4.1, Clause 13) may:

o) Support a greater number of FIDs than spanning trees (8.8.8).

p) Support SMIv2 MIB modules for the management of VLAN Bridge capabilities (Clause 17).

5.4.1.2 Port-and-Protocol-based VLAN classification (optional)

A VLAN Bridge component implementation in conformance to the provisions of this standard for Port-and-Protocol-based VLAN classification (5.4.1) shall:

a) Support one or more of the following Protocol Classifications and Protocol Template formats: Ethernet, RFC_1042, SNAP_8021H, SNAP_Other, or LLC_Other (6.12).

A VLAN Bridge component implementation in conformance to the provisions of this standard for Port-and-Protocol-based VLAN classification (5.4.1) may:

b) Support configuration of the contents of the Protocol Group Database.

5.4.1.3 Multiple MAC Registration Protocol (MMRP) operation (optional)

A Bridge implementation in conformance to the provisions of this standard for the support of MMRP shall:

a) Conform to the operation of the MRP Applicant, Registrar, LeaveAll, and Periodic Transmission state machines, as defined in 10.7.7, 10.7.8, 10.7.9, and 10.7.10, as required for one or the other of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
   1) The Full Participant
   2) The Full Participant, point-to-point subset
b) Exchange Multiple Registration Protocol Data Units (MRPDUs) as required by those state machines, formatted in accordance with the generic protocol data unit (PDU) format described in 10.8, and able to carry application-specific information as defined in 10.12, using the group MAC addresses reserved for use by MRP applications, as defined in Table 10-1.
c) Implement the MMRP Application component as defined in 10.12.
d) Propagate registration information in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 10.3.1.
e) Forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6.

5.4.1.4 Connectivity Fault Management (CFM) (optional)

A VLAN Bridge component implementation that conforms to the provisions of this standard for CFM (Clause 18 through Clause 22) shall:

a) Support the creation of Maintenance Domains at eight Maintenance Domain Levels (MD Levels), with multiple nonoverlapping Maintenance Domains at each MD Level, using the managed objects specified in 12.14.
b) Support the creation of a Maintenance Association (MA) for each VID supported by the Bridge for each MD Level.
c) Support the creation of a single Maintenance Domain Intermediate Point (MIP) for each Maintenance Domain on each Port, all MIPs being at the same MD Level.
d) Support the creation of eight Up MA Endpoints (MEPs) for each VID on each Port, each MEP at a different MD Level.
e) Support the creation of eight Down MEPs for each VID on each Port, each MEP at a different MD Level.
f) Support the creation of eight Down MEPs attached to no VID on each Port, each MEP at a different MD Level.
g) Support the maintenance of a MEP CCM Database.
h) Provide control via all of the required managed objects specified in 12.14.
i) Conform to the state machines and procedures in Clause 20.
j) Transmit and receive required CFM PDUs in the formats specified in Clause 21.

A VLAN Bridge component implementation that conforms to the provisions of this standard for CFM may:

k) Support the creation of MIPs at different MD Levels on a single Port.
l) Support the creation of MIPs at MD Levels lower than or equal to MEPs on the same Port.
m) Support the maintenance of a MIP CCM Database in a MIP or MEP.
n) Support the CFM MIB module defined in 17.5 and/or the CFM YANG modules defined in Clause 48.

o) Support the creation of MAs that are associated with more than one VID (22.1.5).

p) Support the creation and operation of Reflection Responder (RR) and Reflected Frame Message (RFM) Receiver for the forward path test (FPT).

q) Support the creation and operation of Decapsulator Responder (DR) and Send Frame Message (SFM) Originator for the return path test (RPT).

5.4.1.5 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)—requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS shall:

a) Support a minimum of two traffic classes on all Ports, of which:
   1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
   2) One traffic class is a stream reservation (SR) class.

b) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.

c) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class “B.”

d) Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.

A VLAN Bridge component implementation that conforms to the provisions of this standard for FQTSS may:

e) Support the management entities defined in 12.20 by means of the SNMPv2 MIB module defined in 17.7.12.

f) Support two or more SR classes (a maximum of seven), and support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for those SR classes. The number of SR classes supported shall be stated in the PICS.

g) Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class “A.” If more than two SR classes are supported, the default priority regeneration override values used for the additional SR classes shall be stated in the PICS.

h) Support the classMeasurementInterval attribute (12.20.1).

i) Support the SR Class to Priority Mapping Table (12.20.4).

5.4.1.6 ETS Bridge requirements

A device supporting ETS shall:

a) Support at least 3 traffic classes (37.3).

   NOTE—A minimum of 3 traffic classes allows a minimum configuration such that one traffic class contains priorities with PFC enabled, one traffic class contains priorities with PFC disabled, and one traffic class using strict priority.

b) Support bandwidth configuration with a granularity of 1% or finer (37.3).

c) Support bandwidth allocation with a precision of 10% (37.3).

d) Support a transmission selection policy such that if one of the traffic classes does not consume its allocated bandwidth, then any unused bandwidth is available to other traffic classes (37.3).

e) Support DCBX (Clause 38).

5.4.1.7 DCBX Bridge requirements

A device supporting DCBX shall:

a) Support Link Layer Discovery Protocol (LLDP) transmit and receive mode (IEEE Std 802.1AB).
b) Support the DCBX ETS Configuration Type, Length, Value (TLV) (D.2.8).
c) Support the ETS Recommendation TLV (D.2.9).
d) Support the Priority-based Flow Control Configuration TLV (D.2.10).
e) Support the Application Priority TLV (D.2.11).
f) Support the asymmetric and symmetric DCBX state machines (38.4).
g) Support the Application VLAN TLV (D.2.14).

5.4.1.8 Per-Stream Filtering and Policing (PSFP) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for PSFP shall:

a) Support PSFP as specified in 8.6.5.2.1 and 8.6.6 items d) and e).
b) Support the state machines for stream gate control as specified in 8.6.10.
c) Support the management entities for PSFP as specified in 12.31.

5.4.1.9 Cyclic queuing and forwarding (CQF) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall:

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.
b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for Per-Stream Filtering and Policing (PSFP) as stated in 5.4.1.8.
f) Support the management entities for PSFP as specified in 12.31.

5.4.1.10 Asynchronous Traffic Shaping (ATS) requirements

A VLAN Bridge component implementation that conforms to the provisions of this standard for ATS shall:

a) Support per-stream classification and metering for ATS as specified in 8.6.5.2.2.
b) Support queuing with support for stream gates as specified in 8.6.6 items d) and e).
c) Support the ATS transmission selection algorithm as specified in 8.6.8.5.
d) Support the ATS scheduler state machines as specified in 8.6.11.
e) Support the management entities for ATS as specified in 12.31.

5.4.1.10 Stream reservation remote management (optional)

A VLAN-aware Bridge component implementation that conforms to the provisions of this standard for Stream reservation remote management shall:

a) Support the management functionality defined in Clause 12.
b) Support the use of a remote management protocol. Bridges claiming to support remote management shall state the following:
    1) Which remote management protocol standard(s) or specification(s) are supported for the server implementation.

2) Which standard(s) or specification(s) for managed object definitions and encodings are supported for use by the remote management protocol.

c) Support TE-MSTID (5.5.2).

d) Support the entities for Stream reservation remote management (12.32).

e) Support the adminIdleSlope attribute (12.20.1).

5.4.2 Multiple VLAN Registration Protocol (MVRP) requirements

A VLAN Bridge implementation in conformance to the provisions of this standard for the support of MVRP shall:

a) Conform to the operation of the MRP Applicant, Registrar, LeaveAll, and Periodic Transmission state machines, as defined in 10.7.7, 10.7.8, 10.7.9, and 10.7.10, as required for one or the other of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
   1) The Full Participant
   2) The Full Participant, point-to-point subset

b) Exchange MRPDUs as required by those state machines, formatted in accordance with the generic PDU format described in 10.8, and able to carry application-specific information as defined in 11.2, using the group MAC addresses reserved for use by MVRP.

c) Implement the MVRP Application component as defined in 11.2.

d) Propagate registration information:
   1) In a Single Spanning Tree (SST) Bridge, in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 10.3 and 10.3.1; or
   2) In an MST Bridge, in accordance with the operation of MAP for MST contexts as specified in 11.2.3.1.2 of this standard.

e) Forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6.

f) If a VID Translation Table (6.9) is in use for a Bridge Port, translate VIDs in Multiple VLAN Registration Protocol Data Units (MVRPDUs) as specified in 11.2.4.

5.4.3 VLAN Bridge requirements for congestion notification

A VLAN Bridge implementation that conforms to the provisions of this standard for congestion notification (Clause 30 through Clause 33) shall:

a) Support, on one or more Ports, the creation of at least one Congestion Point (CP) (32.1.1).

b) Support, at each CP, the generation of Congestion Notification Messages (CNMs) (32.7) and the removal of Congestion Notification tags (CN-TAGs) (32.1.1).

c) Support the ability to configure the variables controlling the operation of each CP (12.21.1, 12.21.2, 12.21.3, 12.21.4).

d) Support the operation of each Port in each of the Congestion Notification Domain (CND) defense modes separately for each Congestion Notification Priority Value (CNPV) (32.1.1).

e) Support the LLDP capabilities required for conformance to IEEE Std 802.1AB.

f) Support the use of the Congestion Notification TLV in LLDP (32.1.1).

A Provider Instance Port (PIP, 6.10) that conforms to the provisions of this standard for congestion notification shall:

g) Support CNM translation (32.16).

A Provider Edge Port (PEP) (15.4) that conforms to the provisions of this standard for congestion notification shall:

h) Support CNM translation (32.16).

A VLAN Bridge implementation that conforms to the provisions of this standard for congestion notification may:

i) Support the creation of up to seven CPs on a Bridge Port (31.1.1).

j) Support the IEEE8021-CN-MIB (17.7.13).

5.4.4 Multiple Stream Registration Protocol (MSRP) requirements

A VLAN Bridge implementation in conformance to the provisions of this standard for the support of MSRP shall:

a) Conform to the operation of the MRP Applicant, Registrar, and LeaveAll state machines, as defined in 10.7.7, 10.7.8, and 10.7.9, as required for one or more of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
   1) The Full Participant
   2) The Full Participant, point-to-point subset

b) Exchange MRPDUs as required by those state machines, formatted in accordance with the generic PDU format described in 10.8, and able to carry application-specific information as defined in Clause 35, using the "Individual LAN Scope group address, Nearest Bridge group address" as defined in Table 8-1, Table 8-2, and Table 8-3 (C-VLAN, S-VLAN, and TPMR component Reserved addresses, respectively).

c) Implement the MSRP Application component as defined in Clause 35.

d) Propagate registration information in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 10.3.1.

e) Forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6.

f) Not redeclare its attributes unless responding to a LeaveAll event.

   NOTE—In order to meet the requirement specified in 5.4.4(f), the Periodic Transmission state machine (10.7.10) is specifically excluded from MSRP. A Bridge is allowed to generate an MSRP LeaveAll event to force an immediate redeclaration of all MSRP attributes from its neighbor(s).

5.4.5 Shortest Path Bridging (SPB) operation (optional)

A VLAN Bridge implementation that conforms to the provisions of this standard for SPB in Clause 27 shall:

a) Support SPB, in either VID mode (SPBV) or MAC mode (SPBM), as specified in Clause 27.

b) Support the IS-IS Link State Protocol with procedures to ensure Loop Prevention as specified in Clause 28 to provide Shortest Path Tree (SPT) computation for SPB.

c) Encode, decode, and validate SPT BPDUs for the Agreement Protocol (13.17) and support Agreement Protocol logic in Intermediate System to Intermediate System (IS-IS) Protocol as specified in Clause 28.

d) Support at least three FIDs.

e) Support the management functionality specified in Clause 12.

A VLAN Bridge implementation in conformance to the provisions of this standard for SPB in Clause 27 may:

f) Support both SPB VID mode (SPBV) and SPB MAC mode (SPBM).

g) Support the SPB MIB module defined in 17.7.19.

h) Support both the VID Translation Table and Egress VID translation table (6.9) on SPBV Boundary Ports.

i) Support the CFM modifications for SPBM as specified in Clause 20 and summarized in 27.18.

j) Support Equal Cost Multiple Paths (ECMP) operation of SPBM (5.4.5.1).

k) Support ECMP operation of SPBM with flow filtering (5.4.5.2).

5.4.5.1 SPBM ECMP operation (optional)

An SPBM-capable VLAN-aware bridge implementation that conforms to the provisions of this standard for ECMP in 44.1 shall:

a) Support SPBM ECMP as specified in 44.1.
b) Support the management functionality specified in Clause 12.

An SPBM-capable VLAN-aware bridge implementation that conforms to the provisions of this standard for ECMP may:

c) Support the IEEE8021-ECMP-MIB module objects ieee8021EcmpEctStaticTable and ieee8021EcmpTopSrvTable defined in 17.7.21.

5.4.5.2 SPBM ECMP operation with flow filtering (optional)

An SPBM-capable VLAN-aware bridge implementation that conforms to the provisions of this standard for ECMP with flow filtering shall:

a) Support SPBM ECMP as specified in 44.1.
b) Support flow filtering as specified in 44.2, including inserting, modifying, and removing flow filtering tags (F-TAGs) from relayed frames as required by the applicable values in the Flow Filtering Control Table for each port.
c) Support the management functionality specified in Clause 12.

An SPBM-capable VLAN-aware bridge implementation that conforms to the provisions of this standard for ECMP with flow filtering may:

d) Support the CFM modifications for ECMP using flow filtering as specified in Clause 20 and summarized in 44.2.5.
e) Support the IEEE8021-ECMP-MIB module defined in 17.7.21.

5.4.6 Path Control and Reservation (PCR) (optional)

A VLAN Bridge implementation that conforms to the provisions of this standard for PCR in Clause 45 shall:

a) Support the IS-IS link state protocol with the extensions for explicit path control (ISIS-PCR) as specified in 45.1.
b) Support the SPB Link Metric sub-TLV as specified in 28.12.7.
c) Support the SPB Base VLAN-Identifiers sub TLV as specified in 28.12.4.
d) Support the SPB Instance sub-TLV as specified in 28.12.5.
e) Support the SPBV MAC address sub-TLV as specified in 28.12.9.
f) Support the SPBM Service Identifier and Unicast Address sub-TLV as specified in 28.12.10.
g) Support the ST ECT Algorithm as specified in 45.1.2 and the use of the ST ECT Algorithm as specified in 45.3.2.
h) Support the Topology sub-TLV, the Hop sub-TLV, and the corresponding ISIS-PCR operations for explicit trees as specified in 45.1.
i) Support the management functionality specified in 12.26.

A VLAN Bridge implementation that conforms to the provisions of this standard for PCR in Clause 45 may:

j) Support the LT ECT Algorithm as specified in 45.1.2.
k) Support the LTS ECT Algorithm as specified in 45.1.2.
l) Support the MRT ECT Algorithm as specified in 45.3.3.
m) Support the MRTG ECT Algorithm as specified in 45.3.4.

n) Support the Administrative Group sub-TLV and the corresponding ISIS-PCR operations as specified in 45.1.11.
o) Support the Bandwidth Constraint sub-TLV and the corresponding ISIS-PCR operations as specified in 45.1.12.
p) Support the Bandwidth Assignment sub-TLV and the corresponding ISIS-PCR operations as specified in 45.2.1.
q) Support the Timestamp sub-TLV as specified in 45.2.2.
r) Support LFA for unicast data flows as specified in 45.3.1.
s) Support the PCR Management Information Base (MIB) objects defined in 17.7.19.

5.5 C-VLAN component conformance

A C-VLAN component comprises a VLAN Bridge component with the EISS on all Ports supported by the use of a C-VLAN tag (C-TAG) (6.8, 9.5).

A conformant implementation of a C-VLAN component shall:

a) Comprise a single conformant VLAN Bridge component.
b) Recognize and use C-TAGs.
c) Filter the reserved MAC addresses specified in Table 8-1.
d) Use the Customer Bridge MVRP Address specified in Table 10-1.

A conformant implementation of a C-VLAN component shall not:

e) Use S-VLAN tags (S-TAGs) except in support of the functionality specified in 6.13.

5.5.1 C-VLAN component options

A conformant C-VLAN component may implement the options specified for a VLAN Bridge component whose use is not specifically prohibited by 5.4.1 and may:

a) Support encoding the drop_eligible parameter in the PCP field of the tag header (6.9.3).
b) Allow support of the ISS as specified in 6.13 to facilitate priority selection on a Provider Bridged Network (PBN).
c) Implement RSTP, with the enhancements to support Customer Edge Ports (CEPs), as specified in 13.41.
d) Support TE-MSTID (5.5.2).

5.5.2 TE-MSTID (optional)

A C-VLAN component implementation that conforms to the provisions of this standard for TE-MSTID shall:

a) Disable learning for a set of Customer VLAN Identifiers (C-VIDs) allocated to the Traffic Engineering Multiple Spanning Tree Instance Identifier (TE-MSTID) as specified in 8.4 and 8.9, with the exception that support for PBB-TE is not required; and
b) Discard frames with unregistered destination addresses for C-VIDs allocated to the TE-MSTID (8.8.1).

A C-VLAN component implementation that conforms to the provisions of this standard for TE-MSTID may

c) Allow control of all C-VIDs by an external agent, conforming to the Reserved VID values of Table 9-2.

5.6 S-VLAN component conformance

An S-VLAN component comprises a VLAN Bridge component with the EISS on all Ports supported by the use of an S-TAG (6.8, 9.5).

A conformant implementation of an S-VLAN component shall:

a) Comprise a single conformant VLAN Bridge component.
b) Recognize and use S-TAGs.
c) Support encoding the drop_eligible parameter in the PCP field of the tag header (6.9.3).
d) Filter the reserved MAC addresses specified in Table 8-2.
e) Use the Provider Bridge MVRP Address specified in Table 8-1.
f) Allow the Acceptable Frame Types parameter (6.9) to be set to *Admit All Frames* for each Port.
g) Allow the Enable Ingress Filtering parameter (8.6.2) to be set for each Port.

A conformant implementation of an S-VLAN component shall not:

h) Recognize or use C-TAGs.
i) Allow support of the ISS as specified in 6.13 for any of its Ports.
j) Configure the Customer Bridge MVRP Addresses specified in Table 10-1 in the FDB (8.8) or Permanent Database (8.8.11).
k) Use the Customer Bridge MVRP Address specified in Table 10-1.

5.6.1 S-VLAN component options

A conformant S-VLAN component may implement any of the options specified for a VLAN Bridge component (5.4.1).

5.6.2 S-VLAN component requirements for Provider Backbone Bridge Traffic Engineering (PBB-TE)

An S-VLAN component implementation that conforms to the provisions of this standard for PBB-TE (25.10) shall:

a) Disable learning for a set of Backbone VLAN Identifiers (B-VIDs) allocated to Traffic Engineering Multiple Spanning Tree Instance Identifier (TE-MSTID) as specified in 8.4 and in 8.9.
b) Discard frames with unregistered destination addresses for B-VIDs allocated to TE-MSTID (8.8.1).

An S-VLAN component implementation that conforms to the provisions of this standard for PBB-TE (25.10) may:

c) Allow control of all B-VIDs by an external agent, conforming to the Reserved VID values of Table 9-2.
d) Support MIP creation and the corresponding CFM extensions for Traffic Engineering service instances (TESIs) as specified in 26.9.
e) Support Infrastructure Protection Switching (IPS) as specified in 26.11.

5.6.3 S-VLAN component requirements for PBB-TE IPS

An S-VLAN component implementation that conforms to the provisions of this standard for PBB-TE IPS (26.11) shall:

a) Support 1:1 IPS as specified in 26.11.2.

An S-VLAN component implementation that conforms to the provisions of this standard for PBB-TE IPS (26.11) may:

b) Support M:1 IPS as specified in 26.11.5.

5.6.4 S-VLAN component requirements for ECMP with flow filtering

An S-VLAN component implementation that conforms to the provisions of this standard for ECMP with flow filtering shall:

a) Support F-TAG processing as specified in 44.2.2 on each Provider Network Port (PNP).

5.7 I-component conformance

An I-component comprises an S-VLAN component (5.6) with the EISS on each Customer Network Port (CNP) supported by the use of an S-TAG (6.9, 9.5), and the EISS for each Virtual Instance Port (VIP) configured on a PIP supported by the use of both an S-TAG (6.9, 9.5) and a Backbone Service Instance tag (I-TAG) (6.10, 9.5).

A conformant implementation of an I-component shall:

a) Comprise a single conformant S-VLAN component.
b) Recognize and use I-TAGs on one or more PIPs (6.10).
c) Support 1:1 mapping between Service VLAN Identifier (S-VID) values and Backbone Service Instance Identifier (I-SID) values.
d) Support the connection_identifier parameter on the EISS of each VIP (6.10) and in the FDB (8.8.12).
e) Support the termination of PBN spanning trees by inhibiting transmission of PBN BPDUs at a PIP.

5.7.1 I-component options

A conformant I-component may implement any of the options specified for an S-VLAN component (5.6.1), and may:

a) Support many-to-one mapping from S-VID values to I-SID values.
b) Support a Common Spanning Tree (CST) among PBNs interconnected with one or more backbone service instances by permitting transmission of PBN BPDUs through VIPs at a PIP.
c) Filter frames received at PIPs that have the Backbone Source MAC address (B-SA) used by the PIP, to prevent such frames from circulating if backbone service instances in two or more attached PBBNs are configured in a loop.
d) Use back-to-back Backbone Service Instance Multiplex Entities (6.18) on a PIP to enable monitoring of backbone service instances with CFM.
e) Support the Multiple I-SID Registration Protocol (MIRP) defined in 39.1.1.
f) Support the MVRP Extension MIB module defined in 17.7.15.
g) Support the MIRP MIB module defined in 17.7.16.

5.8 B-component conformance

A B-component comprises an S-VLAN component with the EISS on each PNP supported by the use of an S-TAG (6.9, 9.5), and the EISS on each Customer Backbone Port (CBP) supported by the use of both an S-TAG (6.9, 9.5) and an I-TAG (6.11, 9.5). A conformant implementation of a B-component shall:

a) Comprise a single conformant S-VLAN component.
b) Recognize and use I-TAGs on one or more CBPs (6.11).
c) Terminate PBBN spanning tree by inhibiting transmission of PBBN BPDUs at a CBP.

5.8.1 B-component options

A conformant B-component may implement any of the options specified for an S-VLAN component (5.6.1), and may:

a) Translate I-SID values by supporting the Local-SID field in the Backbone Service Instance table in CBPs (6.11).
b) Assign B-VID values based on I-SID values by supporting the B-VID field in the Backbone Service Instance table in CBPs (6.11).
c) Use the Default Backbone Destination field in the Backbone Service Instance table in CBPs (6.11) as the destination MAC address for any frames received with the Backbone Service Instance Group address (26.4).
d) Use back-to-back Backbone Service Instance Multiplex Entities (6.18) on a CBP to enable monitoring of backbone service instances with CFM.
e) Support the MIRP defined in 39.1.2.
f) Support the MVRP Extension MIB module defined in 17.7.15.
g) Support the MIRP MIB module defined in 17.7.16.

5.8.2 B-component requirements for PBB-TE

A B-component implementation that conforms to the provisions of this standard for PBB-TE (25.10) shall:

a) Disable learning for a set of B-VIDs allocated to TE-MSTID as specified in 8.4 and in 8.9.
b) Discard frames with unregistered destination addresses for B-VIDs allocated to TE-MSTID (8.8.1).
c) Support the Default Backbone Destination field in the Backbone Service Instance tables on the CBPs providing TESIs as specified in 6.11.
d) Support the B-VID field in the Backbone Service Instance tables on the CBPs providing TESIs as specified in 6.11.
e) Support the creation of MEPs for the TESIs on CBPs as specified in 26.9.
f) Support 1:1 protection switching as specified in 26.10.3.
g) Provide control via all of the PBB-TE required managed objects specified in Clause 12.

A B-component implementation that conforms to the provisions of this standard for PBB-TE (25.10) may:

h) Allow control of all B-VIDs by an external agent, conforming to the Reserved VID values of Table 9-2.
i) Support MIP creation and the corresponding CFM extensions for TESIs as specified in 26.9.
j) Support the Hold-Off timer used by the protection switching protocol as specified in 26.10.3.
k) Support sharing of TESIs among TE protection groups in order to provide 1:1 protection switching that is capable load sharing as specified in 12.14.1.2 and 25.10.2.
l) Support the Mismatch defect identification as specified in 26.11.
m) Support the PBB-TE MIB module defined in Clause 17.
n) Support IPS as specified in 26.11.

5.8.3 B-component requirements for PBB-TE IPS

A B-component implementation that conforms to the provisions of this standard for PBB-TE IPS (26.11) shall:

a) Support 1:1 IPS as specified in 26.11.2.

A B-component implementation that conforms to the provisions of this standard for PBB-TE IPS (26.11) may:

b) Support M:1 IPS as specified in 26.11.5.

5.8.4 B-component requirements for ECMP with flow filtering

A B-component implementation that conforms to the provisions of this standard for ECMP with flow filtering shall:

a) Support F-TAG processing as specified in 44.2.2 on each CBP and PNP.

5.9 C-VLAN Bridge conformance

A C-VLAN Bridge shall comprise a single conformant C-VLAN component (5.5).

Each C-VLAN Bridge Port shall be capable of attaching directly to an IEEE 802 LAN.

5.9.1 C-VLAN Bridge options

A C-VLAN Bridge may implement any C-VLAN component option (5.5).

5.10 Provider Bridge conformance

A Provider Bridge shall comprise one S-VLAN (5.6) component, zero or more C-VLAN components (5.5), and zero or more Port-mapping S-VLAN components (5.6).

NOTE—The one mandatory S-VLAN component in a Provider Bridge is generally referred to simply as the S-VLAN component; however, when this component needs to be distinguished from other components in a Provider Bridge (particularly Port-mapping S-VLAN components), it is sometimes referred to as the “primary S-VLAN component.”

Each Port shall be capable of being configured as one of, and may be capable of being configured as any of:

a) A Provider Network Port (PNP)
b) A Customer Network Port (CNP)
c) A Customer Edge Port (CEP)
d) A Remote Customer Access Port (RCAP)

as specified in Clause 15. Each Port configured as a PNP or CNP shall be capable of attaching the S-VLAN component of the Provider Bridge directly to an IEEE 802 LAN. Each Port configured as a CEP shall be capable of attaching a C-VLAN component within the Provider Bridge directly to an IEEE 802 LAN. Each Port configured as an RCAP shall be capable of attaching a Port-mapping S-VLAN component (15.6) within the Provider Bridge directly to an IEEE 802 LAN.

5.10.1 S-VLAN Bridge conformance

An S-VLAN Bridge shall comprise a single conformant S-VLAN component (5.6). An S-VLAN Bridge does not have any physical interfaces configured as a CEP or RCAP, nor does it include any C-VLAN components.

5.10.2 Provider Edge Bridge conformance

A Provider Edge Bridge is a conformant Provider Bridge with a primary S-VLAN component, the capability to include one or more C-VLAN components as specified in 15.4 and the capability to include zero or more Port-mapping S-VLAN components as specified in 15.6.

Each C-VLAN component shall comprise a single CEP and a single distinct PEP for each service instance that can be provided through that CEP. Each PEP shall be connected within the Provider Edge Bridge, as specified in 6.14, to a distinct CNP on the S-VLAN component. Each C-VLAN component shall implement RSTP, with the enhancements to support CEPs, as specified in 13.41.

Each Port-mapping S-VLAN component shall comprise a single RCAP and one or more Provider Access Ports (PAPs) each associated with one Remote Customer Service Interface (RCSI) provided through that RCAP. Each PAP shall be connected within the Provider Edge Bridge, as specified in 6.14, to a distinct CNP on the primary S-VLAN component or CEP on a C-VLAN component. A PNP shall also be provided, connected internally to a PNP on the primary S-VLAN component as specified in 15.6.

NOTE—The single CEP supported by a C-VLAN component and the single RCAP supported by a Port-mapping S-VLAN component can be supported by two or more independent instances of a MAC, aggregated as specified by Link Aggregation (IEEE Std 802.1AX).

5.11 System requirements for Priority-based Flow Control (PFC)

A system that conforms to the provisions of this standard for PFC (see Clause 36) shall:

a) Support, on one or more ports, enabling PFC on at least one priority (36.1.2).
b) Support, for each PFC Priority, processing PFC M_CONTROL.requests (36.1.3.1).
c) Support, for each PFC Priority, processing PFC M_CONTROL.indications (36.1.3.3).
d) Abide by the PFC delay constraints (36.1.3.3).
e) Provide PFC-aware system queue functions (36.2).
f) Enable use of PFC only in a domain controlled by DCBX (Clause 38).

A system that conforms to the provisions of this standard for PFC may:

g) Support enabling PFC on up to eight priorities per port.
h) Support the IEEE8021-PFC-MIB (17.7.17).

5.12 Backbone Edge Bridge (BEB) conformance

A BEB system shall comprise zero or more I-components and zero or one B-component and zero or more T-components, but at least one I-component or one B-component or one T-component, supporting externally accessible ports as specified in Clause 25. Each externally accessible port shall be designated as one of, and may be capable of being configured as any of the following:

a) A PNP
b) A PIP
c) A CBP
d) A CNP

e) A CEP
f) A RCAP

5.12.1 BEB requirements for PBB-TE

A BEB that conforms to the provisions of this standard for PBB-TE (25.10) shall comprise one B-component capable of providing TESIs (5.8.2) and one or more I-components (5.7) or T-components (5.17).

5.13 MAC Bridge component requirements

An implementation of a VLAN-unaware MAC Bridge component shall:

a) Conform to the relevant standard for the MAC technology implemented at each Port in support of the MAC ISS, as specified in IEEE Std 802.1AC.
b) Support the VLAN-unaware MAC Relay Entity by means of an ISS interface (not an EISS interface).
c) Implement an ISO/IEC 8802-2 conformant LLC class with Type 1 operation as required by 8.2.
d) Maintain the information required to support Basic Filtering Services, as described in IEEE Std 802.1AC and in 8.1 and specified in 8.5, 8.7, and 8.8.
e) Conform to the provisions for addressing specified in 8.13.
f) Implement RSTP, as specified in Clause 13.
g) Encode transmitted BPDUs and validate received BPDUs as specified in Clause 14.
h) Specify the following parameters of the implementation:
    1) Filtering Database Size, the maximum number of entries
    2) Permanent Database Size, the maximum number of entries
i) Specify the following performance characteristics of the implementation:
    1) A Guaranteed Port Filtering Rate for each Bridge Port
    2) A Guaranteed Bridge Relaying Rate for the Bridge
    3) The related time intervals T_F and T_R for these parameters as specified in Clause 24
j) Operation of the Bridge within the specified parameters shall not violate any of the other conformance provisions of this standard.

5.13.1 MAC Bridge component options

An implementation of a MAC Bridge component may:

a) Support Extended Filtering Services (6.16.5) and the operation of MMRP (10.9) to support automatic configuration and management of MAC address information on all Ports (5.4.1.3).
b) Support the management functionality defined in Clause 12.
c) Support the use of a remote management protocol. Bridges claiming to support remote management shall:
    1) State which remote management protocol standard(s) or specification(s) are supported.
    2) State which standard(s) or specification(s) for managed object definitions and encodings are supported for use by the remote management protocol.
d) Support multiple Traffic Classes for relaying and filtering frames through one or more outbound Ports, controlling the mapping of the priority of forwarded frames as specified in IEEE Std 802.1AC and 6.9.4.
e) Allow configuration of the Restricted_MAC_Address_Registration parameter (10.12.2.3) for each Port of the Bridge.
f) Support the ISS with signaled priority on each Bridge Port (6.20).
g) Support SMIv2 MIB modules for the management of MAC Bridge capabilities (Clause 17).

h) Support YANG modules for the management of MAC Bridge capabilities (Clause 48);
i) Support CFM operation (5.4.1.4).
j) Support ETS (5.4.1.6).
k) Support PFC (5.11).
l) Support DCBX (5.4.1.7).
m) Support the enhancements for scheduled traffic as specified in 8.6.8.4.
n) Support the state machines for scheduled traffic as specified in 8.6.9.
o) Support frame preemption as specified in 6.7.1, 6.7.2, and 8.6.8.

5.13.1.1 Per-Stream Filtering and Policing (PSFP) requirements

A MAC Bridge component implementation that conforms to the provisions of this standard for PSFP shall:

a) Support PSFP as specified in 8.6.5.2 and 8.6.6.
b) Support the state machines for stream gate control as specified in 8.6.10.
c) Support the management entities for PSFP as specified in 12.31.

5.13.1.2 Cyclic queuing and forwarding requirements

A MAC Bridge component implementation that conforms to the provisions of this standard for CQF (see Annex T) shall:

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.
b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for PSFP as stated in 5.13.1.1.
f) Support the management entities for PSFP as specified in 12.31.

5.13.1.3 Asynchronous Traffic Shaping (ATS) requirements

A MAC Bridge component implementation that conforms to the provisions of this standard for ATS shall:

a) Support per-stream classification and metering for ATS as specified in 8.6.5.2.2.
b) Support queuing with support for stream gates as specified in 8.6.6 items d) and e).
c) Support the ATS transmission selection algorithm as specified in 8.6.8.5.
d) Support the ATS scheduler state machines as specified in 8.6.11.
e) Support the management entities for ATS as specified in 12.31.

5.14 MAC Bridge conformance

A MAC Bridge shall comprise a single conformant MAC Bridge component (5.13).

Each Bridge Port shall be capable of attaching directly to an IEEE 802 LAN.

5.14.1 MAC Bridge options

A MAC Bridge may implement any MAC Bridge component option (5.13.1).

5.15 TPMR component conformance

A TPMR component comprises a MAC Bridge component. A conformant implementation of a TPMR component shall:

a) Support exactly two Bridge Ports other than a Management Port.
b) Support the operation of the following functions of the Forwarding Process:
    1) Frame filtering (8.6.3)
    2) Queuing frames (8.6.6)
    3) Transmission selection (8.6.8)
c) Support the operation of the MAC Status Propagation Entity (MSPE), by means of the functions and protocol specified in Clause 23.
d) Support at least one traffic class on each Bridge Port.
e) Support the management functionality specified in 12.19.
f) Support only the following entries in the FDB:
    1) Static Filtering Entries, permanently configured in the FDB and that cannot be modified by management, that specify filtering on both of the TPMR's Bridge Ports for the group MAC addresses defined in Table 8-3.
    2) A Static Filtering Entry, permanently configured in the FDB and that cannot be modified by management, that specifies forwarding or filtering on each of the TPMR's Bridge Ports for the MAC address associated with the management entity of the TPMR. The values that are configured into this filtering entry are determined by the implementer, and shall be stated in the PICS.
g) Support a MIP on an MA that is not associated with any VLAN on each of the TPMR's Bridge Ports. The default MD level shall be zero.

    NOTE—As a TPMR is a non-VLAN-aware Bridge, these MPs are not associated with a particular VID (22.1.7). This default level 0 MIP allows detection and identification of the TPMR without configuration. Such a MIP can of course be disabled by management.

A conformant implementation of a TPMR component shall not:

h) Implement RSTP defined in Clause 13.
i) Encode transmitted BPDUs and validate received BPDUs (Clause 14).
j) Support Extended Filtering Services for relaying and filtering frames (6.16.5).

5.15.1 TPMR component options

An implementation of a TPMR component may:

a) Support multiple traffic classes on each Bridge Port.
b) Support the ISS with signaled priority on each Bridge Port (6.20).

5.16 TPMR conformance

An implementation of a TPMR shall:

a) Comprise a single conformant TPMR component (5.15).
b) Support exactly two externally accessible Ports, each capable of attaching directly to an IEEE 802 LAN.
c) Be capable of supporting a management entity using the TPMR Port Connectivity (8.5.2) on one of its externally accessible ports.
d) Support remote management of the TPMR managed objects specified in 12.19.

5.16.1 TPMR options

A TPMR may implement any TPMR component option (5.15.1).

An implementation of a TPMR may:

a) Support a management entity using the Bridge Port Connectivity (8.5.1) on a Management Port (8.3) or the externally accessible ports.
b) Support remote management using Simple Network Management Protocol (SNMP) over IEEE 802 Networks (IETF RFC 4789, 8.13.7).
c) Support remote management using the TPMR MIB module defined in 17.7.11.
d) Support remote management using the TPMR YANG modules defined in 48.3.2.

NOTE—While IETF RFC 4789 is specifically referenced, the standard does not preclude the support of other transports for SNMP.

5.17 T-component conformance

A T-component comprises a TPMR component (5.15) with one PIP (6.11).

A conformant implementation of an T-component shall:

a) Comprise a single conformant TPMR component.
b) Recognize and use I-TAGs on one PIP (6.10).
c) Support a single VIP at the PIP.

5.17.1 T-component options

A conformant T-component may implement any of the options specified for a TPMR component (5.15.1).

5.18 End station requirements for MMRP, MVRP, and MSRP

This subclause defines the conformance requirements for end station implementations claiming conformance to MVRP, MMRP, and MSRP. Although this standard is principally concerned with defining the requirements for VLAN Bridges, the conformance requirements for end station implementations of MVRP, MMRP, and MSRP are included in order to give guidance to such implementations. The PICS proforma defined in Annex B is concerned with conformance claims with respect to end station implementations.

For the reasons stated in 10.6, it is recommended that end stations that do not require the ability to perform Source Pruning implement the Applicant-Only Participant, in preference to the Simple-Applicant Participant.

5.18.1 MMRP requirements and options

An end station for which conformance to MMRP is claimed shall:

a) Conform to the operation of the MRP Applicant, Registrar, LeaveAll, and Periodic Transmission state machines, as defined in 10.7.7, 10.7.8, 10.7.9, and 10.7.10, as required for one or more of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
    1) The Full Participant
    2) The Full Participant, point-to-point subset
    3) The Applicant-Only Participant
    4) The Simple-Applicant Participant

b) Exchange MPDUs as required by the MRP state machine(s) implemented, formatted in accordance with the generic PDU format described in 10.8, and able to carry application-specific information as defined in 10.12.1, using the "Individual LAN Scope group address, Nearest Bridge group address" as defined in Table 8-1, Table 8-2, and Table 8-3 (C-VLAN and MAC Bridge, S-VLAN, and TPMR component Reserved addresses, respectively).

An end station for which conformance to the operation of the Applicant state machine (10.7.7) is claimed may:

c) Perform source pruning, as defined in 10.10.3 and 10.12.

It is recommended that only those end stations that require the ability to perform Source Pruning (10.10.3) conform to the operation of the Full Participant or the Full Participant, point-to-point subset.

NOTE—If an end station does not require the ability to perform Source Pruning, then there is no need for it to implement Registrar functionality.

5.18.2 MVRP requirements and options

An end station for which conformance to MVRP is claimed shall:

a) Conform to the operation of the MRP Applicant, Registrar, LeaveAll, and Periodic Transmission state machines, as defined in 10.7.7, 10.7.8, 10.7.9, and 10.7.10, as required for one or more of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
   1) The Full Participant
   2) The Full Participant, point-to-point subset
   3) The Applicant-Only Participant
   4) The Simple-Applicant Participant
b) Exchange MPDUs as required by the MRP state machine(s) implemented, formatted in accordance with the generic PDU format described in 10.8, and able to carry application-specific information as defined in 11.2.3, using the MVRP Application address as defined in Table 10-1.

An end station for which conformance to MVRP is claimed may:

c) Perform source pruning, as defined in 10.10.3 and 11.2.1.1.

It is recommended that only those end stations that require the ability to perform Source Pruning (11.2.1.1) conform to the operation of the Full Participant or the Full Participant, point-to-point subset.

NOTE—If an end station does not require the ability to perform Source Pruning, then there is no need for it to implement Registrar functionality.

d) Support the operation of MVRP (5.4.2, 11.2) as a New-Only Participant.
e) Support the MVRP Extension MIB module defined in 17.7.15.

5.18.3 MSRP requirements and options

An end station for which conformance to MSRP is claimed shall:

a) Conform to the operation of the MRP Applicant, Registrar, and LeaveAll state machines, as defined in 10.7.7, 10.7.8, and 10.7.9, as required for one or more of the following variants of the MRP Participant, as defined in 10.6 and 10.7:
   1) The Full Participant
   2) The Full Participant, point-to-point subset
   3) The Applicant-Only Participant
   4) The Simple-Applicant Participant

b) Exchange MPDUs as required by the MRP state machine(s) implemented, formatted in accordance with the generic PDU format described in 10.8, and able to carry application-specific information as defined in 35.2.2, using the "Individual LAN Scope group address, Nearest Bridge group address" as defined in Table 8-1, Table 8-2, and Table 8-3 (C-VLAN, S-VLAN, and TPMR component Reserved addresses, respectively).
c) Not redeclare its attributes unless responding to a LeaveAll event.

An end station for which conformance to the operation of the Applicant state machine (10.7.7) is claimed may:

d) Perform Talker pruning, as defined in 35.2.1.4(b), 35.2.3.1, and 35.2.4.3.2.
e) Perform Listener pruning as described in 35.2.3.1.

NOTE—In order to meet the requirement specified in 5.18.3(c), the Periodic Transmission state machine (10.7.10) is specifically excluded from MSRP. An end station is allowed to generate an MSRP LeaveAll event to force an immediate redeclaration of all MSRP attributes from its neighbor(s).

5.19 VLAN-aware end station requirements for CFM

A VLAN-aware Station implementation that conforms to the provisions of this standard for CFM (Clause 18 through Clause 22) shall:

a) Support the creation of Maintenance Domains at eight MD Levels, with multiple nonoverlapping Maintenance Domains at each MD Level, using the managed objects specified in 12.14.
b) Support the creation of an MA on each VID supported by the Station for each MD Level.
c) Support the creation of eight Down MEPs on each VID on each Port, each MEP at a different MD Level.
d) Support the creation of eight Down MEPs attached to no VID on each Port, each MEP at a different MD Level.
e) Support the maintenance of a MEP CCM Database.
f) Provide control via all of the required managed objects specified in 12.14.
g) Conform to the state machines and procedures in Clause 20.
h) Transmit and receive required CFM PDUs in the formats specified in Clause 21.

A VLAN-aware Station implementation that conforms to the provisions of this standard for CFM may:

i) Support the CFM MIB module defined in 17.5.
j) Support the CFM YANG modules defined in Clause 48.
k) Support the creation of MAs that are associated with more than one VID (22.1.5).

5.20 End station requirements—FQTSS

An end station implementation that conforms to the provisions of this standard for FQTSS shall:

a) Support a minimum of two traffic classes on all Ports, of which:
    1) A minimum of one traffic class supports the strict priority algorithm for transmission selection (8.6.8.1), and
    2) One traffic class is an SR class.
b) Support the operation of the credit-based shaper algorithm (8.6.8.2) as the transmission selection algorithm used for frames transmitted for each stream associated with the SR class.
c) Support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for the SR class.
d) Use the default priority associated with SR class "B" as shown in Table 6-5 as the priority value carried in transmitted SR class "B" data frames.

An end station implementation that conforms to the provisions of this standard for FQTSS may:

e) Support two or more SR classes (a maximum of seven), and support the operation of the credit-based shaper algorithm (8.6.8.2) on all Ports as the transmission selection algorithm used for those SR classes. The number of SR classes supported shall be stated in the PICS.

f) Use the default priority associated with SR class "A" as shown in Table 6-5 as the priority value carried in transmitted SR class "A" data frames. If more than two SR classes are supported, the priority value carried in transmitted data frames for the additional SR classes shall be stated in the PICS.

5.21 End station requirements for congestion notification

A VLAN-aware end station implementation that conforms to the provisions of this standard for congestion notification (Clause 30 through Clause 33) shall:

a) Support the creation of at least one Reaction Point (RP) (31.2.2.2).

b) Support, if CPs are supported, the ability to configure the variables controlling the operation of each CP, if any (12.21.1, 12.21.2. 12.21.3. 12.21.4).

c) Support, at each supported CP, if any, the generation of CNMs (32.7).

d) Support the ability to configure the variables controlling the operation of each RP (12.21.1, 12.21.5, 12.21.6).

e) Support the operation of its Port in at least the cptDisabled and cptInterior CND defense modes separately for each CNPV (32.1.1).

f) Conform to the required specifications of the LLDP of IEEE Std 802.1AB.

g) Support the use of the Congestion Notification TLV in LLDP (32.1.1).

h) Support, in each RP, the limiting of frames output in response to the reception of CNMs (31.2.2.2).

i) Support, if multiple RPs are supported, the ability to distinguish among CNMs pertaining to different RPs, and direct each such message to the correct RP (31.2.5).

A VLAN-aware end station implementation that conforms to the provisions of this standard for congestion notification (Clause 30 through Clause 33) may:

j) Support the creation of one or more CPs (31.1.1).

k) Support the creation of more than one RP (31.2.2.2).

l) Support more than one CNPV per RP (31.2.1).

m) Support the operation of its Port in both the cptInterior and cptInteriorReady CND defense modes separately for each CNPV (31.1.1).

n) Support the IEEE8021-MIRP-MIB (17.7.13).

5.22 MAC-specific bridging methods

MAC-specific bridging methods may exist. Use of a MAC-specific bridging method and the method specified in this standard on the same LAN shall:

a) Not prevent communication between stations in a network.

b) Preserve the MAC Service.

c) Preserve the characteristics of each bridging method within its own domain.

d) Provide for the ability of both bridging techniques to coexist simultaneously on a LAN without adverse interaction.

5.23 EVB Bridge requirements

An EVB Bridge shall comprise a single conformant C-VLAN component (5.5) and zero or one Port-mapping S-VLAN component (5.6) per externally accessible port.

Each externally accessible port shall be capable of being configured as one of, and may be capable of being configured as any of the following:

a) A C-VLAN Bridge Port
b) A Station-facing Bridge Port (SBP)
c) An Uplink Access Port (UAP)

as specified in Clause 40.

A conformant EVB Bridge implementation shall:

d) Support the functionality of a C-VLAN component (5.5).
e) Support at least one SBP on the C-VLAN component (Clause 40).
f) Support the EVB status parameters for EVBMode = EVB Bridge (40.4).
g) Support an LLDP nearest Customer Bridge database (Clause 40).
h) Support the EVB TLV on each SBP (D.2.12).
i) Support Edge Control Protocol (ECP) on each SBP (Clause 43).
j) Support the Bridge role of Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP) on each SBP (Clause 41).

A conformant EVB Bridge may support S-channels. A conformant EVB Bridge with S-channel support shall:

k) Support at least one Port-mapping S-VLAN component (22.6.4) and associated UAP, configured as specified in 40.2 a)–d).
l) Support S-channel Discovery and Configuration Protocol (CDCP), as specified in Clause 42, operating in Bridge mode.
m) Support the enhanced filtering utility criteria (8.7.2) and not support the default filtering utility criteria (8.7.1).

A conformant EVB Bridge implementation may:

n) Support configuration of reflective relay on each SBP of the C-VLAN component (8.6.1).
o) Support management for the EVB components (12.4–12.12, 12.26).
p) Support the MIB module defined in 17.7.20.
q) Support assignment of VIDs to GroupIDs (41.2.9).
r) Support the use of the M and S bits in VDP (41.2.3).

5.24 EVB station requirements

An EVB station shall comprise one or more conformant ERs (5.24.1) and zero or one Port-mapping S-VLAN component (5.6) per externally accessible port.

Each externally accessible port shall be capable of being configured as one of, and may be capable of being configured as any of the following:

a) An Uplink Access Port (UAP)
b) An uplink relay port (URP)

as specified in Clause 40.

Each downlink relay port (DRP) shall be capable of attaching to one or more VSIs.

Each URP shall be capable of attaching its ER to the LAN connecting to an EVB Bridge, or in the case where a Port-mapping S-VLAN component is present, to an internal LAN (6.14) connecting the URP to a S-channel Access Port (CAP).

A conformant EVB station implementation shall:

c) Support at least one ER (5.24.1, Clause 40).
d) Support the EVB status parameters for EVBMode = EVB station on each URP (40.4).
e) Support an LLDP nearest Customer Bridge database (Clause 40).
f) Support the EVB TLV on each URP of each ER (D.2.12).
g) Support ECP on each URP of each ER (Clause 43).
h) Support the station role of VDP for each URP of each ER (Clause 41).

In addition, a conformant EVB station implementation that supports a Port-mapping S-VLAN components shall:

i) Support a Port-mapping S-VLAN component (22.6.4) on each port configured as a UAP (40.2) configured as specified in 40.2 (a)–(d).
j) Support CDCP, as specified in Clause 42, operating in Station mode.
k) Support the enhanced filtering utility criteria (8.7.2) and not support the default filtering utility criteria (8.7.1).

A conformant EVB station implementation may:

l) Support multiple ERs (Clause 40).
m) Support management for the EVB components (12.4–12.12, 12.26).
n) Support the MIB module defined in 17.7.20.
o) Support assignment of VIDs to GroupIDs (41.2.9).
p) Support the use of the M and S bits in VDP (41.2.3).

5.24.1 Edge relay (ER) requirements

A conformant implementation of an ER shall:

a) Conform to the relevant standard for the MAC technology implemented at each Port in support of the MAC ISS, as specified in IEEE Std 802.1AC and 6.14.
b) Support the MAC EISS at each Port, as specified in 6.8 and 6.9.
c) Recognize and use C-TAGs (6.9).
d) Relay and filter frames as described in 8.1 and specified in 8.5, 8.6, and 8.8.
e) Support the following on each DRP Port that supports untagged and priority-tagged frames:
    1) A PVID value (6.9)
    2) Configuration of at least one VID whose untagged set includes that Port (8.8.2)
f) Support setting the Acceptable Frame Types parameter (6.9) to *Admit Only VLAN-tagged Frames* on the URP.
g) Allow tag headers to be inserted, modified, and removed from relayed frames, as specified in 8.1 and Clause 9, as required by the value(s) of the Acceptable Frame Types parameter supported on each Port, and by the ability of each Port to transmit VLAN-tagged and/or untagged frames.
h) Support at least one FID (IEEE Std 802.1AC, 8.8.3, 8.8.8, and 8.8.9).
i) Allow allocation of at least one VID to each FID that is supported (IEEE Std 802.1AC, 8.8.3, 8.8.8, and 8.8.9).

j) Support exactly one URP (Clause 40) supporting the parameters of 40.4 for EVBMode = EVB station.
k) Support one or more DRPs each supporting access to VSIs (Clause 40).
l) Filter the reserved MAC addresses specified in Table 8-1.
m) If more than one DRP is supported, support setting the Enable Ingress Filtering parameter (8.6.2) on each DRP and the URP.
n) Support the requirements of either a virtual edge bridge (VEB) ER (5.24.1.1) or a virtual edge port aggregator (VEPA) ER (5.24.1.2).

A conformant implementation of an ER may:

o) Support the following if the URP supports untagged and priority-tagged frames:
    1) A PVID value (6.9)
    2) Configuration of at least one VID whose untagged set includes that Port (8.8.2)
p) Comprise a single conformant C-VLAN component (5.4).
q) Support disabling of learning on each DRP (8.6.1).
r) Support the ability to discard frames received at each DRP if there is no entry in the FDB that specifies forwarding on that Port for the frame's source MAC address and VLAN.
s) Support the operation of the learning process as described in 8.7.

5.24.1.1 VEB ER requirements

In addition to the requirements stated in 5.24.1, a conformant VEB ER implementation shall:

a) Request that reflective relay service not be provided by setting adminReflectiveRelayRequest to FALSE (40.4).

5.24.1.2 VEPA ER requirements

In addition to the requirements stated in 5.24.1, a conformant VEPA ER implementation shall:

a) Disable learning on the URP (8.6.1).
b) Filter frames as specified in 8.6.3.1.

A conformant VEPA ER implementation may:

c) Filter frames received at each DRP that are destined for the URP until reflective relay is enabled (40.4).

A conformant VEPA ER implementation should:

d) Request the provision of reflective relay service by setting adminReflectiveRelayRequest to TRUE (40.4).

    NOTE—This item is optional because there can be cases where an EVB station is configured to prohibit VSIs from communicating with each other in VEPA mode.

5.25 End station requirements—enhancements for scheduled traffic

An end station implementation that conforms to the provisions of this standard for enhancements for scheduled traffic shall:

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.
b) Support the state machines for scheduled traffic as specified in 8.6.9.

5.26 End station requirements—enhancements for frame preemption

An end station implementation that conforms to the provisions of this standard for frame preemption shall:

a) Support the provisions of 6.7.1, 6.7.2, and 8.6.8.

5.27 End station requirements—PSFP

An end-station implementation that conforms to the provisions of this standard for PSFP shall:

a) Support PSFP as specified in 8.6.5.2.1 and 8.6.6.
b) Support the state machines for stream gate control as specified in 8.6.10.
c) Support the management entities for PSFP as specified in 12.31.

5.28 End station requirements—Cyclic queuing and forwarding

An end station implementation that conforms to the provisions of this standard for CQF (see Annex T) shall:

a) Support the enhancements for scheduled traffic as specified in 8.6.8.4.
b) Support the state machines for scheduled traffic as specified in 8.6.9.
c) Support the state machines for stream gate control as specified in 8.6.10.
d) Support the management entities for scheduled traffic as specified in 12.29.
e) Support the requirements for PSFP as stated in 5.27.
f) Support the management entities for PSFP as specified in 12.31.

5.29 TSN CNC station requirements

This subclause defines the conformance requirements for a station that supports the Time-Sensitive Networking (TSN) Centralized Network Configuration (CNC) requirements (46.1.3). The TSN CNC station component is implemented within an end station or Bridge.

A TSN CNC station implementation that conforms to the provisions of this standard shall:

a) Support the use of a remote management protocol. The TSN CNC claiming to support remote management shall state the following:
    1) Which remote management protocol standard(s) or specification(s) are supported for the client implementation.
    2) Which standard(s) or specification(s) for managed object definitions and encodings are supported for use by the remote management protocol.
b) Support the managed object definitions and encodings for Stream reservation remote management (12.32).
c) Support the use of at least one protocol for User/network configuration information that complies with the requirements for protocol integration defined in 46.2. The TSN CNC shall state which User/network configuration information protocol standard(s) or specification(s) are supported.
d) If a YANG-based protocol is supported by the TSN CNC for the User/network configuration information, that protocol shall use the YANG module specified in 46.3.
e) If SRP (Clause 35) is supported by the TSN CNC for the User/network configuration information, the TSN CNC shall support MRP External Control (12.32.4).

5.30 VDP-NVO3 requirements

In the Split-NVE scenario, the nNVE implements the bridge role VDP and tNVE implements the station role VDP. While the nNVE and tNVE share the VDP functionality of an EVB Bridge and an EVB Station, their conformance requirements are different. This clause lists the conformance requirements for nNVE and tNVE to operate VDP in the Split-NVE scenario.

5.30.1 VDP-NVO3 nNVE requirements

A conformant VDP-NVO3 nNVE implementation shall:

a) Support the Bridge role of VDP on each SBP (Clause 41).
b) Support assignment of VIDs to GroupIDs (41.2.9).

A conformant VDP-NVO3 nNVE implementation may:

c) Support the functionality of a C-VLAN component (5.5).
d) Support at least one SBP on the C-VLAN component (Clause 40).
e) Support an LLDP nearest Customer Bridge database (Clause 40).
f) Support the EVB status parameters for EVBMode = NVO3 Mode (40.4.4) and NVERole = nNVE (40.5.1).
g) Support the EVB Bridge status parameters about IPv4 and IPv6 address capability (D.2.12.3).
h) Support the EVB TLV on each SBP (D.2.12).
i) Support ECP on each SBP (Clause 43).
j) Support the use of the M, S, and N bits in VDP (41.2.3).
k) Support the use of IP addresses in VDP filter info format (41.2.9).

5.30.2 VDP-NVO3 tNVE requirements

A conformant VDP-NVO3 tNVE implementation shall:

a) Support the station role of VDP for each URP (Clause 41).
b) Support assignment of VIDs to GroupIDs (41.2.9).

A conformant VDP-NVO3 tNVE implementation may:

c) Support one ER (5.24.1, Clause 40).
d) Support an LLDP nearest Customer Bridge database (Clause 40).
e) Support the EVB status parameters for EVBMode = NVO3 Mode (40.4.4) and NVERole = tNVE (40.5.2).
f) Support the EVB station status parameters about IPv4 and IPv6 address capability (D.2.12.4).
g) Support the EVB TLV on each URP (D.2.12).
h) Support ECP on each URP (Clause 43).
i) Support the use of the M, S, and N bits in VDP (41.2.3).
j) Support the use of IP addresses in VDP filter info format (41.2.9)

5.31 End station requirements—ATS

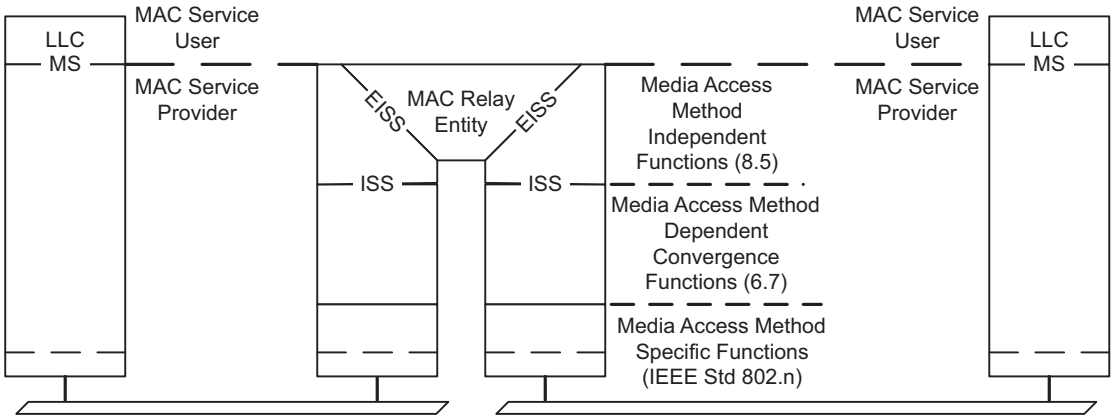
An end station implementation that conforms to the provisions of this standard for ATS shall:

a) Support a minimum of two traffic classes, of which:
    1) One traffic class supports the strict priority transmission selection algorithm (8.6.8.1) and
    2) One traffic class supports the ATS transmission selection algorithm (8.6.8.5).
b) Support the ATS talker transmission behavior, as specified in 47.1.

6. Support of the MAC Service

VLAN Bridges interconnect the separate IEEE 802 LANs that compose a Virtual Bridged Network by relaying and filtering frames between the separate MACs of the bridged LANs.

The position of a VLAN Bridge's MAC Relay Entity (8.2) within the MAC Sublayer is shown in Figure 6-1.



NOTE-The notation IEEE Std 802.n in this figure indicates that the specifications for these functions can be found in the relevant standard for the media access method concerned; for example, n would be 3 (IEEE Std 802.3) in the case of Ethernet.

Figure 6-1—Internal organization of the MAC sublayer

The MAC Sublayer comprises:

a) Media access method-specific functions[23] that realize transmission and reception of MAC Protocol Data Units (MPDUs).
b) Media access method-dependent convergence functions that use item a) to provide a media access method-independent service.
c) Media access method-independent functions that use a media-independent service to provide the same or another media-independent service.

A MAC Bridge's MAC Relay Entity forwards frames between the instances of the media-independent ISS (IEEE Std 802.1AC).

A VLAN Bridge's MAC Relay Entity forwards frames between the instances of the media-independent EISS (6.8). The EISS is provided by the functions specified in 6.9 using the media-independent ISS (IEEE Std 802.1AC). The convergence functions that provide the ISS using the media-specific functions for each IEEE 802 LAN MAC type are specified in IEEE Std 802.1AC.

[23] The media access method-specific functions that realize a MAC Service for use in end stations are specified for each IEEE 802 LAN media access control method or "MAC type" (e.g., IEEE 802.3, IEEE 802.11) by the relevant standard for that media access control method and are commonly referred to as "the MAC." The media access method-dependent convergence functions are specified in IEEE Std 802.1AC.

This clause:

a) Summarizes basic architectural concepts and terms used throughout this standard, introduces the primitives and parameters of the MAC Service, and defines VLANs in terms of the connectivity provided to service users (IEEE Std 802.1AC, 6.2, 6.3).
b) Describes how Bridges preserve and maintain the quality of the MAC Service (6.4, 6.5).
c) Specifies the MAC ISS and MAC status parameters, their support by specific media access methods (IEEE Std 802.1AC), and support for signaled priority (IEEE Std 802.1AC, 6.14, 6.15, 6.20).
d) Specifies the EISS used by VLAN-aware stations, the encoding of VID and priority parameters in transmitted frames, and the classification of received frames that do not explicitly convey those parameters (6.8, 6.9, 6.12).
e) Specifies how entities defined in terms of the ISS can support the EISS (6.17).

6.1 Basic architectural concepts and terms

The architectural concepts used in this and other IEEE 802.1 standards are based on the layered protocol model introduced by the OSI Reference Model (ISO/IEC 7498-1) and used in the MAC Service definition (IEEE Std 802.1AC), in IEEE Std 802, in other IEEE 802 standards, and elsewhere in networking. IEEE 802.1 standards in particular have developed terms and distinctions useful in describing the MAC Service and its support by protocol entities within the MAC Sublayer.[24] For further detailed discussion of these concepts and terms, see IEEE Std 802.1AC.

6.2 Provision of the MAC Service

The MAC Service provided in end stations attached to MAC Bridged Networks and Virtual Bridged Networks is the (unconfirmed) connectionless mode MAC Service defined in IEEE Std 802.1AC. The MAC Service is defined as an abstraction of the features common to a number of specific MAC Services; it describes the transfer of user data between source and destination end stations, via MA-UNITDATA request primitives and corresponding MA-UNITDATA indication primitives issued at MAC Service Access Points (MSAPs). Each MA-UNITDATA request and indication primitive has four parameters: Destination Address, Source Address, MAC Service data unit (MSDU), and Priority.

NOTE 1—The primitives of the MAC Service are closely aligned with those of the ISS (IEEE Std 802.1AC).

In a MAC Bridged Network, MAC Bridges provide a single instance of the MAC Service for the network as a whole—a single LAN, as defined in IEEE Std 802.1AC—by forwarding between the individual LANs that compose the network, though frames with specified group destination addresses are confined to individual LANs.

NOTE 2—MAC Bridges can be configured to completely partition a bridged network, though that is rarely intended.

In a Virtual Bridged Network, VLANs are defined in terms of the connectivity associations (IEEE Std 802.1AC) supported by the network: if service requests made at two different MSAPs both result in service indications at any third MSAP, then the two MSAPs are transmitting on the same VLAN; and if the service requests made at any given MSAP can result in service indications at either (or both) of two MSAPs, then those two MSAPs are receiving on the same VLAN. When only two MSAPs are in bidirectional communication, they are using the same VLAN for both transmit and receive if a third station could be added in such a way that it would receive transmissions from both.

NOTE 3—This definition of a VLAN accommodates an unavoidable and sometimes useful consequence of configuration possibilities: use of a single MSAP can result in transmission on one VLAN and reception on another.

NOTE 4—Protocol VLAN classification can be used to classify frames transmitted from a single MSAP into separate VLANs. Where protocol classification is used, the preceding rules apply to frames of a single classification.

[24] Drawing on prior network layer standards, including ISO/IEC 7498-1, wherever possible.

6.2.1 Point-to-point, multipoint-to-multipoint, and rooted-multipoint connectivity

The types of connectivity supported by associations of Bridge Ports in Virtual Bridged Networks are often classified into three categories: point-to-point, multipoint-to-multipoint, and rooted-multipoint. Point-to-point connectivity is an association of exactly two Bridge Ports such that an ingress frame (for a given VLAN) at one Bridge Port may result in an egress frame at the other Bridge Port. Multipoint-to-multipoint connectivity is an association of two or more Bridge Ports such that an ingress frame at one Bridge Port may result in an egress frame at any or all of the other Bridge Ports. Rooted-multipoint connectivity is an association of two or more Bridge Ports where each Bridge Port is designated as either a Root or a Leaf Port, and an ingress frame at a Root Port may result in an egress frame at any or all Leaf Ports and other Root Ports, while an ingress frame at a Leaf Port may result in an egress frame at any or all Root Ports but never results in an egress frame at another Leaf Port. Note that point-to-point connectivity is a special case of the more general multipoint-to-multipoint connectivity, and that both point-to-point connectivity and multipoint-to-multipoint connectivity are special cases of rooted-multipoint connectivity where all Bridge Ports are designated as Root Ports.

6.3 Support of the MAC Service

In a MAC Bridged Network at most one LAN can be supported on each of the individual LANs that, bridged together, compose the network. On the individual LANs of a Virtual Bridged Network, frames for different VLANs can be distinguished by the addition of a VLAN tag as the initial octets of a frame's MSDU.

When a VLAN-unaware end station is attached to an individual LAN, it will transmit and receive only untagged frames, and thus uses the VID(s) assigned by the Bridge Ports that classify those frames.

NOTE 1—Where there are only two stations attached to an individual LAN, each can assign received untagged frames to a different VID. However, such assignments can defeat the operation of network configuration protocols and can only be recommended at the edge of a network to facilitate initial classification of untagged frames transmitted by VLAN-unaware end stations. Otherwise, a change in a frame's VID can severely impact network operation by introducing frame forwarding loops. The same considerations apply to the use of protocol VLAN classification. The use of different VID assignments by Bridge Ports attached to the same LAN is usually a network configuration error.

NOTE 2—The LLC Entity in a VLAN-unaware end station can receive MAC Service indications that correspond to the receipt of VLAN-tagged frames but, being unable to recognize the tag's EtherType value, will discard the frame and not deliver it to any LLC User.

A VLAN-aware end station can use the EISS Multiplex Entity (6.17) to provide multiple SAPs, one per VID of interest, to separate MAC Clients.

The objective of Bridge operation is to maximize the availability of the MAC Service to end stations and to assist in the maintenance of the network. Bridges can be configured to provide redundant paths between end stations, enabling the network to continue providing service in the event of component failure (of Bridge or LAN). The paths supported between end stations are predictable and configurable. Group addressed (multicast and broadcast) frames for any given VLAN take the same path as frames addressed to an individual end station (unicast), thus permitting the use of either individually addressed or group addressed frames to configure or diagnose paths for frames with either group or individual destination addresses. The paths taken for frames for any given VLAN between any two stations are symmetric, i.e., frames from station A (say) to station B traverse the same Bridges and LANs as those from B to A, only in the reverse order. This symmetry reduces the probability of one-way connectivity between stations and permits the use of station location learning to localize traffic (6.5.10).

The VLAN Identifier (VID) conveyed in the VLAN tag associates each frame with the following:

a) A VLAN
b) A loop-free active topology

6.4 Preservation of the MAC Service

The MAC Service offered by a network consisting of LANs interconnected by Bridges is similar to that offered by a single LAN (see 6.5).

a) Frames transmitted between end stations carry the MAC addresses of the peer-end stations in their destination and source address fields, not an address of a Bridge. The MAC Relay is not directly addressed by communicating end stations.
b) The MAC addresses of end stations are not restricted by the network's topology or configuration.
c) All MAC addresses need to be unique within a VLAN, and within any set of VLANs for which filtering information is shared by a Bridge.

6.5 Quality of service (QoS) maintenance

6.5.1 Service availability

Service availability is measured as that fraction of some total time during which the MAC Service is provided. The operation of a Bridge can increase or lower the service availability.

The service availability can be increased by automatic reconfiguration of the network in order to avoid the use of a failed component (e.g., repeater, cable, or connector) in the data path. The service availability can be lowered by failure of a Bridge, through denial of service by the Bridge, or through frame filtering by the Bridge. Changes in topology, caused by component failures, the addition or removal of components, or administrative changes, are detected and signaled by the following means:

a) Physical detection of component failure and signaling of that failure by the EISS (6.8 and 6.9).
b) Detection of component failure through the operation of a spanning tree algorithm and protocol.
c) Explicit signaling of reconfiguration events through the operation of a spanning tree algorithm and protocol.

NOTE 1—Each reference to spanning tree algorithms and protocols throughout Clause 6 includes any whose purpose is to verify that each transmitted frame gives rise to at most one service indication at any of the MSAPs for which frames for that LAN or VLAN are to be received. Such protocols include RSTP (13.4), MSTP (13.5), and SPB (Clause 27).

Automatic reconfiguration can be achieved rapidly on the detection of a physical topology change (see Clause 13), thus minimizing any service denial that is caused by the reconfiguration.

A Bridge may deny service and discard frames (6.5.2) in order to preserve other aspects of the MAC Service (6.5.3 and 6.5.4) when automatic reconfiguration takes place. Service may be denied to end stations that do not benefit from the reconfiguration; hence, the service availability is lowered for those end stations. Bridges may filter frames in order to localize traffic in the network. Should an end station move, it may then be unable to receive frames from other end stations until the filtering information held by the Bridges is updated.

To minimize the effects of service denial caused by reconfiguration events, filtering information that has been dynamically learned can be modified when automatic reconfiguration takes place, or in preparation for future reconfiguration events (Clause 13 and 13.16). However, filtering information that is statically configured cannot be modified in this way.

A Bridge may deny service and discard frames in order to prevent access to the network by devices that are not authorized for such access.

To maximize the service availability, no loss of service or delay in service provision should be caused by Bridges, except as a consequence of a failure, removal, or insertion of a network component; or as a consequence of the movement of an end station; or as a consequence of an attempt to perform unauthorized

access. These events are regarded as extraordinary. The operation of any additional protocol necessary to maintain the quality of the MAC Service is thus limited to the configuration of the network and is independent of individual instances of service provision.

NOTE 2—This is true only in circumstances where admission control mechanisms are not present, i.e., where the Bridges provide a "best effort" service.

NOTE 3—The operation of management on the Bridge can result in the Bridge being reset, either as a result of a specific Bridge reset operation or as a consequence of manipulating the Bridge's configuration. From the point of view of service availability, resetting the Bridge is an extraordinary event that has a similar effect to physical removal of the Bridge from the network, followed by reinsertion of the Bridge into the network.

6.5.2 Frame loss

The MAC Service does not guarantee the delivery of Service Data Units (SDUs). Frames transmitted by a source station arrive, uncorrupted, at the destination station with high probability. The operation of a Bridge introduces minimal additional frame loss.

A frame transmitted by a source station can fail to reach its destination station as a result of:

a) Frame corruption during physical layer transmission or reception.
b) Frame discard by a Bridge because:
    1) It is unable to transmit the frame within some maximum period of time and, hence, must discard the frame to prevent the maximum frame lifetime (6.5.6) from being exceeded.
    2) It is unable to continue to store the frame due to exhaustion of internal buffering capacity as frames continue to arrive at a rate in excess of that at which they can be transmitted.
    3) The size of the SDU carried by the frame exceeds the maximum supported by the MAC procedures employed on the LAN to which the frame is to be relayed.
    4) Changes in the connected topology of the network necessitate frame discard for a limited period of time to maintain other aspects of QoS (13.16).
    5) The device attached to the Bridge is not authorized for access to the network.
    6) The configuration of Static Filtering Entries or Static VLAN Registration Entries in the FDB (8.8.1, 8.8.2) disallows the forwarding of frames with particular destination addresses or VLAN classifications on specific Ports.
    7) A flow metering algorithm (8.6.5) determines that discard is necessary.
    8) The Bridge supports enhancements for scheduled traffic (8.6.8.4) and the size of the service data unit exceeds the value of queueMaxSDU (8.6.8.4) for the traffic class queue on which the frame is to be queued.

NOTE—As Static Filtering Entries and Static VLAN Registration Entries are associated with particular Ports or combinations of Ports, there is a possibility that misconfiguration of such entries will lead to unintended frame discard during or following automatic reconfiguration of the network.

6.5.3 Frame misordering

The MAC Service (IEEE Std 802.1AC) permits a negligible rate of reordering of frames with a given priority for a given combination of destination address, source address, and flow hash, if present, transmitted on a given VLAN. MA_UNITDATA.indication service primitives corresponding to MA_UNITDATA.request primitives, with the same requested priority and for the same combination of VLAN classification, destination address, source address, and flow hash, if present, are received in the same order as the request primitives were processed.

NOTE 1—The operation of the Forwarding Process in Bridges (8.6) is such that the frame-ordering characteristics of the MAC Service are preserved.

Where Bridges in a network are capable of connecting the individual MACs in such a way that multiple paths between any source station–destination station pairs exist, the operation of a protocol is required to ensure that a single path is used for every sequence of frames whose order must be maintained.

NOTE 2—Where STP is in use (see Clause 8 of IEEE Std 802.1D, 1998 Edition [B11]), frame misordering cannot occur during normal operation. When a protocol that is capable of rapid reconfiguration after network component failure (such as RSTP, MSTP, or SPB) is used, there is an increased probability that frames that are in transit through the network will be misordered, because a Bridge can buffer frames awaiting transmission through its Ports. The probability of misordering occurring as a result of such an event is dependent on implementation choices and is associated with reconfiguration events. Some known LAN protocols, for example, LLC Type 2 (ISO/IEC 8802-2), are sensitive to frame misordering and duplication; in order to allow Bridges that support RSTP to be used in environments where sensitive protocols are in use, the forceVersion parameter (13.7.2) can be used to force a Bridge that supports RSTP to operate in an STP-compatible manner. A more detailed discussion of misordering in RSTP can be found in K.3 of IEEE Std 802.1D-2004 [B12].

6.5.4 Frame duplication

The MAC Service (IEEE Std 802.1AC) permits a negligible rate of duplication of frames. The operation of Bridges introduces a negligible rate of duplication of user data frames.

The potential for frame duplication in a bridged network arises through the possibility of the following:

a) Repeated transmission, through a given Bridge Port, of a frame received on another Bridge Port
b) Multiple paths between source and destination end stations
c) A loop in a path between source and destination stations

A Bridge does not transmit any received frame more than once through any Port (8.6.7).

When Bridges in a network connect individual LANs in such a way that physical topology is capable of providing multiple paths between any source and destination, a protocol is required to ensure that the active topology comprises a single path. SST Bridges assign all frames to a single active topology, other Bridges assign frames to an active topology using the VID or VID and destination address. For frames assigned to Ethernet Switched Paths (ESPs) by PBB-TE, the protocol comprises the operation of an external agent that configures Static Filtering Entries in the FDB (see 25.10); for all other frames RSTP, MSTP, or Intermediate System to Intermediate System Protocol for Shortest Path Bridging (ISIS-SPB) is used to configure the controls used for active topology enforcement (8.6.1). Reception of duplicate copies of a single transmitted frame can be avoided by loop prevention (6.5.4.1) or loop mitigation (6.5.4.2).

NOTE—Where RSTP, MSTP, or SPB is used (see Clause 13), there is a probability that a reconfiguration event can cause frames that are in transit through the network to be duplicated, because a Bridge can buffer frames awaiting transmission through its Ports. As the probability of duplication occurring as a result of such an event is small, and the frequency of reconfiguration events is also small, the degradation of the properties of the MAC Service caused by this source of frame duplication is considered to be negligible. A more detailed discussion of frame duplication in RSTP can be found in K.2 of IEEE Std 802.1D-2004 [B12].

6.5.4.1 Loop prevention

Each Bridge that participates in RSTP, MSTP, or ISIS-SPB calculates a spanning tree for each active topology, and prevents loops by exchanging information between neighboring Bridges to ensure either that their topology calculations are consistent and each frame is consistently allocated to the same active topology, or that frames are not relayed.

6.5.4.2 Loop mitigation

Each Bridge that participates in SPBM may mitigate loops. The properties of loop mitigation are listed below. Allowing temporary loops to form for unicast traffic and using loop mitigation provides for faster response to topology changes. Loop mitigation is accomplished if a unicast frame can only be forwarded by the Bridges as follows:

a) From at most one reception Port to at most one transmission Port; and
b) To a different transmission Port from the reception Port;

   and

c) Each Bridge does not relay, from any reception Port, a frame whose source address and VID are the same as that used by any entity within the Bridge; and
d) Each Bridge does not transmit, through any Port, a frame whose destination address and VID are the same as that used by any entity within the Bridge;

   and

e) All LANs in the network provide only point-to-point connectivity.

Loop mitigation limits the effect of loops since any loop in the active topology cannot include either the source or destination of the frame, nor can the loop cause multiple copies of the initial frame to be delivered to the destination, or to or from any LAN in the network that is not part of the loop.

Loop mitigation does not require that neighboring Bridges assign a given frame to the same active topology; or even that the reception and transmission Ports for that frame have been derived from the same topology calculation within a given Bridge. While this standard specifies the calculation of paths that are reverse path congruent (Clause 3) to support bidirectional communication, that property has no bearing on loop mitigation. As a consequence, the Dynamic Filtering Entries that are used for active topology enforcement (8.6.1) and loop mitigation with SPBM (27.4.1) can be updated one at a time after ISIS-SPB has completed a link state calculation or during the course of that calculation.

6.5.5 Transit delay

The MAC Service introduces a frame transit delay that is dependent on the particular media and MAC method employed. Frame transit delay is the elapsed time between an MA_UNITDATA.request primitive and the corresponding MA_UNITDATA.indication primitive. Elapsed time values are calculated only on SDUs that are successfully transferred.

Since the MAC Service is provided at an abstract interface within an end station, it is not possible to specify precisely the total frame transit delay. It is, however, possible to measure those components of delay associated with media access and with transmission and reception; and the transit delay introduced by an intermediate system, in this case a Bridge, can be measured.

The minimum additional transit delay introduced by a Bridge is the time taken to receive a frame plus that taken to access the media onto which the frame is to be relayed. Note that the frame is completely received before it is relayed as the Frame Check Sequence (FCS) is to be calculated and the frame discarded if in error.

6.5.6 Frame lifetime

The MAC Service ensures that an upper bound to the transit delay is experienced for a particular instance of communication. This maximum frame lifetime is necessary to ensure the correct operation of higher layer protocols. The additional transit delay introduced by a Bridge is discussed in 6.5.5.

To enforce the maximum frame lifetime, a Bridge may be required to discard frames. Since the information provided by the MAC Sublayer to a Bridge does not include the transit delay already experienced by any particular frame, Bridges discard frames to enforce a maximum delay in each Bridge.

The value of the maximum Bridge transit delay is based on both the maximum delays imposed by all Bridges in the network and the desired maximum frame lifetime. A recommended and an absolute maximum value are specified in Table 6-1.

Table 6-1—Bridge transit delay

Parameter	Recommended value	Absolute maximum
Maximum Bridge transit delay	1.0s	4.0s

6.5.7 Undetected frame error rate

The MAC Service introduces a very low undetected frame error rate in transmitted frames. Undetected errors are protected against by the use of an FCS that is appended to the frame by the MAC Sublayer of the source station prior to transmission, and checked by the destination station on reception.

The FCS calculated for a given SDU is dependent on the MAC method employed. It is therefore necessary to recalculate the FCS within a Bridge providing a relay function between IEEE 802 LAN MACs of dissimilar types if differences in the method of calculation and/or the coverage of the FCS, or changes to the data that is within the coverage of the FCS, would lead to a different FCS being calculated for the SDU by the two MAC methods. This introduces the possibility of additional undetected errors arising from the operation of a Bridge. For frames relayed between LANs of the same MAC type, the Bridge shall not introduce an undetected frame error rate greater than that which would have been achieved by preserving the FCS.

NOTE—Application of the techniques described in Annex O allows an implementation to achieve an arbitrarily small increase in undetected frame error rate, even in cases where the data that is within the coverage of the FCS is changed.

6.5.8 Maximum Service Data Unit Size

The Maximum Service Data Unit Size that can be supported by an IEEE 802 LAN varies with the MAC method and its associated parameters (e.g., speed, electrical characteristics). It may be constrained by the owner of the LAN. The Maximum Service Data Unit Size supported by a Bridge between two LANs is the smaller of that supported by the LANs. No attempt is made by a Bridge to relay a frame to a LAN that does not support the size of SDU conveyed by that frame.

6.5.9 Priority

The MAC Service includes priority as a QoS parameter. MA_UNITDATA.request primitives with a high priority may be given precedence over other request primitives made at the same station, or at other stations attached to the same LAN and can give rise to earlier MA_UNITDATA.indication primitives.

The MAC Sublayer maps the requested priority onto the priorities supported by the individual MAC method. The requested priority may be conveyed to the destination station.

The transmission delay experienced by a frame in a Bridge can be managed by associating a priority with the frame.

The transmission delay comprises:

a) A queuing delay until the frame becomes first in line for transmission on the Port, in accordance with the procedure for selecting frames for transmission described in 8.6.8.
b) The access delay for transmission of the frame.

Queuing delays can be managed using priority. Access delays can be managed using priority in MAC methods that support more than one priority.

The priority associated with a frame can be signaled by means of the priority signaling mechanisms inherent in some IEEE 802 LAN MAC types. Since not all IEEE 802 LAN MAC types are able to signal the priority associated with a frame, VLAN Bridges regenerate priority based on a combination of signaled information and configuration information held in the Bridge.

The Bridge maps priority values onto one or more traffic classes; Bridges that support more than one traffic class are able to support expedited classes of traffic. The Forwarding Process, 8.6, describes the use of priority and traffic classes in Bridges. Given the constraints placed on frame misordering in a Bridge, as expressed in 6.5.3, the mappings of priority and traffic class are static.

NOTE 1—The term “traffic class,” as used in this standard, is used only in the context of the operation of the priority handling and queuing functions of the Forwarding Process, as described in 8.6. Any other meanings attached to this term in other contexts do not apply to the use of the term in this standard.

The ability to signal priority in IEEE 802 LANs, coupled with a consistent approach to the mapping of priority to traffic classes, and of priority to the priority requested from the individual LAN or supporting service, allows consistent use of priority information to be made, according to the capabilities of the Bridges and MAC methods that are involved in the transmission path.

NOTE 2—This standard defines a frame format and associated procedures that can be used to carry priority information across LAN MAC types that are not able to signal priority.

Under normal circumstances, priority is not modified in transit through the relay function of a Bridge; however, there may be some circumstances where it is desirable for management purposes to control how priority is propagated. The Priority Regeneration Table (Table 6-4) provides the ability to map incoming priority values on a per-Port basis, under management control. In its default state, this table provides an identity mapping from priority values to Regenerated priority values; i.e., by default, the Regenerated priority is identical to the incoming priority.

6.5.10 Throughput

The total throughput provided by a network can be significantly greater than that provided by an equivalent single LAN. Bridges may localize traffic within the network by filtering frames. Filtering services available in bridged networks are described in 6.16.

The throughput between end stations on individual LANs, communicating through a Bridge, can be lowered by frame discard in the Bridge due to the inability to transmit at the required rate on the LAN forming the path to the destination for an extended period.

6.6 Internal Sublayer Service (ISS)

The service and control primitives and parameters, the status parameters, and the point-to-point parameters of the ISS are specified in IEEE Std 802.1AC.

6.7 Support of the ISS by specific MAC procedures

Support of the ISS by MAC Entities that use specific IEEE 802 media access methods is specified in IEEE Std 802.1AC.

6.7.1 Support of the ISS by IEEE Std 802.3 (Ethernet)

Mapping between M_CONTROL.requests/indications and IEEE 802.3 MA_CONTROL.requests/indications is performed as specified in IEEE Std 802.1AC. If the MAC supports the MAC Merge sublayer specified in IEEE Std 802.3, then PFC M_CONTROL.requests are mapped onto the MAC control interface associated with the express MAC (eMAC).

If frame preemption (6.7.2) is supported on a Port, then the IEEE 802.3 MAC provides the following two MAC service interfaces:

a) A preemptable MAC (pMAC) service interface
b) An express MAC (eMAC) service interface

For priority values that are identified in the frame preemption status table (6.7.2) as *preemptable*, frames that are selected for transmission shall be transmitted using the pMAC service instance, and for priority values that are identified in the frame preemption status table as *express*, frames that are selected for transmission shall be transmitted using the eMAC service instance.

In all other respects, the Port behaves as if it is supported by a single MAC service interface. In particular, all frames received by the Port are treated as if they were received on a single MAC service interface regardless of whether they were received on the eMAC service interface or the pMAC service interface, except with respect to frame preemption.

If the value of the holdRequest managed object (12.30.1.5) transitions from *release (2)* to *hold (1)*, a MM_CTL.request(hold_req) primitive is issued to the underlying IEEE 802.3 MAC, with a hold_req parameter value of HOLD, as described in IEEE Std 802.3. If the value of the holdRequest managed object (12.30.1.5) transitions from *hold (1)* to *release (2)*, a MM_CTL.request(hold_req) primitive is issued to the underlying IEEE 802.3 MAC, with a hold_req parameter value of RELEASE.

NOTE—This additional material will be moved to IEEE Std 802.1AC in a future revision.

6.7.2 Frame preemption

If the Port supports frame preemption, then a value of frame preemption status is assigned to each value of priority via a *frame preemption status table*. The possible values of frame preemption status are *express* or *preemptable*.

The frame preemption status table can be changed by management as described in 12.30.1.1. The default value of frame preemption status is *express* for all priority values.

6.8 Enhanced Internal Sublayer Service (EISS)

The EISS is derived from the ISS (IEEE Std 802.1AC) by augmenting that specification with elements necessary to the operation of the tagging and untagging functions of a VLAN Bridge (3.296). Within the attached end station, these elements can be considered either to be below the MAC Service boundary, and pertinent only to the operation of the service provider, or to be local matters not forming part of the peer-to-peer nature of the MAC Service.

The EISS provides the same service status and point-to-point parameters as the ISS (IEEE Std 802.1AC).

6.8.1 Service primitives

The unit-data primitives that define this service are:

EM_UNITDATA.indication (
destination_address,
source_address,
mac_service_data_unit,
priority,
drop_eligible,
vlan_identifier,
frame_check_sequence,
service_access_point_identifier,
connection_identifier,
flow_hash,
time_to_live
)

EM_UNITDATA.request (
destination_address,
source_address,
mac_service_data_unit,
priority,
drop_eligible,
vlan_identifier,
frame_check_sequence,
service_access_point_identifier,
connection_identifier,
flow_hash,
time_to_live
)

The **destination_address, source_address, mac_service_data_unit, priority, drop_eligible, service_access_point_identifier, connection_identifier,** and **frame_check_sequence** parameters are as defined for the ISS.

NOTE—Some of the functions supporting the EISS may result in changes to the mac_service_data_unit or other parameters used to construct a frame. The original FCS associated with a frame is invalidated if there are changes to any fields of the frame, if fields are added or removed, or if bit ordering or other aspects of the frame encoding have changed. An invalid FCS is signaled in the EISS by an unspecified value in the frame_check_sequence parameter. This signals the need for the FCS to be regenerated according to the normal procedures for the transmitting MAC. Two options for regenerating the FCS under these circumstances are discussed in Annex O.

The **vlan_identifier** parameter carries the VID.

The **flow_hash** parameter either is null or carries a value that may be used by the forwarding process in selecting a single forwarding port from a set of available forwarding ports (8.6.3). Transmission order is maintained for all frames from a source to a destination with the same flow hash value. A flow hash value may be retrieved from an F-TAG or otherwise derived from the contents of a service primitive (44.2.2). A flow hash is not required by the MAC Relay Entity, and successful filtering can be provided without this additional information; however, it is required for flow filtering services supported by SPBM with ECMP. Any protocol entity in the interface stack that does not specify use of the flow_hash assigns the flow_hash value (if any) supplied with a request from the user of the protocol entity (or with an indication from the provider of the service used by the protocol entity) to the flow_hash on associated requests made (or indications generated) by the protocol entity.

The **time_to_live** parameter either is null or carries a value that may be used to filter frames that have reached their limit of permitted network hops. A time_to_live value may be retrieved from an F-TAG in the mac_service_data_unit and processed as described in 44.2.2. Any protocol entity in the interface stack that does not specify use of the time_to_live assigns the time_to_live value (if any) supplied with a request from the user of the protocol entity (or with an indication from the provider of the service used by the protocol entity) to the time_to_live on associated requests made (or indications generated) by the protocol entity.

6.8.2 Status parameters

The EISS also makes available the **MAC_Enabled** and **MAC_Operational** status parameters that reflect the operational state and administrative controls over each instance of the service provided. The values of these parameters are mapped directly from the values made available by the ISS (IEEE Std 802.1AC).

6.8.3 Point-to-point parameters

The EISS also makes available the **operPointToPointMAC** and **adminPointToPointMAC** status parameters that reflect the point-to-point status of each instance of the service provided and provide administrative control over the use of that information. The values of these parameters are mapped directly from the values made available by the ISS (IEEE Std 802.1AC).

6.8.4 Control primitives and parameters

The EISS provides two control primitives, an EM_CONTROL.request and an EM_CONTROL.indication, and their associated parameters. The values of these parameters are mapped directly to/from the values made available by the corresponding ISS primitives (11.4 of IEEE Std 802.1AC-2016 [B8]).

The EM_CONTROL.request primitive has the form:

```
EM_CONTROL.request      (
                        destination_address
                        opcode
                        request_operand_list
                        )
```

The EM_CONTROL.indication primitive has the form:

```
EM_CONTROL.indication   (
                        opcode
                        indication_operand_list
                        )
```

6.9 Support of the EISS

The EISS is supported by tagging and detagging functions that in turn use the ISS (IEEE Std 802.1AC). Any given instance of the EISS shall be supported by using one but not both of the following VLAN tag types:

a) C-VLAN tag (C-TAG) or
b) S-VLAN tag (S-TAG)

selected as specified in 9.5.

Each Bridge Port shall support the following parameters for use by these functions:

c) An Acceptable Frame Types parameter with at least one of the following values:
   1) *Admit Only VLAN-tagged frames*
   2) *Admit Only Untagged and Priority-tagged frames*
   3) *Admit All frames*
d) A PVID parameter for Port-based VLAN classification

Each Bridge Port may support the following parameters:

e) A VID Set for Port-and-Protocol-based classification (6.12)
f) A VID translation table
g) An Egress VID translation table

All three values for Acceptable Frame Types may be supported; if so, they shall be configurable using the management operations defined in Clause 12, and the default shall be *Admit All Frames*. A frame is treated as Untagged if the initial octets of the mac_service_data_unit parameter do not contain a VLAN tag of the type used to support the EISS (9.5), as Priority-tagged if the value contained in the VID field of the VLAN tag is zero, and as VLAN-tagged if the value is nonzero.

NOTE 1—The VID translation tables are for use only at the edge of administrative or control protocol domains, e.g., Network-Network Interfaces, SPB domains, or Root and Leaf interfaces to a rooted-multipoint service, as described in this standard. Control protocols that are designed for operation through ports where VID translation is permitted (e.g., MSTP, MVRP, CFM) explicitly compensate for the translation of VID values carried within their PDUs. Successful operation and maintenance of Bridged Networks depends on the fact that VID values are not translated at other ports or at ports within the operational span of control protocols that do not recognize translation.

The PVID and VID Set shall contain valid VID values (Table 9-2) and may be configured by management. If they have not been explicitly configured, the PVID shall assume the value of the default PVID defined in Table 9-2 and the VID Set shall be empty.

NOTE 2—The default behavior of a Bridge that supports Port-and-Protocol-based classification is the same as that of a Bridge that supports only Port-based classification, since all the Protocol Group Identifiers in the VID Set for each Port assign the same VID as the PVID.

The VID translation table and Egress VID translation table provide a mapping between “local VID” values and “relay VID” values. The local VID is the value encoded in a VLAN tag header in the initial octets of the mac_service_data_unit parameter of an ISS service primitive (M_UNITDATA.indication or M_UNITDATA.request). The relay VID is the value contained in the vlan_identifier parameter of an EISS service primitive (EM_UNITDATA.indication or EM_UNITDATA.request). The VID translation table may be supported by itself, or in combination with the Egress VID translation table. When only the VID translation table is supported it is used for bidirectional mapping between the local VID and the relay VID in both indication and request service primitives. This enforces a symmetric one-to-one translation (i.e., if local VID A maps to relay VID B then relay VID B will map to local VID A). When both tables are supported the VID translation table is used only for mapping the local VID to a relay VID in indication service primitives, and the Egress VID translation table is used for mapping the relay VID to a local VID in request service primitives. This allows asymmetric and many-to-one translations (e.g., for translating to and from SPVIDs at the edge of an SPT Region). Both tables are configurable by management, and the default configuration maps each value of the local VID to the same value for the relay VID, and vice versa. For Bridge Ports at the boundary of an SPBV SPT Region the tables are dynamically modified by the ISIS-SPB.

6.9.1 Data indications

On receipt of an M_UNITDATA.indication primitive from the ISS, the received frame is discarded if:

a) The initial octets of the mac_service_data_unit do not contain a valid VLAN tag header (9.3) of the type used to support the EISS (9.5), and the Acceptable Frame Types is *Admit Only VLAN-tagged frames*; or
b) The initial octets of the mac_service_data_unit contain a valid VLAN tag header (9.3) of the type used to support the EISS (9.5), and:
    1) The VID value is FFF, reserved in Table 9-2 for implementation use; or
    2) The VID translation table is supported and the translated VID value (relay VID) is FFF (indicating local discard); or
    3) The VID value is 000 (indicating Priority-tagged), and the Acceptable Frame Types is *Admit Only VLAN-tagged frames*; or
    4) The VID value is in the range 001-FFE, and the Acceptable Frame Types is *Admit Only Untagged and Priority-tagged frames*.

Otherwise, an EM_UNITDATA.indication primitive is invoked, with parameter values determined as follows:

The **destination_address, source_address,** and **frame_check_sequence** parameters carry values equal to the corresponding parameters in the received data indication. The values of the remaining parameters are affected by the contents of the tag header if the frame contains a VLAN tag of the type supported by this instance of the EISS.

The value of the **mac_service_data_unit** parameter is as follows:

c) If the frame is tagged, then the value used is equal to the value of the received mac_service_data_unit following removal of the tag header.
d) Otherwise, the value used is equal to the value of the received mac_service_data_unit.

The value of the **vlan_identifier** parameter is as follows:

e) The value contained in the VID field, optionally translated using the VID translation table, if the frame is VLAN-tagged.
f) The value of the PVID for the Port, if Port-and-Protocol-based VLAN classification is not supported and the frame is untagged, Priority-tagged, or the VID translation table is supported and the translated VID value (relay VID) is zero.
g) As determined by Port-and-Protocol-based VLAN classification (6.12) if that capability is implemented and the frame is untagged or Priority-tagged or the VID translation table is supported and the translated VID value (relay VID) is zero.

The value of the **drop_eligible** and **priority** parameters are determined as follows:

h) If the frame is tagged, the value of the drop_eligible parameter and the received priority value are decoded from the tag header as described in 6.9.3. Otherwise,
i) The received priority value and the drop_eligible parameter value are the values in the M_UNITDATA.indication.
j) The value of the priority parameter is then regenerated from the received priority, as specified in 6.9.4.

6.9.2 Data requests

On invocation of an EM_UNITDATA.request primitive by a user of the EISS, the frame is discarded if the Egress VID translation table is supported and the translated VID value (local VID) is FFF (reserved in Table 9-2). Otherwise, an M-UNITDATA.request primitive is invoked, with parameter values as follows:

The **destination_address, source_address, drop_eligible**, and **priority** parameters carry values equal to the corresponding parameters in the received data request.

Unless the Bridge Port is a member of the untagged set (8.8.2) for the VID identified by the **vlan_identifier** parameter, then a tag header, formatted as necessary for the destination MAC type, is inserted as the initial octets of the mac_service_data_unit parameter. The values of the **vlan_identifier** (optionally translated using the VID translation table or Egress VID translation table), **priority**, and **drop_eligible** parameters are used to determine the contents of the tag header, in accordance with Clause 9.

If the Bridge Port is a member of the untagged set (8.8.2) for the VID identified by the **vlan_identifier** parameter, no tag header is inserted.

The remaining octets of the **mac_service_data_unit** parameter are those accompanying the EISS-request. If the data request is a consequence of relaying a frame and the MAC type of the Port differs from that used to receive the frame, they are modified, if necessary, in accordance with the procedures described in ISO/IEC 11802-5, IETF RFC 1042, and IETF RFC 1390.

The value of the **frame_check_sequence** parameter is determined as follows:

a) If the frame_check_sequence parameter received in the data request either is unspecified or still carries a valid value, then that value is used.
b) Otherwise, the value used is either unspecified or derived from the received FCS information by modification to take account of the conditions that have caused it to become invalid.

6.9.3 Priority Code Point encoding

The priority and drop_eligible parameters are encoded in the PCP field of the VLAN tag using the Priority Code Point Encoding Table for the Port, and they are decoded from the PCP using the Priority Code Point Decoding Table. For each Port, the Priority Code Point Encoding Table has 16 entries, corresponding to each of the possible combinations of the eight possible values of priority (0 through 7) with the two possible values of drop_eligible (True or False). For each Port, the Priority Code Point Decoding Table has 8 entries, corresponding to each of the possible PCP values.

Alternative values for each table are specified as rows in Table 6-2 and Table 6-3, with each alternative labeled by the number of distinct priorities that can be communicated, and the number of these for which drop precedence can be communicated. For example, the table entries 6P2D allow six distinct priorities with drop precedence for two. The default values (8P0D) specify a PCP value equal to the priority value and do not support communication of drop precedence in the PCP field. The combination of the priority and drop_eligible parameters is shown by the priority alone if drop_eligible is False, and by the priority followed by the letters “DE” if drop_eligible is True.

If the VLAN tag is an S-TAG, then Table 6-2 and Table 6-3 shall be supported. If the VLAN tag is a C-TAG, then the 8P0D row of each table shall be supported, and the remaining rows may be supported.

NOTE—To avoid potential misordering of frames, all Ports on a LAN should select the same row of Table 6-2 and Table 6-3. Interoperability considerations with Bridges supporting only the 8P0D row are discussed in I.8.

Table 6-2—Priority Code Point encoding

priority drop_eligible		7	7DE	6	6DE	5	5DE	4	4DE	3	3DE	2	2DE	1	1DE	0	0DE
PCP	8P0D (default)	7	7	6	6	5	5	4	4	3	3	2	2	1	1	0	0
	7P1D	7	7	6	6	5	4	5	4	3	3	2	2	1	1	0	0
	6P2D	7	7	6	6	5	4	5	4	3	2	3	2	1	1	0	0
	5P3D	7	7	6	6	5	4	5	4	3	2	3	2	1	0	1	0

Table 6-3—Priority Code Point decoding

PCP		7	6	5	4	3	2	1	0
priority drop_eligible	8P0D (default)	7	6	5	4	3	2	1	0
	7P1D	7	6	4	4DE	3	2	1	0
	6P2D	7	6	4	4DE	2	2DE	1	0
	5P3D	7	6	4	4DE	2	2DE	0	0DE

The values in the Priority Code Point Encoding Table and Priority Code Point Decoding Table may be modified by management, as described in Clause 12. If this capability is provided, the value of the table entries shall be independently settable for each Port. The values shall be constrained as follows:

a) For any two priority values with the same drop_eligible value, the lower priority shall not map to a higher PCP than the higher priority.
b) The lower of any two PCP values shall not map to a higher priority than the higher PCP.
c) With the exception of values 0 and 1, any priority value combined with drop_eligible True shall not map to a higher PCP than the same priority value combined with drop_eligible False.
d) With the exception of values 0 and 1, any PCP value shall not map to a priority value combined with drop_eligible True if a lower PCP maps to the same priority value combined with drop_eligible False.

The values may be further constrained, but if the tables can be modified, the default values shown in Table 6-2 and Table 6-3, and the alternative sets of values in Table 6-2 and Table 6-3 shall be settable.

The drop_eligible parameter may also be encoded in and decoded from the Drop Eligible Indicator (DEI) in the VLAN tag. Use of the DEI allows the VLAN tag to convey eight distinct priorities, each with a DEI. If this capability is provided, it shall be independently manageable for each Port by means of a Use_DEI parameter. If the Use_DEI is True for the Port, the drop_eligible parameter is encoded in the DEI of transmitted frames, and the drop_eligible parameter shall be True for a received frame if the DEI is set in the VLAN tag or the Priority Code Point Decoding Table indicates drop_eligible True for the received PCP value. If the Use_DEI parameter is False, the DEI shall be transmitted as zero and ignored on receipt. The default value of the Use_DEI parameter is False.

6.9.4 Regenerating priority

The priority of each received frame is regenerated using priority information contained in the frame and the Priority Regeneration Table for the reception Port. For each reception Port, the Priority Regeneration Table has eight entries, corresponding to the eight possible values of priority (0 through 7). Each entry specifies, for the given value of received priority, the corresponding regenerated value.

For untagged frames, the priority parameter signaled in the corresponding M_UNITDATA.indication is taken to be the received priority. For tagged frames, the priority signaled in the PCP field of the tag header is taken to be the received priority.

NOTE 1—IEEE 802 LAN technologies signal a maximum of eight priority values. Annex I further explains the use of priority values and how they map to traffic classes.

Table 6-4 specifies default regenerated priority values for each of the eight possible values of the received priority. These default values shall be used as the initial values of the corresponding entries of the Priority Regeneration Table for each Port.

Table 6-4—Priority regeneration

Received priority	Default regenerated priority	Range
0	0	0–7
1	1	0–7
2	2	0–7
3	3	0–7
4	4	0–7
5	5	0–7
6	6	0–7
7	7	0–7

The values in the Priority Regeneration Table may be modified by management, as described in Clause 12. If this capability is provided, the value of the table entries shall be independently settable for each reception Port and for each value of received priority, and the Bridge shall have the capability to use the full range of values in the parameter ranges specified in Table 6-4.

NOTE 2—The regeneration and mapping of priority within the Bridge should be consistent with the end-to-end significance of that priority across the rest of the Bridged Network. The regenerated priority value is used:

— Via the traffic class table (8.6.6) to determine the traffic class for a given outbound Port, and

— Via fixed, MAC type-specific mappings (IEEE Std 802.1AC) to determine the access priority that will be used for certain media access methods.

In Bridges that support SRP, an SRP domain boundary port priority regeneration override table is maintained for each reception Port. This table associates a priority value with each SR class supported by the Bridge, and specifies the priority value to be used as the regenerated priority, in preference to the value in the Priority Regeneration table, when the SRPdomainBoundaryPort parameter (35.1.4) for that SR class has the value TRUE. Table 6-5 specifies the default values for priority and regenerated priority for two SR classes, SR class A and SR class B. In cases where only SR class B is supported, only the default value shown in the table for SR Class B is used.

Table 6-5—Default SRP domain boundary port priority regeneration override values

SR class	Default priority	Default regenerated priority for SRP domain boundary Ports	Range
A	3	0	0–7
B	2	0	0–7

The priority values contained in the SRP domain boundary port priority regeneration override table may be modified by management, as described in Clause 12. If this capability is provided, the value of the table entries shall be independently settable for each reception Port and for each supported SR class, and the Bridge shall have the capability to use the full range of values in the parameter ranges specified in Table 6-5.

NOTE 3—The default values specified for the SRP domain boundary port Priority Regeneration Table map inbound PCP values onto the next lowest priority that is available, leaving the remaining priority values unchanged. The consequence of this remapping is that traffic entering an SRP domain that carries the priority value associated with that domain is forwarded by the Bridge at the domain boundary using a lower priority. There is no means of mapping these priority values back to their original values as frames exit from an SRP domain. The default mappings are based on the assumption that normally, two SR classes (A and B) are used to support traffic for which bandwidth has been reserved; if only the lower class (B) is supported, then the default override value for the unsupported A class does not apply.

NOTE 4—The ability for the priority regeneration table to be freely modified by management means that it is possible to create mappings that result in reserved and nonreserved traffic sharing the same priority. This will have unpredictable effects upon the behavior of the network with respect to the worst-case latency that can be assumed for reserved traffic.

6.10 Support of the ISS/EISS by PIPs

Each PIP on a BEB uses a single ISS-SAP (IEEE Std 802.1AC) and the I-TAG (9.5) to provide a separate Bridge Port (the VIP) for each backbone service instance configured for the PIP. Each VIP supports either the VLAN-unaware MAC Relay Entity of a T-component or the VLAN-aware MAC Relay Entity of an I-component. A single VIP ISS-SAP is provided to a T-component. An I-component uses an EISS-SAP, supported by its own instance of the functions specified in 6.9 with the S-TAG (9.5), for each VIP ISS-SAP. See Figure 6-2.

The EISS of each Virtual Instance Port (VIP-EISS) shall be supported by an instance of the functions of 6.9 using the S-TAG type (9.5). The ISS of all of the Virtual Instance Ports (VIP-ISS) shall be supported by a single instance of the functions specified in this subclause using the I-TAG type (9.5).

NOTE 1—Higher Layer Entities may interface to any VIP and/or the PIP at the Service Access Points (SAPs) represented by any VIP-ISS and/or the PIP-ISS using the Bridge Port Connectivity specified in 8.5.1. Protocol shims such as CFM MPs may interface at any VIP-EISS using the EISS Multiplex Entity specified in 6.17, or at the PIP-ISS using the Backbone Service Instance Multiplex Entity specified in 6.18. Figure 26-2 shows a PIP with both Bridge Port Connectivity and CFM shims.

Each PIP shall have an individual Backbone Media Access Control (B-MAC) address referred to as the PIP MAC address (26.4) for use by the functions specified in this subclause.

Each VIP shall support the following parameters for use by these functions:

a) A VIP-ISID parameter for the I-SID of the backbone service instance associated with this VIP
b) A Default Backbone Destination
c) An adminPointToPointMAC
d) An enableConnectionIdentifier

The VIP-ISID shall contain a valid I-SID value (9.7), which is configured by management.

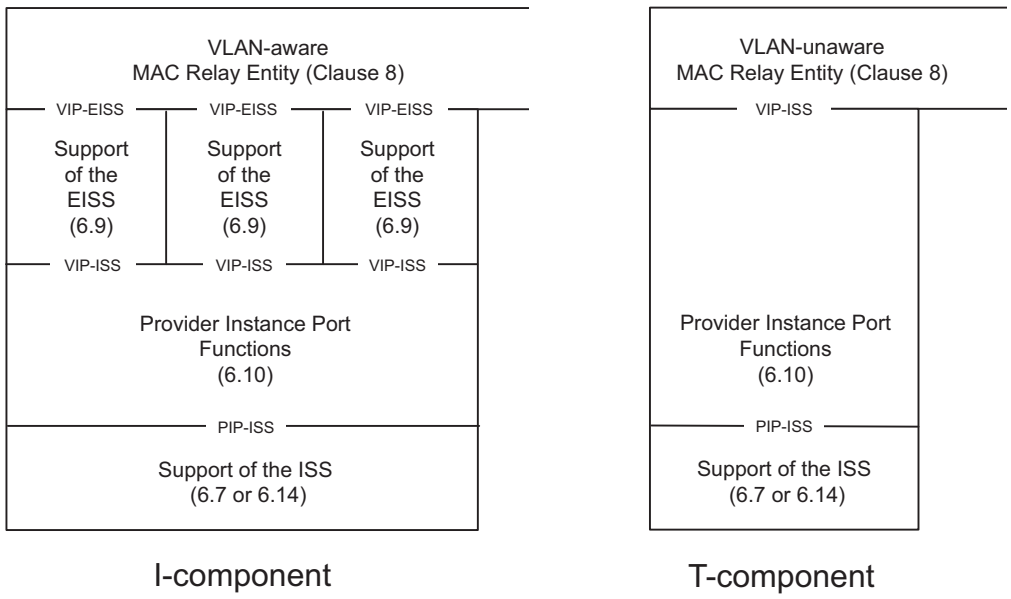


Figure 6-2—Provider Instance Ports (PIPs)

The Default Backbone Destination parameter contains a MAC address to be used in the destination_address parameter of an M_UNITDATA.request at the PIP-ISS when a backbone destination address cannot be derived from the connection_identifier parameter of the M_UNITDATA.request from the VIP-ISS. The default value of the Default Backbone Destination is the Backbone Service Instance Group address for the VIP-ISID (generated by concatenating the Provider Backbone Bridge (PBB) organizationally unique identifier (OUI) with the VIP-ISID value as specified in 26.4).

The adminPointToPointMAC parameter of the VIP-ISS reflects the point-to-point status of the backbone service instance associated with the VIP. The default value of the adminPointToPointMAC parameter is ForceFalse. The value may be configured by management to ForceTrue when instantiating a VIP for a point-to-point backbone service instance. A value of ForceFalse or Auto results in a operPointToPointMAC value of FALSE; a value of ForceTrue results in a operPointToPointMAC value of TRUE. Whenever the operPointToPointMAC parameter transitions to FALSE, the value for the Default Backbone Destination parameter is set to the Backbone Service Instance Group address for the VIP-ISID. When the operPointToPointMAC parameter is TRUE, the Default Backbone Destination parameter is modified by subsequent M_UNITDATA.indications as specified in 6.10.1 (and described in 26.4.1).

The enableConnectionIdentifier parameter allows the VIP to use the connection_identifier parameter to learn associations between a B-MAC address and a Customer Media Access Control (C-MAC) address. The default value is TRUE. This parameter should be configured to FALSE at the root node of a point-to-multipoint TESI.

NOTE 2—There is a 1:1 relationship between a given value of the connection_identifier and a B-MAC address. This level of indirection is provided to allow the use of the connection_identifier parameter for other purposes by other types of Bridge Ports. The relationship between a given connection_identifier value and a B-MAC address is maintained as long as any FDB entry contains this value for the connection_identifier. No ageing mechanism other than that specified for Dynamic Filtering Entries is implied.

6.10.1 Data indications

On receipt of an M_UNITDATA.indication primitive from the PIP-ISS, if the PIP is congestion aware (5.4.1.4) and the initial octets of the mac_service_data_unit contain a valid CNM encapsulation, the received frame is processed according to 32.16. Otherwise, the received frame shall be discarded if:

a) The initial octets of the mac_service_data_unit do not contain a valid I-TAG header; or
b) The Use Customer addresses (UCA) bit in the I-TAG is not zero; or
c) The Res2 field in the I-TAG is not zero; or
d) The I-SID value in the I-TAG does not match the VIP-ISID parameter for one of the VIPs supported by this PIP; or
e) The destination_address parameter of the received M_UNITDATA.indication primitive does not match one of the following:
    1) The PIP MAC address; or
    2) A Backbone Service Instance Group address; or
    3) The broadcast address.

NOTE 1—The generation of I-tagged frames specified in 6.10.2 and the allowed manipulation of backbone addresses specified in 6.11 never result in an I-tagged frame with a broadcast destination address. The broadcast address is included in the previous list on the principle that the broadcast address is a valid address at any reception port by definition.

The received frame may be discarded if:

f) The source_address parameter of the received M_UNITDATA.indication primitive is the PIP MAC address.

Otherwise, an M_UNITDATA.indication primitive is invoked at the VIP-ISS with a VIP-ISID value matching the I-SID in the I-TAG. The parameter values of the indication are determined as follows:

The **destination_address** parameter contains the value of the encapsulated C-DA field of the I-TAG.

The **source_address** parameter contains the value of the encapsulated C-SA field of the I-TAG.

If enableConnectionIdentifier is TRUE, then the **connection_identifier** parameter references the value of the source_address parameter (B-SA) of the M_UNITDATA.indication primitive received from the PIP-ISS; otherwise, the connection_identifier parameter is null. The connection_identifier parameter in the M_UNITDATA.indication primitive received from the PIP-ISS is ignored.

NOTE 2—The connection_identifier has only local significance meaning that it is used only at a specific PIP. The only requirement imposed by this subclause is that the connection_identifier uniquely identifies an individual B-MAC address. Whether the connection_identifier takes the value of that address, or a value from which that address can be determined, is an implementation decision that is not externally observable.

If the value of the operPointToPointMAC parameter of the VIP-ISS is TRUE, then the Default Backbone Destination parameter is set to the value of the source_address parameter of the M_UNITDATA.indication primitive.

The **service_access_point_identifier** parameter contains a value that uniquely identifies the VIP within the I-component. This is a local value that is used only within the I-component, and is used by the relay functions (Clause 8) as the port number of the VIP. The service_access_point_identifier parameter received in the M_UNITDATA.indication primitive is ignored.

The value of the **drop_eligible** and **priority** parameters are decoded from the I-PCP and I-DEI fields of the I-TAG as described in 6.10.3.

The value of the **mac_service_data_unit** parameter is the value of the received mac_service_data_unit following the removal of the I-TAG.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified to take into account the changes to the frame.

6.10.2 Data requests

On invocation of an M_UNITDATA.request primitive at any VIP-ISS, an M_UNITDATA.request primitive is invoked at the PIP-ISS, with parameter values as follows:

If enableConnectionIdentifier is TRUE, the connection_identifier is not null, and the connection_identifier references an address retained by the PIP, then the value for the **destination_address** is the address referenced by the connection_identifier. Otherwise, the value for the **destination_address** is the contents of the Default Backbone Destination parameter of the VIP.

The value for the **source_address** is the PIP MAC address.

The **priority** and **drop_eligible** parameters carry the same value as the corresponding parameter in the VIP-ISS request.

The **connection_identifier** parameter is NULL.

The **mac_service_data_unit** parameter is constructed from the mac_service_data_unit of the M_UNITDATA.request primitive from the VIP-ISS by prepending an I-TAG as follows:

a) The encapsulated C-SA field is the value of the source_address parameter of the VIP-ISS request.
b) The encapsulated C-DA field is the value of the destination_addresss parameter of the VIP-ISS request.
c) The UCA, Res1, and Res2 fields are all zero.
d) The I-SID field is the value contained in the VIP-ISID parameter.
e) The I-PCP and I-DEI fields are encoded from the priority and drop_eligible parameters of the VIP-ISS request as specified in 6.10.3.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified to take into account the changes to the frame.

6.10.3 Priority Code Point encoding

The encoding (and decoding) of the I-PCP and I-DEI fields from (to) the **priority** and **drop_eligible** parameters is accomplished using a Priority Code Point Encoding Table (and Priority Code Point Decoding Table) as described in 6.9.3.

6.11 Support of the EISS by CBPs

The functions specified in this subclause replace the functions specified in 6.9 when the EISS is supported by a CBP in a BEB (Clause 25). See Figure 6-3. The functions specified in this subclause use a single instance of the ISS (IEEE Std 802.1AC) and provide a single instance of the EISS. The EISS shall be supported by functions using both the S-TAG and the I-TAG as specified in 9.5.

NOTE 1—Although the CBP does not transmit or receive S-tagged frames, it supports the S-TAG type in the sense that it is a port on an S-VLAN component and the vlan_identifier parameter contains a S-VID.

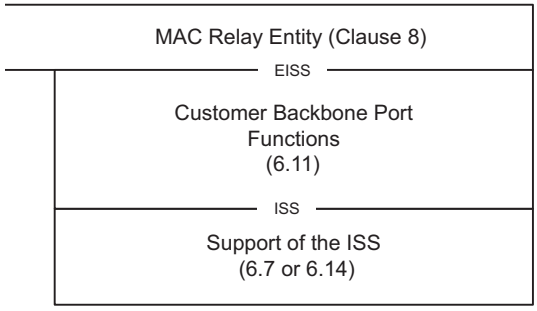


Figure 6-3—B-Component CBP

NOTE 2—Higher Layer Entities may interface to the CBP at the SAP represented by the ISS using the Bridge Port Connectivity specified in 8.5.1. Protocol shims such as CFM MPs may interface at the EISS using the EISS Multiplex Entity specified in 6.17, or at the ISS using the Backbone Service Instance Multiplex Entity specified in 6.18. Figure 26-2 shows a CBP with both Bridge Port Connectivity and CFM shims.

The CBP shall support the following parameters for use by these functions:

a) A PVID parameter for Port-based B-VLAN classification.
b) A Backbone Service Instance table.

The PVID shall contain a valid VID value (Table 9-2) and may be configured by management. If it has not been explicitly configured, the PVID shall assume the value of the default PVID defined in Table 9-2.

The Backbone Service Instance table is configurable by management and has one entry for each backbone service instance supported on the CBP. The Backbone Service Instance table is used to filter frames containing an I-SID value that is not configured on this CBP. It may also be used to provide backbone service instance-specific assignment of a B-VID, to translate I-SID values, and/or to translate backbone destination addresses. Entries in the Backbone Service Instance table may be set automatically by the protection switching procedures described in 26.10.3.4. The Backbone Service Instance table shall contain the following field for each entry:

c) Backbone-SID (I-SID). This contains the identifier used in the backbone network for the backbone service instance.

The Backbone Service Instance table may also contain one or more of the following additional fields for each entry:

d) B-VID (Backbone VLAN Identifier). If the B-VID field is supported, it shall contain a valid VID value (Table 9-2) for that backbone service instance. The default value is the same as the PVID.
e) Local-SID (Local Service Instance Identifier). This field is used to perform a bidirectional 1:1 mapping between the Backbone-SID (contained in the I-TAG in the mac_service_data_unit at the EISS) and the Local-SID (contained in the I-TAG in the mac_service_data_unit at the ISS). The default value of the Local-SID field is the value of the Backbone-SID field.

f) Default Backbone Destination. If this field is present, it is used as the destination_address in the EISS indication when the destination_address parameter of the ISS indication is the Backbone Service Instance Group address. It allows the backbone provider to replace the Backbone Service Instance Group address with an individual or group address to limit the distribution of the frame within a B-VLAN. The default value is the Backbone Service Instance Group address.

NOTE 3—If a CBP is associated with a TESI the Default Backbone Destination field and the B-VID field is supported.

6.11.1 Data indications

On receipt of an M_UNITDATA.indication primitive from the ISS, the received frame shall be discarded if:

a) The initial octets of the mac_service_data_unit do not contain a valid I-TAG; or
b) The Res2 field in the I-TAG is not zero; or
c) The Local-SID field of the Backbone Service Instance table is supported and the I-SID value in the I-TAG does not match the Local-SID value in any entry in the Backbone Service Instance table; or
d) The Local-SID field of the Backbone Service Instance table is not supported and the I-SID value in the I-TAG does not match the Backbone-SID value in any entry in the Backbone Service Instance table.

Otherwise, an EM_UNITDATA.indication primitive is invoked at the EISS with parameter values determined using one entry in the Backbone Service Instance table. If the Local-SID field of the Backbone Service Instance table is supported then the entry with a Local-SID value that matches the I-SID value in the I-TAG is selected. Otherwise, the entry with a Backbone-SID value that matches the I-SID value in the I-TAG is selected. The parameter values are then determined as follows:

The **mac_service_data_unit** parameter is determined as follows:

e) If the Local-SID field of the Backbone Service Instance table is supported, then value of the **mac_service_data_unit** parameter is the value of the mac_service_data_unit parameter of the ISS indication modified by replacing the value of the I-SID field in the I-TAG with the value of Backbone-SID field in the selected Backbone Service Instance table entry.
f) Otherwise, the **mac_service_data_unit** parameter contains the same value as the mac_service_data_unit parameter of the ISS indication.

The **destination_address** parameter is determined as follows:

g) If the destination_address in the ISS indication is the Backbone Service Instance Group address and the Default Backbone Destination field of the Backbone Service Instance table is supported, then the **destination_address** parameter is the Default Backbone Destination value in the selected Backbone Service Instance table entry.
h) Otherwise, if the destination_address in the ISS indication is the Backbone Service Instance Group address and the Local-SID field of the Backbone Service Instance table is supported, then the **destination_address** parameter is the Backbone Service Instance Group address constructed using the Backbone-SID value in the selected Backbone Service Instance table entry.
i) Otherwise, the **destination_address** parameter contains the same value as the destination_address parameter of the ISS indication.

The **source_address** parameter contains the same value as the source_address parameter of the ISS indication.

The value of the **vlan_identifier** parameter is determined as follows:

j) If the B-VID field of the Backbone Service Instance table is supported, then the **vlan_identifier** parameter contains the B-VID value in the selected Backbone Service Instance table entry.
k) Otherwise, the **vlan_identifier** parameter contains the value of the PVID parameter.

The value of the **drop_eligible** and **priority** parameters are determined as follows:

l) The value of the **drop_eligible** parameter and the received_priority value are decoded from the I-DEI and the I-PCP fields of the I-TAG in the mac_service_data_unit as described in 6.11.3.

m) The value of the **priority** parameter is then regenerated from the received_priority value, as specified for the received_priority in 6.11.4.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified as necessary to take into account changes to the frame.

6.11.2 Data requests

On invocation of an EM_UNITDATA.request primitive by a user of the EISS, the frame shall be discarded if:

a) The initial octets of the mac_service_data_unit do not contain a valid I-TAG.

b) The Res2 field in the I-TAG is not zero.

c) The I-SID value in the I-TAG does not match the Backbone-SID value in any of the entries in the Backbone Service Instance table.

Otherwise, an M_UNITDATA.request primitive is invoked, with parameter values determined using the Backbone Service Instance table entry with a Backbone-SID value that matches the I-SID value in the I-TAG. The parameter values are determined as follows:

The value of the **mac_service_data_unit** parameter is determined as follows:

d) If the Local-SID field of the Backbone Service Instance table is supported, then **mac_service_data_unit** parameter contains the value of the mac_service_data_unit parameter of the EISS request modified by replacing the I-SID in the I-TAG with the Local-SID value in the selected Backbone Service Instance table entry.

e) Otherwise, the **mac_service_data_unit** parameter contains the same value as the mac_service_data_unit parameter of the EISS request.

The **destination_address** parameter is determined as follows:

f) If the Local-SID field of the Backbone Service Instance table is supported and the destination_address in the EISS request is the address of this CBP, or is a group address, then the destination_address parameter is the Backbone Service Instance Group address constructed from the Local-SID value in the selected Backbone Service Instance table entry.

g) If the Local-SID field of the Backbone Service Instance table is not supported and the destination_address in the EISS request is the address of this CBP, or is a group address, then the destination_address parameter is the Backbone Service Instance Group address constructed from the Backbone-SID value in the selected Backbone Service Instance table entry.

h) Otherwise, the **destination_address** parameter contains the same value as the destination_address parameter of the EISS request.

The **source_address** parameter contains the same value as the source_address parameter of the EISS request.

The **priority** and **drop_eligible** parameters carry the same value as the corresponding parameter in the EISS request.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified to take into account any changes to the frame.

6.11.3 Priority Code Point decoding

The decoding of the I-PCP and I-DEI fields to the **priority** and **drop_eligible** parameters is accomplished using a Priority Code Point Decoding Table as described in 6.9.3.

6.11.4 Regenerating priority

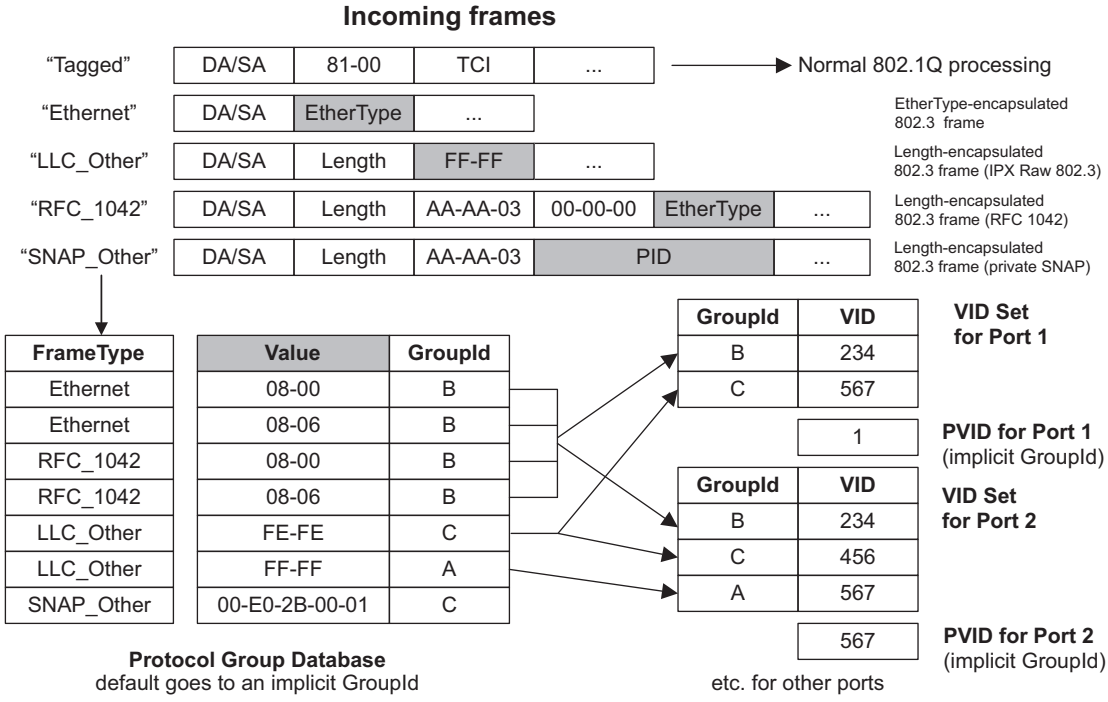
The priority of received frames is regenerated using priority information contained in the I-PCP and the Priority Regeneration table for the reception Port. For each reception Port, the Priority Regeneration table has eight entries, corresponding to the eight possible values of priority (0 through 7). Each entry specifies, for the given value of received_priority, the corresponding regenerated value. The priority decoded from the I-PCP field of the I-TAG is taken to be the received_priority.

NOTE—IEEE 802 LAN technologies signal a maximum of eight priority values. Annex I further explains the use of priority values and how they map to traffic classes.

Table 6-4 specifies default regenerated priority values for each of the eight possible values of the received_priority. These default values shall be used as the initial values of the corresponding entries of the Priority Regeneration table for each Port. The table may be configured as described in 6.9.4.

6.12 Protocol VLAN classification

Each instance of the tagging and detagging functions that supports the EISS (6.9), and implements the optional Port-and-Protocol-based VLAN classification, shall implement a VID Set, each member of which associates values of a Protocol Group Identifier (6.12.2) with a VID. Each Untagged and Priority-tagged frame received is assigned a **vlan_identifier** equal to the VID Set value for the reception Port and the Protocol Group Identifier selected by matching the received frame with a Protocol Template. See Figure 6-4.



NOTE-The PID shown in this figure is a Protocol Identifier, as defined in 5.3 of IEEE Std 802-2014 [B6].
It is a 5-octet value, consisting of a 3-octet OUI or Company ID (CID) value followed by a 2-octet locally administered identifier.

Figure 6-4—Example of operation of Port-and-Protocol-based classification

The **detagged_frame_type** parameter indicates the frame format. Its value is determined as follows:

a) If the frame is Untagged or Priority-tagged, this parameter is present and indicates the link-layer encapsulation format of the *Detagged Frame*. The Detagged Frame of an Untagged Frame is the frame itself. The Detagged Frame of a Tagged Frame or Priority-tagged Frame is the frame that results from untagging the frame in accordance with the frame format described in Clause 9. The value of detagged_frame_type is as follows:
   1) Ethernet, if the Detagged Frame uses EtherType-encapsulated IEEE 802.3 format.
   2) RFC_1042, if the Detagged Frame is of the format specified by 9.4 in IEEE Std 802™-2014 [B5] for the encoding of an IEEE 802.3 EtherType Field in an ISO/IEC 8802-2/SNAP header (this supersedes the original definition, which appeared in IETF RFC 1042 (1988)).
   3) SNAP_Other, if the Detagged Frame contains an LLC UI PDU with DSAP and SSAP fields equal to the LLC address reserved for SNAP and the 5-octet Subnetwork Access Protocol (SNAP) Protocol Identifier (PID) value is not in either of the ranges used for RFC_1042 above.
   4) LLC_Other, if the Detagged Frame contains both a DSAP and an SSAP address field in the positions specified by ISO/IEC 8802-2 Logical Link Control, but is not any of the formats described for LLC frames above.
b) Else the parameter is not present.

The **EtherType** value is present if the detagged_frame_type parameter is present and has the value Ethernet or RFC_1042. Its value is the value of the IEEE 802.3 Length/Type Field present in the Detagged Frame. The value is determined as follows:

c) If the detagged_frame_type parameter is present and has the value Ethernet or RFC_1042, then this parameter is present and has the value of the IEEE 802.3 EtherType Field present in the Detagged Frame.
d) Else the parameter is not present.

The **llc_saps** parameter is present if the detagged_frame_type parameter is present and has the value LLC_Other. Its value is determined as follows:

e) If the detagged_frame_type parameter is present and has the value LLC_Other, then this parameter is present and its value is the pair of LLC ISO/IEC 8802-2 DSAP and SSAP address field values.
f) Else the parameter is not present.

NOTE 1—A frame that is encapsulated using values of hex FF/FF in the position where an LLC header is to be expected (as defined by ISO/IEC 8802-2) is known as a “Novell IPX Raw” encapsulation. Such frames do not conform to ISO/IEC 8802-2, in that they do not include some of the other required LLC fields. For the purposes of this standard, they are treated as LLC_Other, regardless of whether they are legal LLC frames.

NOTE 2—Bridges are not required, for the purposes of this standard, to completely verify whether the format of frames meets ISO/IEC 8802-2. They are required only to recognize the DSAP and SSAP fields of such frames.

The **snap_pid** parameter is present if the detagged_frame_type parameter is present and has the value SNAP_Other. Its value is determined as follows:

g) If the detagged_frame_type parameter is present and has the value SNAP_Other, then the parameter is present and its value is the contents of the 5 octets following the LLC header, i.e., the PID field.
h) Else the parameter is not present.

6.12.1 Protocol Templates

In a Bridge that supports Port-and-Protocol-based VLAN classification, a Protocol Template is a tuple that specifies a protocol to be identified in received frames. A Protocol Template has one of the following formats:

a) A value “Ethernet” and a 16-bit IEEE 802.3 EtherType Field value
b) A value “RFC_1042” and a 16-bit IEEE 802.3 EtherType Field value
c) A value “SNAP_Other” and a 40-bit PID value
d) A value “LLC_Other” and a pair of ISO/IEC 8802-2 LSAP values: DSAP and SSAP

A Protocol Template matches a frame if:

e) The frame’s detagged_frame_type is Ethernet, the Protocol Template is of type Ethernet, and the frame’s IEEE 802.3 EtherType Field is equal to the value of the IEEE 802.3 EtherType Field of the Protocol Template, or
f) The frame’s detagged_frame_type is RFC_1042, the Protocol Template is of type RFC_1042 and the frame’s IEEE 802.3 EtherType Field is equal to the IEEE 802.3 EtherType Field of the Protocol Template, or
g) The frame’s detagged_frame_type is SNAP_Other, the Protocol Template is of type SNAP_Other, and the frame’s snap_pid is equal to the PID of the Protocol Template, or
h) The frame’s detagged_frame_type is LLC_Other, the Protocol Template is of type LLC_Other, and the frame’s llc_saps matches the value of the DSAP and SSAP of the Protocol Template.

NOTE—If a port does not support Protocol Templates of the frame’s detagged_frame_type, then no match will occur.

6.12.2 Protocol Group Identifiers

A Bridge that supports Port-and-Protocol-based VLAN classification shall support Protocol Group Identifiers.

A Protocol Group Identifier, shown as “Group Id” in Figure 6-4, designates a group of protocols that will be associated with one member of the VID Set of a Port. The association of protocols into groups is established by the contents of the Protocol Group Database, as described in 6.12.3. The identifier has scope only within a single Bridge.

An implicit Protocol Group Identifier is assigned to frames that match none of the entries in the Protocol Group Database. Therefore, every incoming frame can be assigned to a Protocol Group Identifier.

6.12.3 Protocol Group Database

A Bridge that supports Port-and-Protocol-based VLAN classification shall support a single Protocol Group Database. The Protocol Group Database groups together a set of one or more Protocols by assigning them the same Protocol Group Identifier (6.12.2). Each entry of the Protocol Group Database comprises the following:

a) A Protocol Template
b) A Protocol Group Identifier

The Protocol Group Database specifies a mapping from Protocol Templates to Protocol Group Identifiers. If two entries of the Protocol Group Database contain different Protocol Group Identifiers, then their Protocol Templates must also be different.

The entries of the Protocol Group Database may be configured by management. A Bridge that supports Port-and-Protocol-based VLAN classification shall support at least one of the Protocol Template formats.

An implicit Protocol Group Database entry exists that matches all frames. This entry is invoked for frames that do not match the template of any of the other entries. It references an implicit Protocol Group Identifier that selects the PVID on each port. In this way, it is ensured that all incoming frames are matched by a Protocol Group Identifier and, hence, are assigned to a VID.

NOTE—If there are no entries in the Protocol Group Database, then the frame relay behavior of this Bridge is identical to the frame relay behavior of a Bridge having the same number of Ports that supports only Port-based VLAN classification.

6.13 Support of the ISS for attachment to a PBN

This standard specifies both Customer Bridges (3.50) and Provider Bridges (3.199). The operation of Provider Bridges and PBNs is, by design, largely transparent to Customer Bridges and Customer Bridged Networks (CBNs). Figure 15-1 illustrates the relationship of the service provided by the MAC Sublayer functionality of Provider Bridges to that used by a Customer Bridge. This subclause enables a mechanism for a Customer Bridge attached to a PBN to request priority handling of frames.

The functions specified in this subclause provide the ISS to the MAC Relay Entity of a Customer Bridge by making use of the underlying ISS provided by the Media Access Method Convergence function as shown in Figure 6-5. These functions shall be one of the following:

a) When Service Access Priority Selection is disabled, the functions shall be null; i.e., each M_UNITDATA.request received from the provided ISS results in an M_UNITDATA.request with identical parameters presented to the underlying ISS, and each M_UNITDATA.indication received from the underlying ISS results in an M_UNITDATA.indication with identical parameters presented to the provided ISS.

b) When Service Access Priority Selection is enabled, the mac_service_data_unit in each M_UNITDATA.request is Priority-tagged with an S-TAG header when presented to the underlying ISS, and if an S-TAG header is present in the mac_service_data_unit parameter in an M_UNITDATA.indication received from the underlying ISS, the S-TAG header is removed before the M_UNITDATA.indication is presented to the provided ISS.

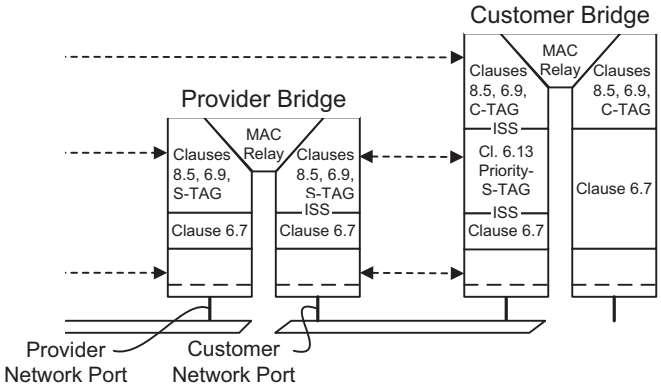


Figure 6-5—Service access priority selection

Specification of a null function allows a Customer Bridge without additional functionality to connect to a PBN.

Specification of the Service Access Priority Selection function allows the Customer Bridge Port to request priority handling of the frame from a Port-based service interface (15.3) to a PBN on the basis of the priority assigned within the CBN, while allowing for differences in cost and service level ascribed to individual values of priority within the service provider and customer networks.

6.13.1 Data requests

For each M_UNITDATA.request received from the provided ISS, an M_UNITDATA.request is presented to the underlying ISS with the following parameters:

The destination_address, source_address, and priority parameters are unchanged.

A tag header, formatted as necessary for the destination MAC type, is inserted as the initial octets of the mac_service_data_unit parameter. The Tag Protocol Identification is the Service VLAN Tag EtherType (9.5). The Tag Control Information (TCI) contains a null VID field, and PCP and DEI fields constructed as specified in 6.9.3 using a drop_eligible value of FALSE and a service_access_priority value derived from the priority parameter using Table 6-6.

Table 6-6—Service Access Priority

Received priority	Default service access priority	Range
0	0	0–7
1	1	0–7
2	2	0–7
3	3	0–7
4	4	0–7
5	5	0–7
6	6	0–7
7	7	0–7

Table 6-6 specifies default service_access_priority values for each of the eight possible values of the priority parameter in the M_UNITDATA.request received from the provided ISS. These default values shall be used as the initial values of the corresponding entries of the Service Access Priority Table for each Port supporting Service Access Priority Selection. The values in the table may be modified by management. If this capability is provided, the value of the table entries shall be independently settable for each Port and for each value of priority, and the Bridge shall have the capability to use the full range of the values in the parameter ranges specified in the table.

The frame_check_sequence parameter is either unspecified or contains a value modified from the received frame_check_sequence value taking into account the changes in the mac_service_data_unit parameter.

NOTE—The priority of the original service request made of the customer network can be carried transparently and unchanged across the PBN in the C-TAG.

6.13.2 Data indications

For each M_UNITDATA.indication received from the underlying ISS, an M_UNITDATA.request is presented to the supported ISS with the following parameters:

The destination_address and source_address parameters are unchanged.

If the initial octets of the mac_service_data_unit do not contain a tag header with the Service VLAN Tag EtherType value (9.5), then the mac_service_data_unit and frame_check_sequence parameters are unchanged. Otherwise,

a) The mac_service_data_unit is detagged by removing the octets of the S-TAG header,
b) The priority parameter is decoded from the PCP field (6.9.3),
c) The drop_eligible parameter is decoded from the Drop Eligible Indicator field (6.9.3), and
d) The frame_check_sequence parameter is either unspecified or contains a value modified from the received frame_check_sequence value taking into account the changes in the mac_service_data_unit parameter.

6.14 Support of the ISS within a system

A single system can comprise two or more instances of VLAN Bridge components connected by one or more of their Ports. If those Ports are not otherwise accessible, the ISS may be provided by means outside the scope of this specification. Figure 15-4 provides an example. Each instance of such an implementation of the ISS shall support the MAC status and Point-to-point parameters. An M_UNITDATA.request at one of the Ports connected to such an instance of the ISS shall result in M_UNITDATA.indications with identical parameters at all other Ports connected to that instance.

For convenience of management, such instances of ISS provision are assigned the LAN MAC Type 802.1. Management parameters common to MACs of this type are specified in Clause 12.

NOTE—The ISS can also be supported at Bridge Ports wholly contained within a system by any IEEE 802 LAN technology, subject to the system requirements of the particular media access method.

6.15 Support of the ISS by additional technologies

The ISS may be supported by other technologies that provide either an IEEE 802 MAC Service or an emulated IEEE 802 MAC Service. The technology is responsible for invoking an M_UNITDATA.indication with appropriate parameters (IEEE Std 802.1AC) for each received frame, and transmitting a frame in response to each M_UNITDATA.request. The mac_service_data_unit parameter in an M_UNITDATA.indication may include a tag header of a type recognized by the functions using the EISS (6.8). If multiplexing of multiple virtual instances of the MAC Service is provided, each virtual service must be:

a) Identified by the VID field in a tag header of a type recognized by the functions using the EISS, or
b) Attached to separate instance of the ISS with no tag header in the mac_service_data_unit

(i.e., the only multiplexing recognized by the functions of the MAC Relay are those identified by a VID).

6.16 Filtering services in Bridged Networks

Bridges provide filtering services that support aspects of the maintenance of QoS—in particular, transit delay, priority, and throughput. In addition, these services provide a degree of administrative control over the propagation of particular MAC addresses in the network.

The services described are services in the most general sense; i.e., descriptions of functionality available to a MAC Service user or an administrator to control and access filtering capabilities. The descriptions make no assumptions about how the service might be realized. There are at least the following possibilities:

a) Use of existing protocols and mechanisms, defined in IEEE 802 standards and elsewhere.
b) Use of management functionality, either locally defined or via remote management protocols.
c) Other means, standardized or otherwise.

6.16.1 Purpose(s) of filtering service provision

Filtering services are provided for the purposes described in 6.16.1.1 and 6.16.1.2.

6.16.1.1 Administrative control

Filtering services provide administrative control over the use of particular source and destination addresses in designated parts of the network. Such control allows network managers and administrators to limit the extent of operation of network layer and other protocols that use individual and group MAC addresses by establishing administrative boundaries across which specific MAC addresses are not forwarded.

6.16.1.2 Throughput and end station load

Filtering services increase the overall throughput of the network, and reduce the load placed on end stations caused by the reception of frames that are destined for other end stations, by:

a) Limiting frames destined for specific MAC addresses to parts of the network that, to a high probability, lie along a path between the source MAC address and the destination MAC address.
b) Reducing the extent of group addressed frames to those parts of the network that contain end stations that are legitimate recipients of that traffic.
c) In Virtual Bridged Networks, reducing the extent of frames on specific VLANs to those parts of the network that contain stations that are legitimate recipients of traffic on that VLAN.

NOTE—Some aspects of the filtering services described in this standard are dependent upon the active participation of end stations. Where such participation is not possible, those aspects of the filtering services will be unavailable.

6.16.2 Goals of filtering service provision

The filtering services provided can be used to:

a) Allow the MAC Service provider to dynamically learn where the recipients of frames addressed to individual MAC addresses are located.
b) Allow end stations that are the potential recipients of MAC frames destined for group MAC addresses to dynamically indicate to the MAC Service provider which destination MAC address(es) they wish to receive.
c) Exercise administrative control over the extent of propagation of specific MAC addresses.

6.16.3 Users of filtering services

The filtering services provided are available to the following users:

a) Network management and administration, for the purposes of applying administrative control. Interactions between administrators of the network and the filtering service provider may be achieved by local means or by means of explicit management mechanisms.
b) End stations, for the purposes of controlling the destination addresses that they will receive. Interactions between end stations and the filtering service provider may be implicit, as is the case with the Learning Process (8.7), or by explicit use of filtering service primitives.

6.16.4 Basis of service

Filtering in Bridged Networks relies on the establishment of filtering rules, and subsequent filtering decisions, that are based on the value(s) contained in the Source MAC Address, Destination MAC Address, or VID fields in MAC frames.

NOTE—The filtering services defined by this standard use source address learning, destination address, and VID filtering.

6.16.5 Categories of service

Filtering services in Bridged Networks fall into the following categories:

a) *Basic Filtering Services.* These services are supported by the Forwarding Process (8.6) and by Static Filtering Entries (8.8.1), Static VLAN Registration Entries (8.8.2), Dynamic Filtering Entries (8.8.3), and Dynamic VLAN Registration Entries (8.8.5) in the FDB. The information contained in the Dynamic Filtering Entries is maintained through the operation of the Learning Process (8.7), while the information contained in the Dynamic VLAN Registration Entries is maintained through the operation of MVRP (11.2) and MIRP (Clause 39).

b) *Extended Filtering Services*. These services are supported by the Forwarding Process (8.6), and the Static Filtering Entries (8.8.1) and MAC Address Registration Entries (8.8.4) in the FDB. The information contained in the MAC Address Registration Entries is maintained through the operation of MMRP (10.9).

All Bridges shall support Basic Filtering Services and may support Extended Filtering Services.

6.16.6 Service configuration

In the absence of explicit information in the FDB, the behavior of the Forwarding Process with respect to the forwarding or filtering of frames destined for group MAC addresses depends upon the categories of service supported by the Bridge.

Basic Filtering Services support the filtering behavior required for regions of a Bridged Network in which potential recipients of multicast frames exist, but where either the recipients or the Bridges are unable to support the dynamic configuration of filtering information for those group MAC addresses, or the recipients have a requirement to receive all traffic destined for group MAC addresses.

Extended Filtering Services support the filtering behavior required for regions of a network in which potential recipients of multicast frames exist, and where both the potential recipients of frames and the Bridges are able to support dynamic configuration of filtering information for group MAC addresses. In order to integrate this extended filtering behavior with the needs of regions of the network that support only Basic Filtering Services, Bridges that support Extended Filtering Services can be statically and dynamically configured to modify their filtering behavior on a per-group MAC address basis, and also on the basis of the overall filtering service provided by each outbound Port with regard to multicast frames. The latter capability permits configuration of the Port’s default forwarding or filtering behavior with regard to group MAC addresses for which no specific static or dynamic filtering information has been configured.

Service configuration provides the ability to configure the overall filtering for the following cases:

a) Bridges that only implement Basic Filtering Services.

b) Bridges that support Extended Filtering Services in a heterogeneous environment, where some equipment is unable to participate in Dynamic Multicast Filtering, or where some equipment (e.g., routers) has specific needs to see unfiltered traffic.

c) Bridges that support Extended Filtering Services in a homogeneous environment, where all equipment is able to participate in Dynamic Multicast Filtering.

6.16.7 Service definition for Extended Filtering Services

The Filtering Services are described by means of service primitives that define particular types of interaction between MAC Service users and the MAC Service provider across the MAC Service boundary. As these interactions are not defined between peer entities, they are described simply in terms of service requests sent from the MAC Service user to the MAC Service provider.

6.16.7.1 Dynamic registration and deregistration services

These services allow MAC Service users dynamic control over the set of destination MAC addresses that they will receive from the MAC Service provider, by:

a) Registering/deregistering membership of specific Groups associated with those addresses.
b) Registering/deregistering individual MAC address information.
c) Registering/deregistering service requirements with regard to the overall forwarding/filtering behavior for Groups.

Provision of these services is achieved by means of MMRP and its associated procedures, as described in 10.9.

NOTE 1—These services can provide the MAC Service user with dynamic control over access to multicast data streams, for example, multiple video channels made available by a server using a different group MAC address for each channel. The ability to both register and deregister Group membership, coupled with the filtering action associated with the Group membership, limits the impact of such services on the bandwidth available in the network. These services can be used to control the reception of other categories of multicast traffic, for similar reasons.

REGISTER_MAC_ADDRESS (MAC_ADDRESS)

Indicates to the MAC Service provider that the MAC Service user wishes to receive frames containing the MAC address indicated in the MAC_ADDRESS parameter as the destination address. The MAC addresses that can be carried by this parameter do not include the following:

d) Any of the Reserved Addresses identified in Table 8-1, Table 8-2, or Table 8-3.
e) Any of the MRP Application addresses, as defined in Table 10-1.

DEREGISTER_MAC_ADDRESS (MAC_ADDRESS)

Indicates to the MAC Service provider that the MAC Service user no longer wishes to receive frames containing the MAC address indicated in the MAC_ADDRESS parameter as the destination address.

REGISTER_SERVICE_REQUIREMENT (REQUIREMENT_SPECIFICATION)

Indicates to the MAC Service provider that the MAC Service user has a requirement for any devices that support Extended Filtering Services to forward frames in the direction of the MAC Service user in accordance with the definition of the service requirement defined by the REQUIREMENT_SPECIFICATION parameter. The values that can be carried by this parameter are as follows:

f) Forward All Groups.
g) Forward Unregistered Groups.

DEREGISTER_SERVICE_REQUIREMENT (REQUIREMENT_SPECIFICATION)

Indicates to the MAC Service provider that the MAC Service user no longer has a requirement for any devices that support Extended Filtering Services to forward frames in the direction of the MAC Service user in accordance with the definition of the service requirement defined by the REQUIREMENT_SPECIFICATION parameter. The values that can be carried by this parameter are as follows:

h) Forward All Groups.
i) Forward Unregistered Groups.

The use of these services can result in the propagation of group MAC address and service requirement information across the spanning tree, affecting the contents of MAC Address Registration Entries (8.8.4) in

Bridges and end stations, and thereby affecting the frame forwarding behavior of the Bridges and end stations with regard to multicast frames.

NOTE 2—If the EISS is supported, the Extended Filtering Service primitives issued by the MAC Service user should also include a VID parameter in order to identify the VLAN associated with the MAC_ADDRESS or REQUIREMENT_SPECIFICATION specified.

6.17 EISS Multiplex Entity

The EISS Multiplex Entity enables shims defined for the ISS to use the EISS. Figure 6-6 illustrates two EISS Multiplex Entities placed back-to-back.

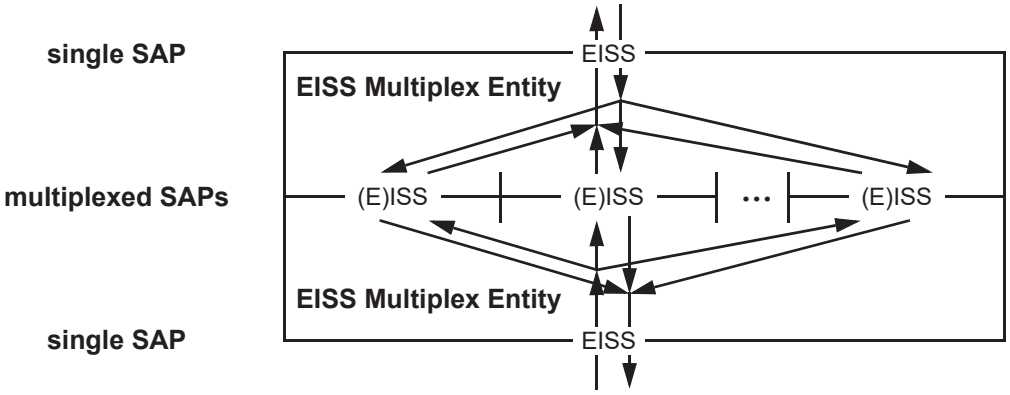


Figure 6-6—Two back-to-back EISS Multiplex Entities

An EISS Multiplex Entity has one EISS SAP, and a number of multiplexed SAPs, each either an ISS SAP or an EISS SAP. Each multiplexed ISS SAP is assigned to a single vlan_identifier value. Each multiplexed EISS SAP is assigned to one or more vlan_identifier values. Every vlan_identifier is assigned to some multiplexed SAP. Upon receiving a Request or Indication from its single EISS SAP, the EISS Multiplex Entity uses the vlan_identifier to select the corresponding one of its multiplexed SAPs to present the Request or Indication. Similarly, any Request or Indication received from a multiplexed SAP is presented to the single EISS SAP; the vlan_identifier parameter presented on the single EISS SAP is the one associated with the multiplexed ISS SAP, or the one obtained from the multiplexed EISS SAP.

Shims can be multiplexed in this fashion to separately serve multiple vlan_identifiers. Figure 22-1 illustrates CFM shims deployed in this manner.

The MAC_Operational status parameter (IEEE Std 802.1AC) presented to the uppermost EISS-SAP in Figure 6-6 is TRUE if and only if:

a) The uppermost EISS-SAP's MAC_Enabled parameter is TRUE; and
b) At least one of its multiplexed SAPs' MAC_Operational status parameters is TRUE.

The MAC_Operational status parameter of each of the lower EISS Multiplex Entity's multiplexed SAPs in Figure 6-6 is computed separately and is TRUE if and only if:

c) The lowermost EISS-SAP's MAC_Operational parameter is TRUE; and
d) That multiplexed SAP's MAC_Enabled parameter is TRUE.

6.18 Backbone Service Instance Multiplex Entity

The Backbone Service Instance Multiplex Entity allows shims defined for the ISS to be instantiated per backbone service instance at a SAP that supports multiple backbone service instances. Figure 6-7 illustrates two Backbone Service Instance Multiplex Entities placed back-to-back. A set of back-to-back Backbone Service Instance Multiplex Entities may be used at the ISS of a PIP or CBP to provide per Backbone Service Instance SAPs that support CFM shims at the Backbone Service Instance MD Level as shown in Figure 6-8 and the figures of 26.8.

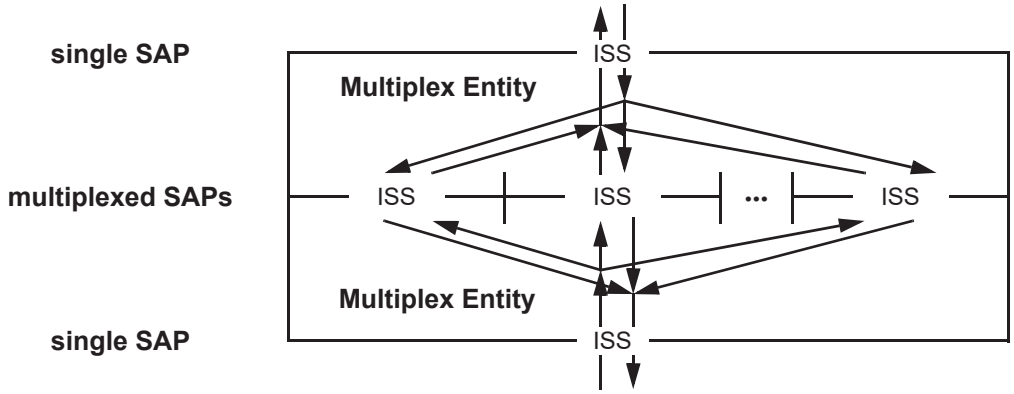


Figure 6-7—Two back-to-back Backbone Service Instance Multiplex Entities

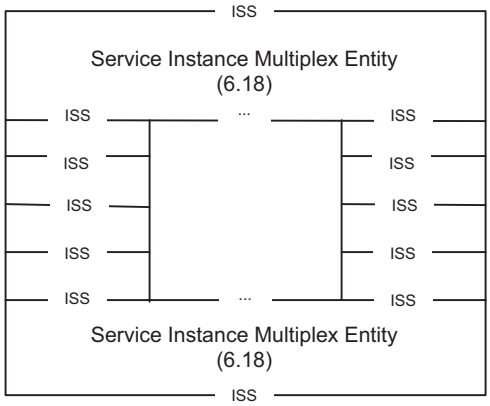


Figure 6-8—Backbone Service Instance Multiplex Entities with example CFM shims

NOTE 1—Figure 6-8 shows a representative placement of CFM shims between back-to-back Backbone Service Instance Multiplex Entities. This is not intended to imply any restriction that this is the only possible configuration of MEPs and MIPs.

A Backbone Service Instance Multiplex Entity has one ISS SAP that supports multiple backbone service instances, and a number of multiplexed ISS SAPs each supporting a single backbone service instance. Each multiplexed SAP has a single assigned I-SID value. Every I-SID value is assigned to a multiplexed SAP, and no I-SID value is assigned to more than one multiplexed SAP.

NOTE 2—There are implicitly 2^{24} multiplexed SAPs—one for each potential I-SID value. This does not require any implementation to support 2^{24} SAPs. The combined structure of back-to-back Backbone Service Instance Multiplex Entities is transparent to any frames with an I-SID value corresponding to a multiplexed SAP that does not have a protocol entity (e.g., CFM) instantiated at that SAP.

In the multiplexing direction, any Request or Indication received from a multiplexed SAP results in the generation of a corresponding Request or Indication to the single ISS SAP, with an I-TAG header added to the mac_service_data_unit as specified in 6.18.2. Similarly, in the demultiplexing direction any Request or Indication received from the single ISS SAP results in the generation of a corresponding Request or Indication at one of the multiplexed SAPs (determined by the I-SID contained in a I-TAG in the mac_service_data_unit), with the I-TAG removed from the mac_service_data_unit as specified in 6.18.1. When an I-TAG header with the UCA field containing a value of zero is removed, the C_DA and C_SA fields of the I-TAG remain in the mac_service_data_unit. In this case, a new EtherType field is prepended so the mac_service_data_unit still begins with a valid EtherType value. The Encapsulated Addresses EtherType value in Table 6-7 is allocated for this purpose.

Table 6-7—Encapsulated Addresses EtherType

Name	Value
IEEE 802.1Q Encapsulated Addresses EtherType	89-10

NOTE 3—This EtherType value is used only internally at the Backbone Service Multiplex Entity and does not appear in any frame on a LAN in the PBBN.

6.18.1 Demultiplexing direction

On receipt of an M_UNITDATA.request or M_UNITDATA.indication primitive from the single ISS SAP, the received frame shall be discarded if:

a) The initial octets of the mac_service_data_unit do not contain a valid I-TAG; or
b) The Res2 field in the I-TAG is not zero.

Otherwise, an M_UNITDATA.request or M_UNITDATA.indication primitive is invoked at the multiplexed ISS SAP corresponding to the I-SID value in the I-TAG. The parameter values are determined as follows:

The **connection_identifier** parameter contains the same value as in the received primitive.

The **destination_address** and **source_address** parameters are determined as follows:

c) If the UCA bit is zero, the **destination_address** and **source_address** parameters contain the respective values in the received primitive.
d) Otherwise, the **destination_address** and **source_address** parameters contain the respective values in the C-DA and C-SA fields of the I-TAG.

The value of the **drop_eligible** and **priority** parameters are decoded from the I-DEI and the I-PCP fields of the I-TAG header in the mac_service_data_unit as described in 6.18.3.

The value of the **mac_service_data_unit** parameter is constructed from the value of the received mac_service_data_unit modified as follows:

e) If the UCA field in the I-TAG is zero, then the I-PCP, I-DEI, UCA, Res1, Res2, and I-SID fields of the I-TAG are removed and the Backbone Service Instance Tag EtherType value is replaced with the Encapsulated Addresses EtherType value (Table 6-7).
f) Otherwise, the entire I-TAG is removed.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified as necessary to take into account changes to the frame.

6.18.2 Multiplexing direction

On receipt of an M_UNITDATA.request or M_UNITDATA.indication primitive from any of the multiplexed ISS SAPs, an M_UNITDATA.request or M_UNITDATA.indication primitive is invoked at the single ISS SAP. The parameter values are determined as follows:

The **source_address**, **priority**, **drop_eligible**, and **connection_identifier** parameters contain the same value as in the received primitive.

The **destination_address** parameter is determined as follows:

a) If the destination_address in the received primitive is a group address and the UCA bit is set, then the **destination_address** parameter contains the Backbone Service Instance Group address constructed from the I-SID corresponding to the multiplexed ISS SAP at which the primitive was received.
b) Otherwise the **destination_address** parameter contains the same value as in the received primitive.

The value of the **mac_service_data_unit** parameter is equal to the value of the received mac_service_data_unit modified as follows:

c) If the initial two octets of the mac_service_data_unit match the Encapsulated Addresses EtherType value, then these octets are replaced with the Backbone Service Instance Tag EtherType value, and the I-PCP, I-DEI, UCA, Res1, Res2, and I-SID fields of an I-TAG are inserted following this EtherType value. The UCA, Res1, and Res2 fields all contain a value of zero. The I-SID field contains the value of the I-SID corresponding to the multiplexed ISS SAP at which the primitive was received. The values of the I-PCP and I-DEI fields are encoded from the **drop_eligible** and **priority** parameters as specified in 6.18.3.
d) If the initial two octets of the mac_service_data_unit do not match the Encapsulated Addresses EtherType value, then a complete I-TAG is prepended to the mac_service_data_unit. The UCA field contains a value of one. The Res1 and Res2 fields contain a value of zero. The C-DA and C-SA fields contain the destination_address and source_address from the received primitive, respectively. The I-SID field contains the value of the I-SID corresponding to the multiplexed ISS SAP at which the primitive was received. The values of the I-PCP and I-DEI fields are encoded from the **drop_eligible** and **priority** parameters as specified in 6.18.3.

The value of the **frame_check_sequence** parameter is either unspecified or derived from the received FCS information modified as necessary to take into account changes to the frame.

6.18.3 Priority Code Point encoding

The encoding (and decoding) of the I-PCP and I-DEI fields from (to) the **priority** and **drop_eligible** parameters is accomplished using a Priority Code Point Encoding Table (and Priority Code Point Decoding Table) as described in 6.9.3.

6.18.4 Status parameters

The MAC_Operational status parameter (IEEE Std 802.1AC) presented to the uppermost single ISS SAP in Figure 6-7 is TRUE if and only if:

a) The uppermost single ISS SAP's MAC_Enabled parameter is TRUE; and
b) At least one of its multiplexed SAPs' MAC_Operational status parameters is TRUE.

The MAC_Operational status parameter of each of the multiplexed SAPs in Figure 6-7 is computed separately, and is TRUE if and only if:

c) The lowermost single ISS SAP's MAC_Operational parameter is TRUE; and
d) That multiplexed SAP's MAC_Enabled parameter is TRUE.

6.19 TESI Multiplex Entity

The TESI Multiplex Entity allows shims defined for PBB-TE to be instantiated per TESI at a SAP that supports multiple TESIs. Figure 6-9 illustrates two TESI Multiplex Entities, placed back-to-back. A set of back-to-back TESI Multiplex Entities may be used at the multiplexed (E)ISS SAPs that are associated with ESP-VIDs on a CBP to provide per TESI SAPs that support CFM shims for PBB-TE MAs as shown in Figure 26-8.

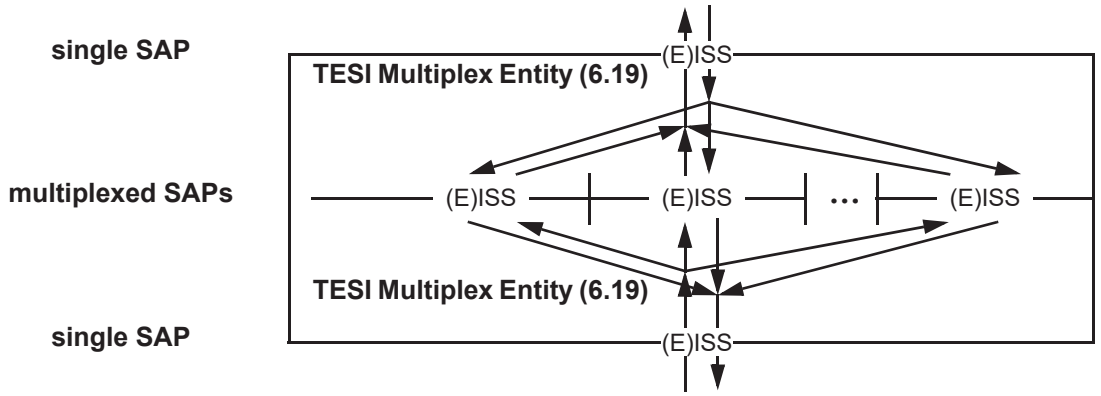


Figure 6-9—Two back-to-back Up and Down TESI Multiplex Entities

A TESI Multiplex Entity has one (E)ISS SAP that supports multiple TESIs, and a number of multiplexed (E)ISS SAPs each supporting a single TESI. Each multiplexed SAP has destination_address, source_address, and vlan_identifier combinations assigned by the TESI Multiplex Entity. Every destination_address, source_address, and vlan_identifier combination can be assigned to a multiplexed SAP, and no destination_address, source_address, and vlan_identifier combination is assigned to more than one multiplexed SAP.

Upon receiving a Request or Indication from its single (E)ISS SAP, the TESI Multiplex Entity uses the destination_address, source_address, and vlan_identifier to select the corresponding one of its multiplexed SAPs to present the Request or Indication. The Request or Indication presented at the multiplexed SAPs has the same parameters as the original Request or Indication at the Single SAP. Similarly, any Request or Indication received from a multiplexed SAP is transparently presented to the single (E)ISS SAP.

The MAC_Operational status parameter (6.8.2) presented to the uppermost single (E)ISS SAP in Figure 6-9 is TRUE if and only if:

a) The uppermost single (E)ISS SAP's MAC_Enabled parameter is TRUE; and
b) At least one of its multiplexed SAPs' MAC_Operational status parameters is TRUE.

The MAC_Operational status parameter of each of the multiplexed SAPs in Figure 6-9 is computed separately, and is TRUE if and only if:

c) The lowermost single (E)ISS SAP's MAC_Operational parameter is TRUE; and
d) That multiplexed SAP's MAC_Enabled parameter is TRUE.

The MAC_Operational parameter of the passive SAP on a PBB-TE MEP is set to FALSE when the PBB-TE MEP declares an errorCCMdefect (20.21.3) or an xconCCMdefect (20.23.3), setting the MAC_Operational parameter of the associated multiplexed SAP on the TESI Multiplex Entity to FALSE. The MAC_Operational parameter of the passive SAP on a PBB-TE MEP is set back to TRUE when both defects are cleared, setting back to TRUE the MAC_Operational parameter of the associated multiplexed SAP.

6.20 Support of the ISS with signaled priority

The functions specified in this subclause comprise a shim (3.234, IEEE Std 802.1AC) that uses an ISS SAP supported by a MAC entity (IEEE Std 802.1AC) to provide explicitly signaled priority information to an ISS SAP that supports a VLAN-unaware MAC Relay (Figure 6-10). Signaled priority information is derived from a VLAN tag header (9.3), if such header is present in the mac_service_data_unit. Any given instance of the ISS shall be supported by recognizing one but not both of the following VLAN Tag EtherTypes:

a) C-VLAN tag (C-TAG) or
b) S-VLAN tag (S-TAG)

The VLAN Tag EtherType is selected as specified in 9.5.

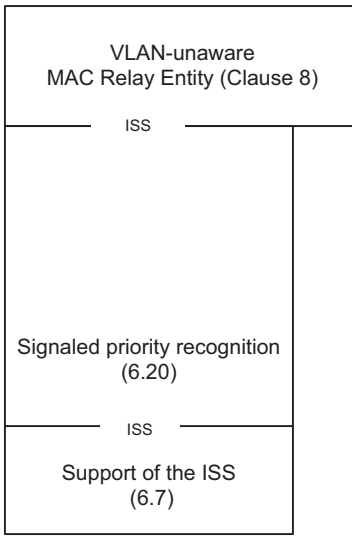


Figure 6-10—Supporting the ISS with signaled priority

6.20.1 Data indications

On receipt of an M_UNITDATA.indication primitive from the lower ISS SAP (Figure 6-10), an M_UNITDATA.indication primitive is invoked at the upper ISS SAP, with parameter values determined as follows:

The **destination_address, source_address, connection_identifier, mac_service_data_unit,** and **frame_check_sequence** parameters carry values equal to the corresponding parameters in the received data indication.

The value of the **drop_eligible** and **priority** parameters are determined as follows:

a) If the initial octets of the mac_service_data_unit contain a valid VLAN tag header (9.3) of the type used to support the EISS (9.5), the value of the drop_eligible parameter and the received priority value are decoded from the tag header as described in 6.9.3. Otherwise,
b) The received priority value and the drop_eligible parameter value are the values in the received data indication.
c) The value of the priority parameter is then regenerated from the received priority, as specified in 6.9.4.

6.20.2 Data requests

On receipt of an M_UNITDATA.request primitive from the upper ISS SAP (Figure 6-10), an M-UNITDATA.request primitive with identical parameter values is invoked at the lower ISS SAP.

6.21 Infrastructure Segment Multiplex Entity

The Infrastructure Segment Multiplex Entity allows shims defined for Segment Endpoint Ports (SEPs) and Segment Intermediate Ports (SIPs) to be instantiated per Infrastructure Segment at a SAP that supports multiple Infrastructure Segments. Figure 6-11 illustrates two Infrastructure Segment Multiplex Entities, placed back-to-back. A set of back-to-back Infrastructure Segment Multiplex Entities may be used at the multiplexed (E)ISS SAPs that are associated with SMP-VIDs on a PNP to provide per Infrastructure Segment SAPs that support CFM shims for Infrastructure Segment MAs as shown in Figure 26-10.

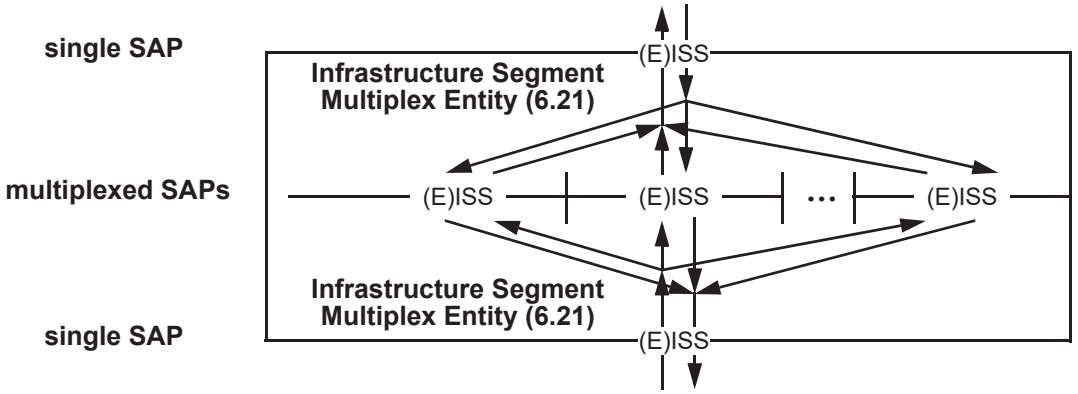


Figure 6-11—Two back-to-back Up and Down Infrastructure Segment Multiplex Entities

An Infrastructure Segment Multiplex Entity has one (E)ISS SAP that supports multiple Infrastructure Segment instances, and a number of multiplexed (E)ISS SAPs each supporting a single Infrastructure Segment instance. Each multiplexed SAP has destination_address, source_address, and vlan_identifier combinations assigned by the Infrastructure Segment Multiplex Entity. Every destination_address, source_address, and vlan_identifier combination can be assigned to a multiplexed SAP, and no destination_address, source_address, and vlan_identifier combination is assigned to more than one multiplexed SAP.

Upon receiving a Request or Indication from its single (E)ISS SAP, the Infrastructure Segment Multiplex Entity uses the destination_address, source_address, and vlan_identifier to select the corresponding one of its multiplexed SAPs to present the Request or Indication. The Request or Indication presented at the multiplexed SAPs has the same parameters as the original Request or Indication at the Single SAP. Similarly, any Request or Indication received from a multiplexed SAP is transparently presented to the single (E)ISS SAP.

The MAC_Operational status parameter (IEEE Std 802.1AC) presented to the uppermost single (E)ISS SAP in Figure 6-9 is TRUE if and only if:

a) The uppermost single (E) ISS SAP's MAC_Enabled parameter is TRUE; and
b) At least one of its multiplexed SAPs' MAC_Operational status parameters is TRUE.

The MAC_Operational status parameter of each of the multiplexed SAPs in Figure 6-9 is computed separately, and is TRUE if and only if:

c) The lowermost single (E)ISS SAP's MAC_Operational parameter is TRUE; and
d) That multiplexed SAP's MAC_Enabled parameter is TRUE.

The MAC_Operational parameter of the passive SAP on an Infrastructure Segment MEP is set to FALSE when the Infrastructure Segment MEP declares an errorCCMdefect (20.21.3) or an xconCCMdefect (20.23.3), setting the MAC_Operational parameter of the associated multiplexed SAP on the Infrastructure Segment Multiplex Entity to FALSE. The MAC_Operational parameter of the passive SAP on an Infrastructure Segment MEP is set back to TRUE when both defects are cleared, setting back to TRUE the MAC_Operational parameter of the associated multiplexed SAP.

6.22 PDU and protocol discrimination and media

As described more fully in Clause 9 of IEEE Std 802-2014 [B5], the format of the data parameter passed to or from a specific MAC procedure (see Figure 6-1 and 6.7) is identified using the first few octets of the MSDU, by either source and destination LLC addresses or a two-octet EtherType.

Length/Type networks have a Length/Type field in the first two octets of the MSDU (e.g., IEEE Std 802.3). Depending on the value of the Length/Type field (see IEEE Std 802.1AC), the Length/Type field is either an EtherType or is a Length followed immediately by the LSAPs and Control octets.

Networks that do not use a Length/Type field in the MSDU (e.g., some applications of IEEE Std 802.11) can implement a Media Access Method Dependent Convergence Function to perform any necessary translations from Length/Type-encoded protocol identifiers. See Clause 13 of IEEE Std 802.1AC-2016 [B8].

NOTE—The encoding of tagged frames is clarified in G.3.

7. Principles of Virtual Bridged Network operation

This clause establishes the principles and a model of Virtual Bridged Network operation. It defines the context necessary for:

a) The operation of individual VLAN Bridges (Clause 8);
b) Their participation in the Spanning Tree Algorithm and Protocol (STP) (Clause 8 of IEEE Std 802.1D, 1998 Edition [B11]), Rapid Spanning Tree Algorithm and Protocol (RSTP) (Clause 13), Multiple Spanning Tree Algorithm and Protocol (MSTP) (Clause 13), Shortest Path Bridging (SPB) (Clause 27), and Path Control and Reservation (PCR) (Clause 45) protocols;
c) The management of individual Bridges (Clause 12); and
d) The management of VLAN Topology (Clause 11)

to support, preserve, and maintain the quality of the MAC Service as discussed in Clause 6.

7.1 Network overview

The operation of a Virtual Bridged Network, the Bridges, and the LANs that compose that network comprises:

a) A physical topology comprising LANs, Bridges, and Bridge Ports. Each Bridge Port attaches a LAN to a Bridge and is capable of providing bidirectional connectivity for MAC user data frames. Each LAN is connected to every other LAN by a Bridge and zero or more other LANs and Bridges.
b) Calculation of one or more active topologies, each a loop-free subset of the physical topology.
c) Rules for the classification of MAC user data frames that allow each Bridge to allocate, directly or indirectly, each frame to one and only one active topology.
d) Management control of the connectivity provided for differently classified data frames by the selected active topology.
e) Implicit or explicit configuration of end station location information, identifying LANs with attached end stations that need to receive user data frames with a given destination address.
f) Communication of end station location information to allow Bridges to restrict user data frames to LANs in the path provided to their destination(s) by the chosen active topology.

These elements and their interrelationships are illustrated in Figure 7-1.

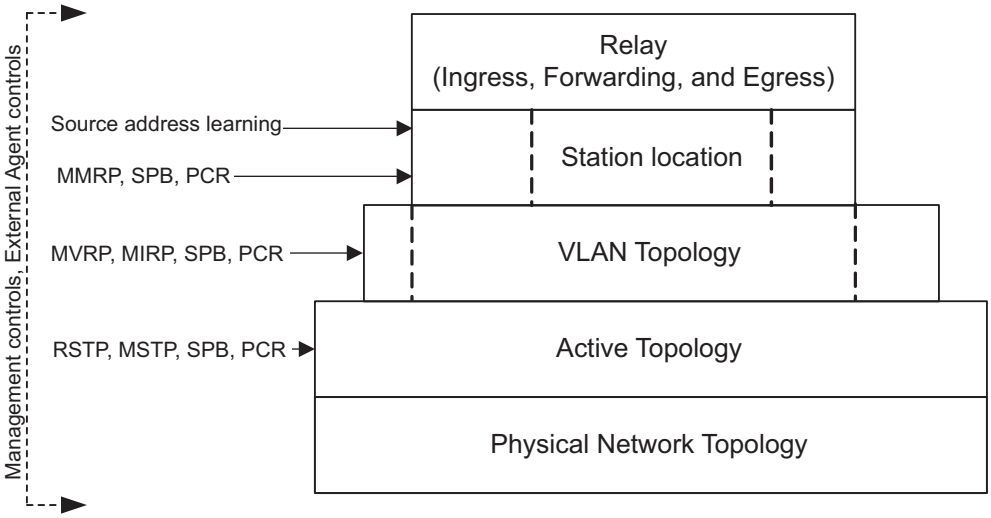


Figure 7-1—VLAN Bridging overview

NOTE 1—The physical and active topologies can be represented as bipartite graphs. Bridges and LANs are nodes in these graphs (including LANs that are point-to-point links) and the Bridge Ports are edges.

NOTE 2—This standard applies the notion of a physical topology to media access control methods, like wireless, where there is no tangible physical connection between a Bridge and an attached LAN. A Bridge Port models this association just as for wired connectivity.

NOTE 3—Each of the active topologies [see item b)] does not necessarily span the entire network, but does span all those Bridges and LANs between which data frame connectivity is desired for frames allocated to that active topology.

NOTE 4—The destination addressing information associated with a MAC user data frame includes the VLAN classification of the frame [see item d)].

NOTE 5—Implicit configuration [see item d)], or recognition, of end station location includes observation of the source address of the user data frame transmitted by that station. The user data frame communicates that location information [see item e)] along the portion of the chosen active topology leading to the frame's destination(s).

7.2 Use of VLANs

VLANs and their VIDs provide a convenient and consistent network-wide reference for VLAN Bridges to:

a) Identify rules for the classification of user data frames into VLANs.
b) Effectively extend the source and destination MAC addresses, by treating frames and addressing information for different VLANs independently.
c) Identify and select from different active topologies.
d) Identify configuration parameters that partition a physical network.

Taken together these capabilities allow VLAN Bridges to emulate a number of separately manageable, or virtual, Bridged Networks. A LAN that has been selected by network management to receive frames assigned to a given VLAN is said to form part of, belong to, or be a member of the VLAN. Similarly, end stations that are attached to those LANs and that can receive frames assigned to the VLAN are said to be attached to that VLAN.

NOTE—Separate control over the transmission and over the reception of frames to and from LANs and end stations is possible. To avoid ambiguity, VLAN membership is defined by reception.

Inclusion of the VID in VLAN-tagged frames guards against connectivity loops arising from differing classifications by different Bridges, and permits enhanced classification rules to be used by some Bridges, while others simply forward the previously classified frames.

The VLAN tag allows frames to carry priority information, even if the frame has not been classified as belonging to a particular VLAN.

7.3 Active topology

Bridges cooperate to calculate one or more loop-free and fully connected active topologies, i.e., spanning trees. The algorithms and protocols—RSTP (13.4), MSTP (13.5), SPB (Clause 27), PCR (Clause 45)—that support that calculation provide rapid recovery from network component failure (6.5.1) by using alternate physical connectivity, without requiring management intervention.

The Bridge's forwarding processes constrain the potential path for each user data frame to a single spanning tree. A Bridge that uses RSTP or STP allocates all frames to a single CST. An MST or SPT Region (13.8, 27.4.1) comprises the transitive closure of Bridges that use MSTP or SPB and that agree on the allocation of frames with a given VID to a given subtree within the region. That subtree can be an MSTI, a SPT, an Explicit Tree (ET), or the IST that is the logical continuation of the CST through the region. Interoperability

between MST and SPT Bridges and SST Bridges, and between differently configured MST/SPT Bridges, is achieved by allocating all frames to the CST at region boundaries. Thus the spanning tree for a given frame can comprise subtrees of the CST together with an MSTI or SPT within each region. Frames with different VIDs can be assigned to the same or to different trees and subtrees within a region.

NOTE—In a stable network, the MSTP and SPB algorithms verify that each MST/SPT Region is fully connected internally. However, if the CST Root lies outside the region, the region can be partitioned temporarily as necessary to prevent external connectivity between Bridge Ports at the region boundary from creating a loop. A given region of the network can be an MST Region, an SPT Region, or both, but the protocol mechanisms that verify connectivity internal to the region require that regions do not overlap or subset other regions.

7.4 VLAN topology

Typically each of the VIDs for frames assigned to the CST, and to the IST or an MSTI within an MST Region, supports a different VLAN, and each VLAN is supported by only one VID and only one subtree within the region. However, frames for VLANs supported by SPB are assigned to the SPT rooted at the Bridge where they enter an SPT Region, and SPBV requires that each source Bridge for a given VLAN uses a unique SPVID. To provide interoperability with other regions and end systems that support a VLAN with a single VID, the VIDs for SPBV VLANs are translated at the SPT Region boundary (6.9, 27.12). SPBM uses a single VID for all the SPTs for a given VLAN.

NOTE 1—Support of a network comprising a single SPT Region with directly attached VLAN-unaware or priority tagging end stations does not require VID translation. This includes, for example, a PBN or PBBN where the edge of the network corresponds with the boundary of the SPT Region.

Within a given region, the SPTs that support any given shortest path VLAN provide full and symmetric connectivity (6.3). To allow frames in different VLANs to make use of equal cost shortest paths, multiple SPT Sets can be used, each providing full symmetric connectivity between all Bridges in the region.

Each VLAN may occupy the full extent of the active topology of its associated spanning tree(s) or a continuously connected subset of that active topology. The connected subset must be continuously connected; otherwise, the VLAN is split. The maximum extent of the connected subset may be bounded by management by explicitly excluding certain Bridge Ports from a VLAN’s connectivity.

At any time the current extent of a VLAN can be further reduced from the maximum to include only those LANs that provide communication between attached devices, by the use of protocol that allows end stations to request and release services that use the VLAN. Such a protocol is specified in Clause 11. The dynamic determination of VLAN extent provides flexibility and bandwidth conservation, at the cost of network management complexity.

NOTE 2—Dynamic determination of VLAN extent is generally preferable to static configuration for bandwidth conservation, as the latter is error prone and can defeat potential alternate connectivity—requiring active management intervention to recover from network component failure.

NOTE 3—To accommodate end stations that do not participate in the MVRP specified in Clause 11, management controls associated with each Bridge Port allow the Port to identify the attached LAN as connecting end stations that require services using specified VLANs.

NOTE 4—Where a given VLAN is supported by multiple VIDs, as for SPB, management controls identify the VLAN by a Base VID (that used when frames are allocated to the CST). Use of this single VID reduces the configuration burden, particularly when Bridges are added to the SPT Region and further SPVIDs are allocated.

7.5 Locating end stations

Functioning as a distributed system, Bridges within the current extent of a VLAN can, through explicit and or implicit cooperation, locate those LANs where an attached end station or end stations are intended to receive frames addressed to a specified individual address or group address. Bridges can thus reduce traffic by confining frames to the LANs where their transmission is necessary.

NOTE 1—Individual Bridges do not determine the precise location of end stations but merely determine which of their Bridge Ports need to forward frames toward the destination(s). For the system of Bridges this is sufficient to restrict frames to the paths necessary to reach the destination LANs.

As specified in 13.6.2 of IEEE Std 802.1AC-2016 [B8], a Bridge with a Point-to-Multipoint Network port (PMPN, G.4.2, G.4.3) can detect when an attached PMPN node establishes or breaks a connection to another PMPN node.

The Multiple MAC Registration Protocol (MMRP), specified in Clause 10, allows end stations to advertise their presence and their desire to join (or leave) a multicast group, or to register an individual MAC address, in the context of a VLAN. The protocol communicates this information to other Bridges, using the VLAN and its active topology.

NOTE 2—To accommodate end stations that do not participate in MMRP, management controls associated with each Bridge Port allow the port to identify the attached LAN as connecting end stations that are intended to receive specified group addresses. The continuous operation of MMRP and the propagation of location information through Bridges using the current active topology for the VLAN support multicast traffic reduction, while ensuring rapid restoration of multicast connectivity without management intervention if alternate connectivity is selected following network component failure.

Each end station implicitly advertises its attachment to an individual LAN and its individual MAC address whenever it transmits a frame. Bridges learn from the source address as they forward the frame along the active topology to its destination or destinations — or throughout the Bridged Network or VLAN if the location of the destination or destinations is unknown. The learned information is stored in the FDB (8.8) and used to filter frames on the basis of their destination addresses.

Address information learned from a frame with a given VID can be used to filter frames with other VIDs. For example, information learned from a frame with any of the VIDs that support SPB for a given VLAN (i.e., VIDs associated with the same Base VID) is used to filter frames with any of the VIDs for that VLAN. In some network configurations, it is also necessary to use address information learned in any one of a set of VLANs to filter frames with VIDs that identify any VLAN in the set (Shared VLAN Learning (SVL), Clause 3). In other configurations it is necessary or desirable not to share learned information between certain VLANs (Independent VLAN Learning (IVL), Clause 3) while in some cases it is immaterial whether address information is shared between VLANs. Annex F discusses the network configuration requirements, and some of the related interoperability issues.

Clause 15 and Clause 16 describe how the mapping of C-VLANs into S-VLANs is accomplished within PBNs and PBBNs. These networks provide additional mapping facilities to support hierarchies of VLANs allowing a provider a separate FDB from customers. The conformance definitions of 5.3 have been extended to support S-VLANs. Clause 25 and Clause 26 describe how the mapping of S-VLANs into backbone service instances is accomplished within PBBNs.

7.6 Ingress, forwarding, and egress rules

The relay function provided by each Bridge controls the following:

a) Classification of each received frame as belonging to one and only one VLAN, and discard or acceptance of the frame for further processing on the basis of that classification and the received frame format, which can be one of three possible types:
   1) Untagged, and not explicitly identifying the frame as being associated with a particular VID.
   2) Priority-tagged, i.e., including a tag header conveying explicit priority information but not identifying the frames as being associated with a specific VID.
   3) VLAN-tagged, i.e., explicitly associating the frames with a particular VID.

   This aspect of relay implements the *ingress* rules.
b) Implementation of the decisions governing where each frame is to be forwarded as determined by the current extent of the VLAN topology (7.4), station location information (7.5), and the additional management controls specified in Clause 8. This aspect of relay implements the *forwarding* rules.
c) Queuing of frames for transmission through the selected Bridge Ports, management of the queued frames, selection of frames for transmission, and determination of the appropriate frame format type, VLAN-tagged or untagged. This aspect of relay implements the *egress* rules.

The structuring of the relay functionality into the implementation of ingress, forwarding, and egress rules constitutes a generic approach to the provision of VLAN functionality. All VLAN Bridges can correctly forward received frames that are already VLAN-tagged. These are classified as belonging to the VLAN identified by the VID in the tag header. All VLAN Bridges can also classify untagged and priority-tagged frames received on any given port as belonging to a specified VLAN. In addition to this default Port-based ingress classification, this standard specifies an optional Port-and-Protocol-based classification.

The classification of untagged and priority-tagged frames, and the addition or removal of tag headers, is performed in support of the EISS (6.9).

Frames that carry control information to determine the active topology and current extent of each VLAN, i.e., spanning tree or SPB and MVRPDUs, and frames from other link constrained protocols, such as EAPOL and LLDP, are not forwarded. Permanently configured static entries in the FDB (8.2, 8.3, and 8.12) ensure that such frames are discarded by the Forwarding Process (8.6).

NOTE—MRPDUs destined for any MRP application are forwarded or filtered depending on whether the application concerned is supported by the Bridge, as specified in 8.1.2.

The forwarding rules specified for VLAN-tagged frames facilitate the interoperation of VLAN Bridges conformant to this standard with end stations that directly support attachment of MAC Service users to VLANs by transmitting VLAN-tagged frames, and with Bridges that are capable of additional proprietary ingress classification methods.

Frames transmitted on a given LAN by a VLAN Bridge for a given VLAN shall be one of the following:

d) All untagged or
e) All VLAN-tagged with the same VID or
f) All VLAN-tagged, each with an SPVID allocated to the Base VID for that VLAN

8. Principles of Bridge operation

This clause:

a) Explains the principal elements of the operation of Bridges, and the operation of Bridge components within systems, and lists the supporting functions.
b) Establishes a Bridge architecture that governs the provision of these functions.
c) Provides a model of Bridge operation in terms of processes and entities that support the functions.
d) Details the addressing requirements in a bridged network.
e) Specifies the addressing of entities in a Bridge.

8.1 Bridge operation

The principal elements of Bridge operation are:

a) Relay and filtering of frames (8.1.1).
b) Maintenance of the information required to make frame filtering and relaying decisions (8.1.2).
c) Management of the above (Clause 12).

8.1.1 Relay

A Bridge relays individual MAC user data frames between the separate MACs of the individual LANs connected to its Ports. The functions that support relaying of frames and maintain the QoS are:

a) Frame reception (8.5).
b) Discard on received frame in error (6.5.2).
c) Discard of frames that do not carry user data (IEEE Std 802.1AC).
d) Priority and drop eligibility decoding from a VLAN tag, if present, and regeneration of priority, if required (6.9).
e) Assignment of a VID to each received frame (6.9).
f) Ensure that each frame is confined to an active topology (8.6.1).
g) Frame discard to support management control over the active topology of each VLAN (6.9, 8.6.2, 8.6.4).
h) Frame discard following the application of filtering information (8.6.3).
i) Metering of frames, potentially marking as drop eligible or discarding frames exceeding bandwidth limits (8.6.5).
j) Forwarding of received frames to other Bridge Ports (8.6.6).
k) Selection of traffic class and queuing of frames by traffic class (8.6.6).
l) Frame discard to ensure that a maximum Bridge transit delay is not exceeded (6.5.6, 8.6.7).
m) Preferential discard of drop eligible frames to preserve QoS for other frames (8.6.7).
n) Selection of queued frames for transmission (8.6.8).
o) Mapping of SDUs and FCS recalculation, if required (6.5.7).
p) Frame discard on transmittable SDU size exceeded (6.5.8).
q) Selection of outbound access priority (6.5.9).
r) Frame transmission (8.5).

A VLAN-unaware MAC Relay Entity is supported by the ISS, and not the EISS, and correspondingly the functions that support relaying of frames in a MAC Bridge cannot make use of any parameters explicit to EISS, like the VIDs. This means in particular that for a MAC Bridge, item e) in the list above is not supported, item d) and item g) would be supported in the form of:

s) Regeneration of priority, if required (6.9.4)
t) Frame discard to support management control over the physical topology of the network

and, every other item on the list is supported but without making any use of, or qualification upon, VIDs.

Figure 8-1 gives an example of the physical topology of a Bridged Network.

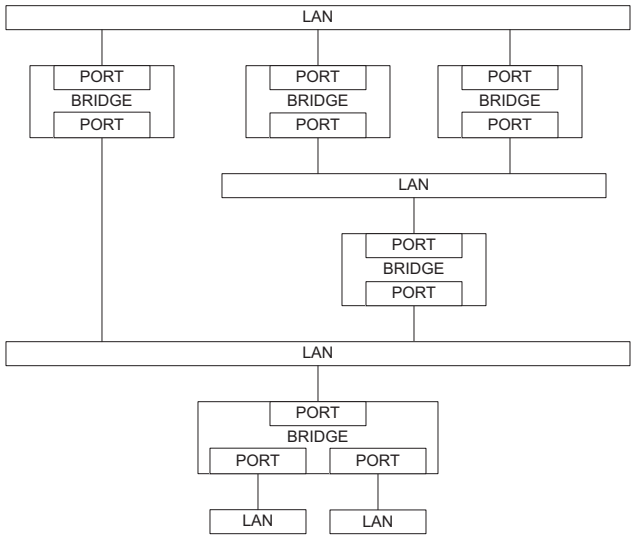


Figure 8-1—A Bridged Network

8.1.2 Filtering and relaying information

A Bridge maintains filtering and relaying information for the following purposes:

a) Duplicate frame prevention: to maintain a loop-free active topology for every frame
b) Traffic segregation: to separate communication by different sets of network users
c) Traffic reduction: to confine frames to the path(s) between their source and destination(s)
d) Traffic expediting: to classify frames in order to expedite time-critical traffic
e) Frame format conversion: to tag or untag as appropriate for the destination LAN and stations

8.1.3 Duplicate frame prevention

A Bridge filters frames, i.e., does not relay frames received by a Bridge Port to other Bridge Port on that Bridge, in order to prevent the duplication of frames (6.5.4). The functions that support the use and maintenance of information for this purpose are:

a) Configuration and calculation of one or more spanning tree active topologies.
b) In MST Bridges, explicit configuration to assign VIDs to MSTIs (8.9).
c) In SPT Bridges: explicit or default selection of shortest path, CIST, or MSTI support for specified VLANs; and automatic assignment of VIDs to SPTs for shortest path VLANs.

8.1.4 Traffic segregation

A VLAN Bridge can filter frames to confine them to LANs that belong to the VLAN to which they are assigned and, thus, define the VLAN's maximum extent (7.4). The functions that support the use and maintenance of information for this purpose are:

a) Configuration of a PVID for each Port, to associate a VID with untagged and priority-tagged received frames (6.9.1), and parameters for Protocol VLAN Classification (6.12) if implemented.

b) Configuration of Static VLAN Registration Entries (8.8.2).
c) Configuration of the Enable Ingress Filtering parameter to enable or disable application of Static VLAN Registration Entries to received frames.

A VLAN Bridge can filter frames to partially partition a Virtual Bridged Network. Frames assigned to any given VID and addressed to specific end stations or groups of end stations can be excluded from relay to certain Bridge Ports. The functions that support the use and maintenance of information for this purpose are:

d) Permanent configuration of Reserved Addresses (Table 8-1, Table 8-2, and Table 8-3).
e) Configuration of Static Filtering Entries (8.8.1) and MAC Address Registration Entries (8.8.4).

NOTE—The use of VLANs is generally less error prone and is preferred to filtering using destination addresses if a Bridged Network is to be partitioned for reasons of scale, efficiency, management, or security. Destination address filtering is the only mechanism available to MAC Bridges.

8.1.5 Traffic reduction

A Bridge can filter frames so that LANs not attaching to or forming part of the path between the source and the potential destination(s) of any given communication do not have to support the transmission of related frames, potentially improving the quality of the MAC Service for other communications. The functions that support the use and maintenance of information for this purpose are:

a) Automatic learning of dynamic filtering information for unicast destination addresses through observation of source addresses of frames.
b) Ageing out or flushing of dynamic filtering information that has been learned to support the movement of end stations and changes in active topology.
c) Automatic configuration of MAC Address Registration Entries by means of MMRP exchanges.
d) Explicit configuration of the management controls associated with the operation of MMRP by means of MAC Address Registration Entries.

A VLAN Bridge can also filter frames to confine them to LANs either that have end stations attached to their assigned VLAN or that connect those LANs and, thus, define the current practical extent of the VLAN (7.5).

e) Automatic inclusion and removal of Bridge Ports in the VLAN, through configuration of Dynamic VLAN Registration Entries by means of MVRP (8.8.5 and 11.2) or MIRP (Clause 39).
f) Explicit configuration of management controls associated with the operation of MVRP and MIRP by means of Static VLAN Registration Entries (8.8.2 and 11.2).

Item e) and item f) are only supported by VLAN Bridges, while all other items in the list above are supported by every Bridge.

8.1.6 Traffic expediting

A Bridge classifies frames into traffic classes in order to expedite transmission of frames generated by critical or time-sensitive services. The function that supports the use and maintenance of information for this purpose is:

a) Explicit configuration of traffic class information associated with the Ports of the Bridge.

8.1.7 Conversion of frame formats

A VLAN Bridge adds and removes tag headers (9.3) from frames and performs the associated frame translations that may be required. The function that supports the use and maintenance of information for this purpose is:

a) Explicit configuration of tagging requirements on transmission for each Port (8.8.2, 6.9.2).

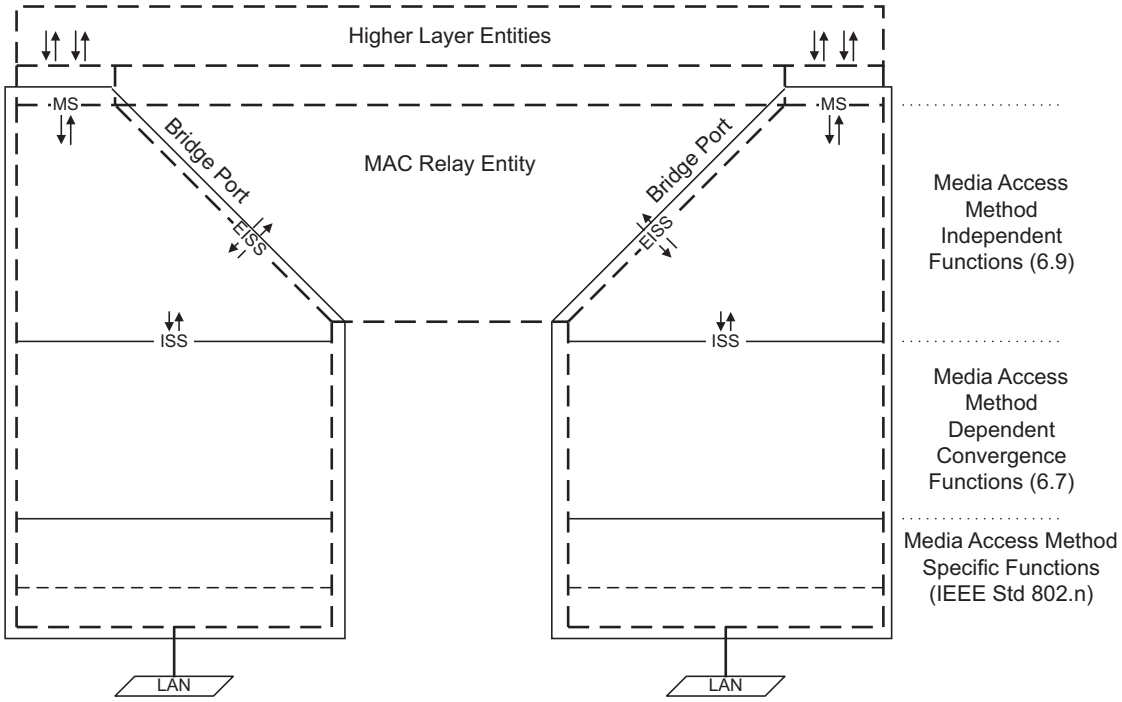
NOTE—As all incoming frames, including priority-tagged frames, are classified as belonging to a VLAN, the transmitting Port transmits VLAN-tagged frames or untagged frames. Hence, a station sending a priority-tagged frame via a Bridge will receive a response that is either VLAN-tagged or untagged, as described in 8.5.

8.2 Bridge architecture

A Bridge comprises at least one Bridge component. A Bridge component comprises the following:

a) A MAC Relay Entity that interconnects the Bridge's Ports
b) At least two Ports
c) Higher layer entities, including at least a Spanning Tree Protocol Entity

The VLAN Bridge architecture is illustrated in Figure 8-2. The MAC Relay Entity handles the media access method-independent functions of relaying frames among Bridge Ports, filtering frames, and learning filtering information. It uses the EISS (6.8, 6.9) provided by each Bridge Port.



NOTE—The notation "IEEE Std 802.n" in this figure indicates that the specifications for these functions can be found in the relevant standard for the media access method concerned; for example, n would be 3 (IEEE Std 802.3) in the case of Ethernet.

Figure 8-2—VLAN Bridge architecture

The MAC Bridge architecture is illustrated in Figure 8-3. The main difference with the VLAN Bridge architecture is that it does not use the EISS and the VLAN-unaware MAC relay entity is supported by the ISS.

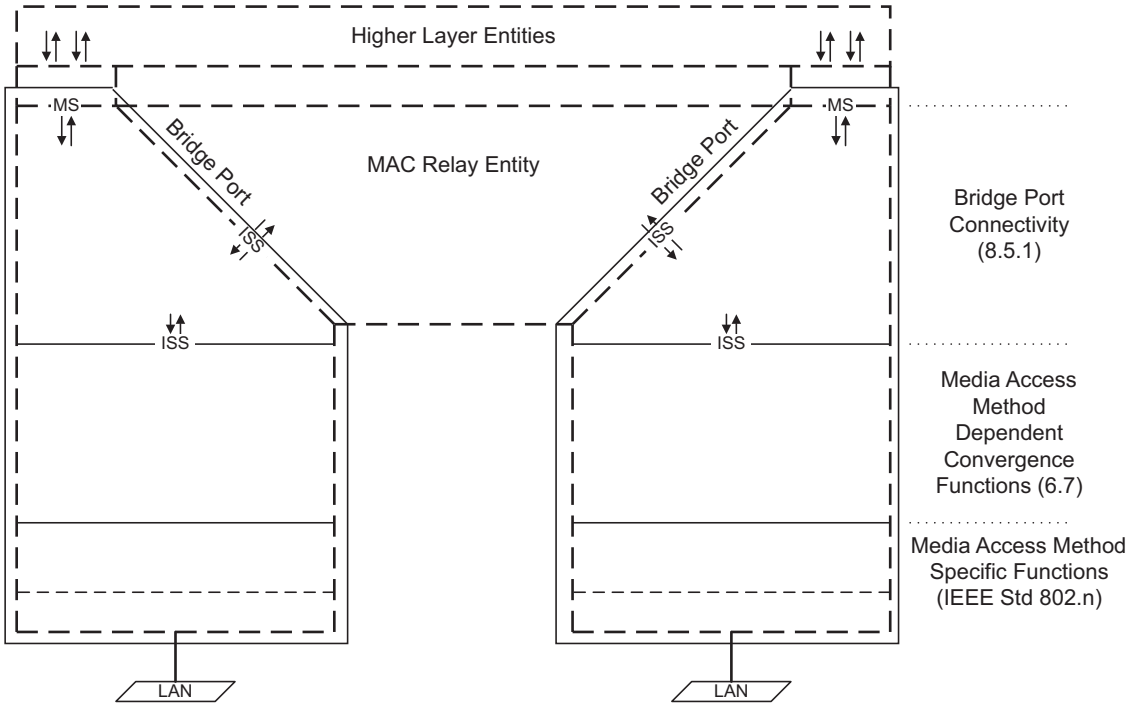


Figure 8-3—MAC Bridge architecture

Each Bridge Port also functions as an end station and shall provide the MAC Service to an LLC Entity that operates LLC Type 1 procedures to support protocol identification, multiplexing, and demultiplexing, for PDU transmission and reception by the Spanning Tree Protocol Entity and other higher layer entities. Other types of LLC procedures can also be supported for use by other protocols. The Bridge Port provides additional MSAPs if those are explicitly required by the specifications of the attached higher layer entities. Each instance of the MAC Service is provided to a distinct LLC Entity that supports protocol identification, multiplexing, and demultiplexing, for PDU transmission and reception by one or more higher layer entities.

NOTE—For simplicity of specification, this standard refers to a single LLC Entity that can provide both the procedures specified by ISO/IEC 8802-2 and EtherType protocol discrimination in the cases where the media access method for the attached LAN supports the latter.

If the Bridge Port can be directly attached to an IEEE 802 LAN, an instance of the MAC for that LAN type is permanently associated with the Port, handles the media access method-specific functions (MAC protocol and procedures), and provides an instance of the ISS as specified in IEEE Std 802.1AC to support frame transmission and reception by the other processes and entities that compose the Port.

Figure 8-2 illustrates a VLAN Bridge, and Figure 8-3 illustrates a MAC Bridge, with two Ports, each directly connected to a LAN.

8.3 Model of operation

The model of operation is simply a basis for describing the functionality of the Bridge. It is in no way intended to constrain real implementations of a Bridge; these may adopt any internal model of operation compatible with the externally visible behavior that this standard specifies. Conformance of equipment to this standard is purely in respect of observable protocol.

The processes and entities that model the operation of a Bridge Port include the following:

a) A Bridge Port Transmit and Receive Process (8.5) that:
   1) Receives and transmits frames from and to the attached LAN (8.5, 6.8, 6.9, IEEE Std 802.1AC).
   2) Can filter received frames if the VLAN tag is absent, or present, or conveys a null VID.
   3) Classifies received frames into VLANs, assigning each a VID value.
   4) Determines the format, VLAN-tagged or untagged, of transmitted frames.
   5) Delivers and accepts frames to and from the MAC Relay Entity and LLC Entities.

b) The LLC Entity or Entities that support Higher Layer Entities such as the following:
   1) Spanning Tree Protocol
   2) Multiple Registration Protocol (MRP)
   3) Bridge Management
   4) Linktrace response

c) Zero or more CFM entities, each of which can be one of the following:
   1) An MA Endpoint (MEP) or
   2) An MA Intermediate Point (MIP) or
   3) A Linktrace Output Multiplexer (LOM)

As Bridge Ports on MAC Bridges provide only the ISS, item a2), item a3), and item a4) in the list above are not supported by MAC Bridges.

d) The Forwarding Process (8.6) that:
   1) Enforces loop-free active topologies for all frames (8.1.3, 8.4, 8.6.1);
   2) Filters frames using their VID and destination MAC addresses (8.1.4, 8.6.2, 8.6.3, 8.6.4);
   3) Optionally, classifies and meters received frames that are to be relayed to other Bridge Ports (8.6.5);
   4) Forwards received frames that are to be relayed to other Bridge Ports (8.6.6, 8.6.7, 8.6.8).

e) The Learning Process (8.7) that observes the source addresses of frames received on each Port and updates the FDB (8.1.5, 8.4).

f) The FDB (8.8) that holds filtering information and supports queries by the Forwarding Process about whether frames with given values of VID and destination MAC address field can be forwarded to a given Port.

NOTE 1—The processes and entities that model the operation of the VLAN-unaware MAC Relays on MAC Bridges are the same as the ones described above but excluding any use or qualification based on VID values.

NOTE 2—In Figure 8-4, Figure 8-5, Figure 8-6, and Figure 8-7, the EISS is used by the VLAN-aware MAC Relay entities and the ISS is used by the VLAN-unaware MAC Relay entities.

Figure 8-4 illustrates a single instance of frame relay between the Ports of a Bridge with two Ports.

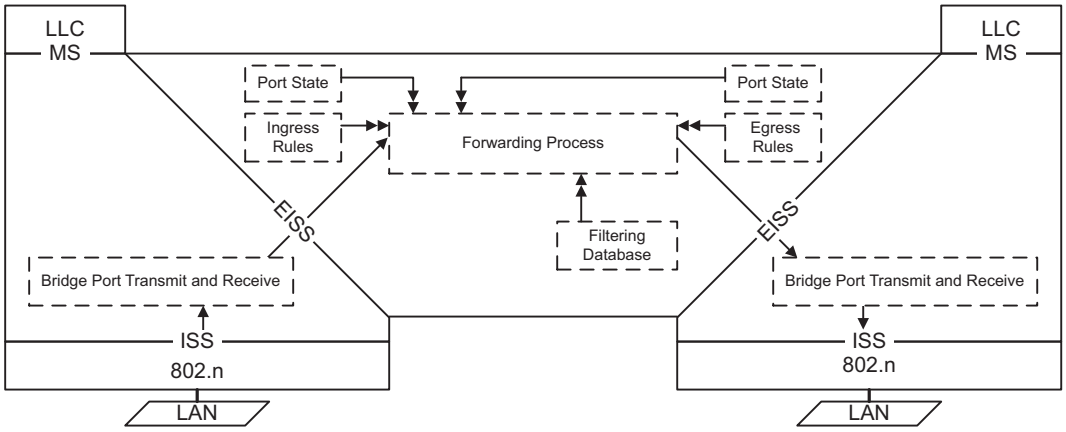


Figure 8-4—Relaying MAC frames

Figure 8-5 illustrates the inclusion of information carried by a single frame, received on one of the Ports of a Bridge with two Ports, in the FDB.

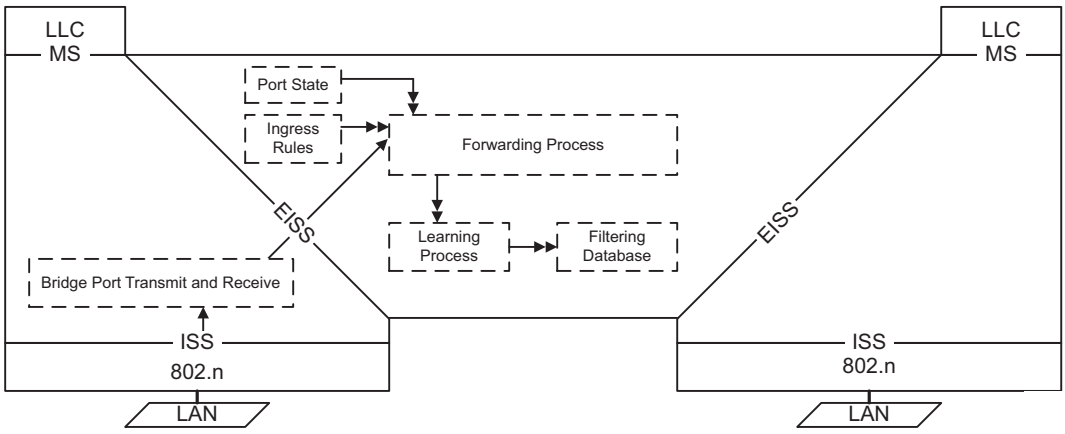


Figure 8-5—Observation of network traffic

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity.

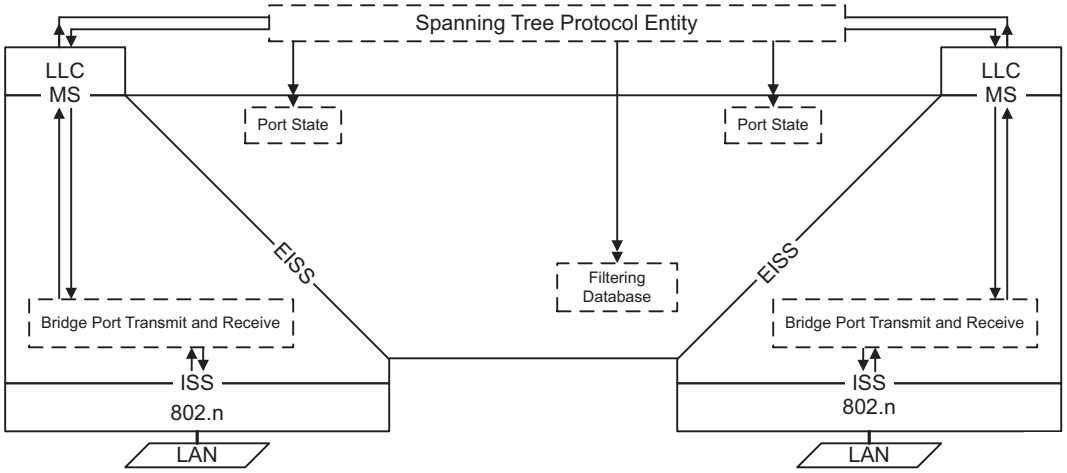


Figure 8-6—Operation of Spanning Tree Protocol Entity

Figure 8-7 illustrates the operation of the MRP Entity (8.11).

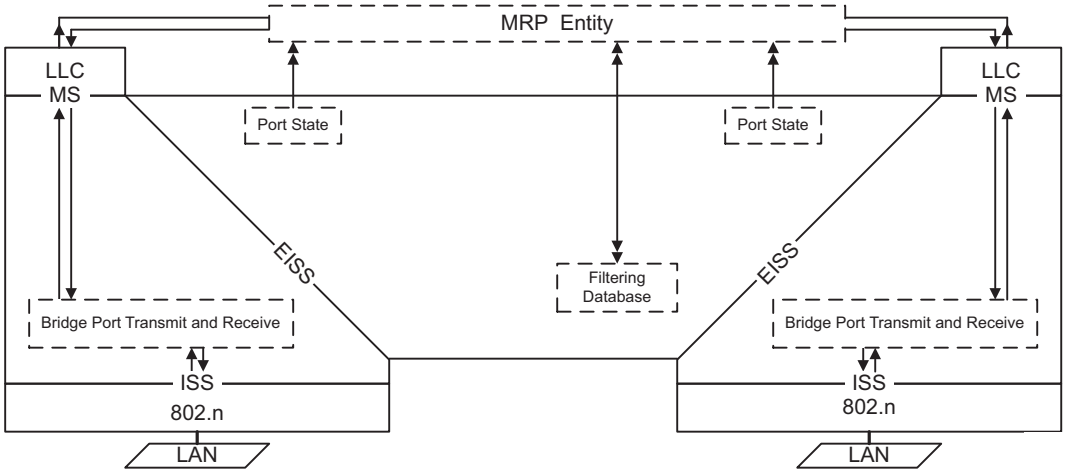


Figure 8-7—Operation of MRP

Higher Layer Entities that require only one point of attachment for the Bridge as a whole may attach to an LLC Entity that uses an instance of the MAC Service provided by a Management Port. A Management Port does not use an instance of the ISS to attach to a network but uses the Bridge Port Transmit and Receive Process and the MAC Relay Entity to provide connectivity to other Bridge Ports and the attached LANs.

NOTE 3—Management port functionality may also be provided by an end station connected to an IEEE 802 LAN that is wholly contained within the system that incorporates the Bridge. The absence of external connectivity to the LAN means that the management port is always forwarding.

Figure 8-8 illustrates the reception and transmission by an entity attached to a Management Port.

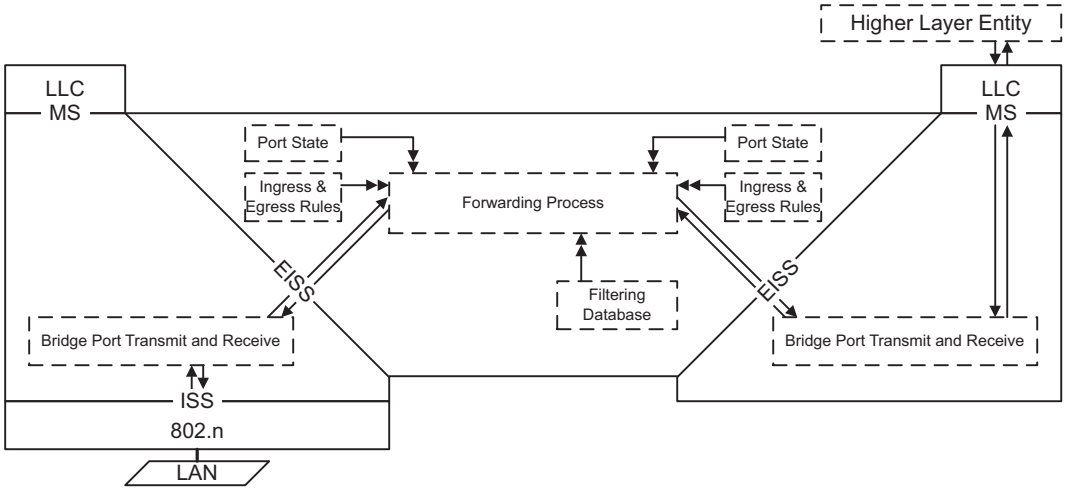


Figure 8-8—Management Port transmission and reception

Figure 8-9 illustrates the operation of the IPS Control entity. The IPS Control entity functions as an intermediary between the Bridge Management entity and the FDB for operations related to TESIs associated with an IPG. Infrastructure Segment MEPs associated with an IPG communicate the operational state of the associated Infrastructure Segment to the IPS control entity (26.11.3).

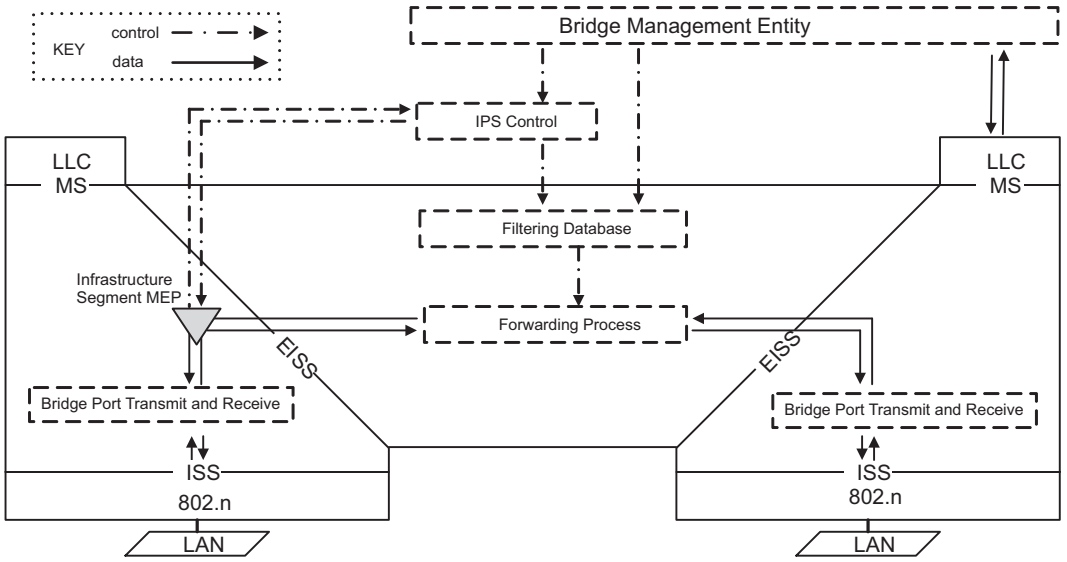


Figure 8-9—Infrastructure Segment MEP placement in a PNP

8.4 Active topologies, learning, and forwarding

An *active topology* is the connectivity provided, for frames with a specified set of VID, destination address, and source address values, by interconnecting the LANs and Bridges in a bridged network with *forwarding* Bridge Ports.

The distributed spanning tree algorithms and protocols, i.e., RSTP (Clause 13), MSTP (Clause 13), and ISIS-SPB (Clause 27), construct one or more active topologies, each simply and fully connected for frames being associated with any given VLAN and transmitted from any end station to any other. The *forwarding* and *learning* performed by each Bridge Port for each spanning tree is dynamically managed by RSTP, MSTP, or ISIS-SPB to prevent temporary loops and reduce excessive traffic in the network while minimizing denial of service following any change in the *physical topology* of the network.

PBB-TE enables construction of active topologies by the external agent that is responsible for setting up Ethernet Switched Paths (ESPs).

Any port that is not enabled, i.e., has MAC_Operational (IEEE Std 802.1AC) False or has been excluded from the active topology by management setting of the Administrative Bridge Port State to Disabled, has both forwarding and learning disabled for all spanning trees and ESPs.

If the Bridge Port is enabled, PBB-TE disables learning and enables forwarding for all frames allocated to each ESP-VID. An external agent manages the FDB to control the forwarding of frames with particular values of ESP-VID and destination MAC address.

The term Port State summarizes per-tree combinations of forwarding and learning, and any additional per-tree variables used by a given spanning tree protocol to enforce the active topologies it has calculated, and is used by RSTP and MSTP as follows. Any port that has learning and forwarding disabled is assigned the Port State *Discarding*. A Port that has learning enabled but forwarding disabled has the Port State *Learning*, and a Port that both learns and forwards frames has the Port State *Forwarding*. However, the RSTP and MSTP state machines (Clause 13) do not control the Port State directly but use independent forwarding and learning variables for each tree.

ISIS-SPB controls both forwarding and learning variables for each SPT and Bridge Port directly when used to support Shortest Path Bridging VID (SPBV, Clause 27) just like RSTP and MSTP. ISIS-SPB disables learning and sets forwarding to TRUE when supporting Shortest Path Bridging MAC (SPBM, Clause 27).

RSTP constructs a single spanning tree, the CST, and maintains a single Port State for each Bridge Port. SST Bridges allocate all frames to that single spanning tree irrespective of their VLAN classification or source and destination MAC addresses.

MSTP constructs multiple spanning trees, the CIST and additional MSTIs, and maintains a Port State for each spanning tree for each Port. An MST Bridge allocates all frames classified as belonging to a given VLAN to the CIST or to one of the MSTIs using the MST Configuration Table. An MSTID of 0 identifies the CIST. A reserved MSTID value (TE-MSTID) is used to identify VIDs for use by PBB-TE with ESPs. Further MSTID values are used to identify the use of SPBV or SPBM. A single VID is used to identify frames assigned to any given VLAN that is supported by the CIST or an MSTI. That VID is used by the Forwarding Process (8.6) to identify the spanning tree for the relayed frame, and thus identifies the applicable Port State.

ISIS-SPB constructs symmetric (Clause 3) SPTs rooted at each Bridge within an SPT Region, and maintains independent forwarding and learning variables for each SPT for each Bridge Port.

Each frame classified as belonging to a VLAN supported by SPBV, is allocated to an SPT rooted at the Bridge that first relays the frame into the Region. If a C-VLAN, S-VLAN, or B-VLAN is supported by

SPBV (Clause 27) the frame is assigned a Shortest Path VLAN Identifier (SPVID) that is used by the Forwarding Process (8.6) to identify both the VLAN and the SPT, and thus identifies the applicable learning and forwarding values.

If a B-VLAN is supported by SPBM, (Clause 27) the frame is assigned a B-VID value that identifies the frame as subject to SPBM and identifies the B-VLAN and the SPT Set (Clause 3). The SPT is identified (from among those in that set) by the source address of the frame (B-SA), which identifies the SPT root. When ISIS-SPB sets forwarding True for that SPT, a Dynamic Filtering Entry for that B-VID, source address tuple is included in the FDB so that it passes the active topology enforcement check (8.6.1). An individual destination address identifies the SPT that is rooted at that destination and belongs to the SPT Set identified by the VID. If relaxed ingress checking (45.3.1) is supported, then a MAC Address Registration Entry is included in the FDB for that VID, individual destination address tuple if there is any source whose path to the destination in that SPT is via the given Bridge. The Port Map of those MAC Address Registration entries comprises only the ports that are upstream for a given individual destination address (45.3.1). If a B-VLAN is supported by SPBM, learning is disabled for all frames for that B-VID.

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity, which operates the spanning tree algorithm and its related protocols, and its modification of Port state information as part of determining the active topology of the network.

Figure 8-4 illustrates the Forwarding Process's use of the Port State: first, for a Port receiving a frame, to determine whether the received frame is to be relayed through any other Ports; and second, for another Port in order to determine whether the relayed frame is to be forwarded through that particular Port.

Figure 8-5 illustrates the use of the Port state information for a Port receiving a frame, in order to determine whether the station location information is to be incorporated in the FDB.

8.5 Bridge Port Transmit and Receive

The Bridge Port Transmit and Receive process supports the attachment of the Bridge Port to a network. It comprises the following functions:

a) In a VLAN Bridge component, mapping between the EISS (6.8) provided to the MAC Relay Entity, and the ISS (IEEE Std 802.1AC), adding, recognizing, interpreting, and removing VLAN tags as specified in 6.9 and illustrated in Figure 8-10.
b) In a MAC Bridge component, an optional shim (IEEE Std 802.1AC) that uses and provides the ISS (IEEE Std 802.1AC), recognizing and interpreting VLAN tags as specified in 6.20 and illustrated in Figure 8-11.
c) Connectivity, as specified in 8.5.1 (for non-TPMR Bridges) or 8.5.2 (for TPMRs), between the following ISS access points:
    1) That provided by the MAC Entity for the LAN attached to the Port, as specified in IEEE Std 802.1AC.
    2) That supporting the MAC Relay Entity.
    3) One or more that support Higher Layer Entities attached to the Port (8.5.3).

A single Port for a Bridge, known as the Management Port, may support Higher Layer Entities without providing a point of attachment to a LAN (see Figure 8-8).

8.5.1 Bridge Port connectivity

Each M_UNITDATA.indication provided by the ISS access point for an attached LAN [(1) in Figure 8-10] shall result in a corresponding M_UNITDATA.indication with identical parameters at each of the access points supporting the MAC Relay and Higher Layer Entities [(2), (3a) and (3b)]. Each

M_UNITDATA.request from the ISS access point supporting the MAC Relay Entity shall result in a corresponding M_UNITDATA.indication with identical parameters at each of the access points for the Higher Layer Entities [(3a) and (3b)], and a corresponding M_UNITDATA.request with identical parameters at the access point for the LAN [(1)]. Each M_UNITDATA.request from an ISS access point supporting a Higher Layer Entity shall result in a corresponding M_UNITDATA.indication with identical parameters at the access points for the MAC Relay Entity, and at other access points for Higher Layer Entities, and a corresponding M_UNITDATA.request with identical parameters at the access point for the LAN.

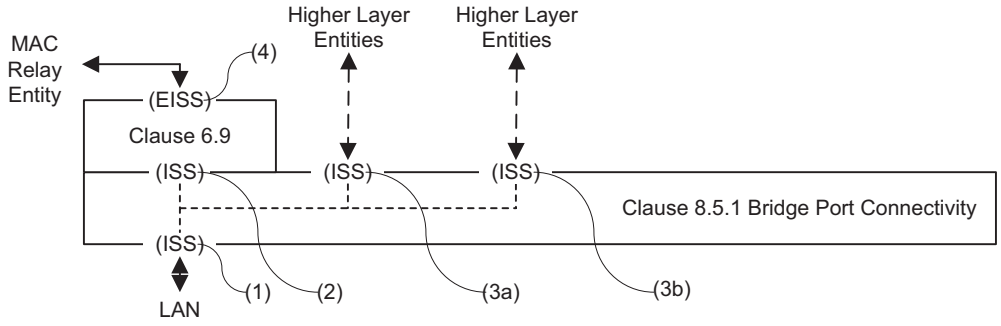


Figure 8-10—Bridge Port Transmit and Receive

NOTE—Figure 8-10 shows the relative position of the Bridge Port Transmit and Receive process and the VLAN tagging function (6.9) for a Customer Bridge or Provider Bridge that does not support CFM. For the relative positioning of these functions in a Bridge supporting CFM, see Figure 8-9. For the relative positioning of these functions in a BEB, see Figure 26-2.

The MAC_Enabled, MAC_Operational, and operPointToPointMAC status parameters for the ISS access point for the MAC Relay Entity and Higher Layer Entities [(2), (3a), and (3b) in Figure 8-10] shall take the same value as that for the LAN (1) if that is present, and shall be True otherwise (i.e., if the Port is a Management Port).

The consequence of the above connectivity is that frames relayed to a Bridge Port are both submitted to that Port's MAC Service users and transmitted on the attached LAN (see 8.13.9).

8.5.2 TPMR Port connectivity

Each M_UNITDATA.indication provided by the ISS access point for an attached LAN [(1) in Figure 8-11] shall result in a corresponding M_UNITDATA.indication with identical parameters at each of the access points supporting the MAC Relay and Higher Layer Entities [(2), (3a), and (3b)].

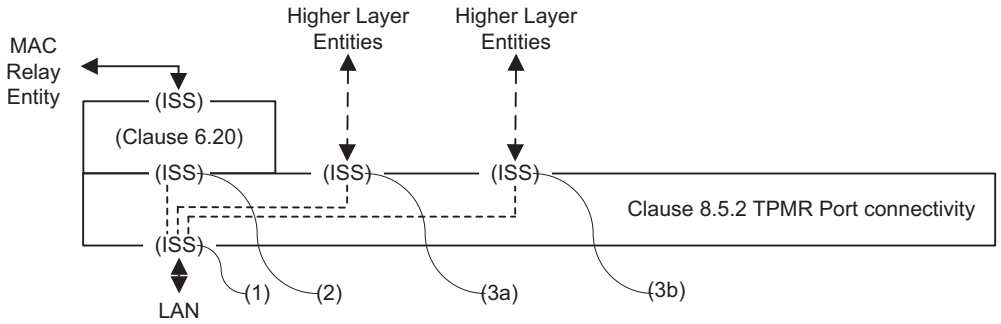


Figure 8-11—TPMR Port Transmit and Receive

Each M_UNITDATA.request from the ISS access point supporting the MAC Relay Entity (2) or a Higher Layer Entity [(3a) or (3b)] shall result in a corresponding M_UNITDATA.request with identical parameters at the access point for the LAN (1).

The MAC_Enabled, MAC_Operational, and operPointToPointMAC status parameters for the ISS access point for the MAC Relay Entity and Higher Layer Entities [(2), (3a), and (3b) in Figure 8-11] shall take the same value as for the LAN (1).

NOTE—These connectivity rules allow a higher layer entity to "listen" on both TPMR Ports to be able to determine the LAN on which a particular frame was received, and ensure that any frames sent by a higher layer entity are propagated only on the LAN associated with the Port on which the frame is transmitted. This differs from the propagation rules for other Bridges, where frames transmitted by a higher layer entity are also submitted to the forwarding process, and frames transmitted by the Forwarding Process on a given Port are received by any higher layer entity associated with that Port.

8.5.3 Support of Higher Layer Entities

The MAC Service is provided to a Higher Layer Entity using one of ISS access points provided for that purpose by the Bridge Port Connectivity function (8.5.1) or the TPMR Port Connectivity function (8.5.2).

Each ISS M_UNITDATA.indication with a destination MAC address that is either the individual address of an MSAP provided by the Bridge Port or a group address used by the attached LLC Entity shall cause an MA_UNITDATA.indication at that MSAP with destination address, source address, MSDU, and priority parameters identical to those in the M_UNITDATA.indication. No other indications or frames give rise to indications to the MAC Service user.

Each MA_UNITDATA.request at the MSAP shall result in an M_UNITDATA.request at the ISS access point with identical destination address, source address, MSDU, and priority parameters.

NOTE 1—Appropriate selection of the PVID for a Management Port facilitates attachment of an Internet Protocol (IP) stack supporting an SNMP Management Agent to any selected VID relayed by the Bridge. This function is not supported in Bridges that do not support the EISS, such as TPMRs.

NOTE 2—Higher Layer Entities attached to a Bridge Port can use the VLAN tag of received frames to achieve VLAN-awareness.

8.6 The Forwarding Process

Each frame submitted to the MAC Relay Entity shall be forwarded subject to the constituent functions of the Forwarding Process (Figure 8-12). Each function is described in terms of the action taken for a given frame received on a given Port (termed "the reception Port"). The frame can be forwarded for transmission on some Ports (termed "transmission Ports") and discarded without being transmitted at the other Ports.

NOTE 1—IEEE Std 802.1Q, 2003 Edition, included frame formatting and FCS recalculation functions within the Forwarding Process. This standard now places those functions below the EISS interface, to allow the specification of additional methods for Bridge Port support of the EISS.

NOTE 2—IEEE Std 802.1D-2004 [B12], included priority mapping functions within the Forwarding Process. This standard now places this function below the ISS interface.

NOTE 3—The Forwarding Process models the MAC relay function and does not take into consideration what may occur once frames are passed to the Bridge Port for transmission. Conformant implementations of some media access methods can vary the transmission order in apparent violation of the transmission selection rules when observing frames on the medium. It may therefore not be possible to test conformance to this standard for some implementations simply by relating observed LAN traffic to the functionality of the forwarding process; tests also have to allow for the (conformant) behavior of the MAC.

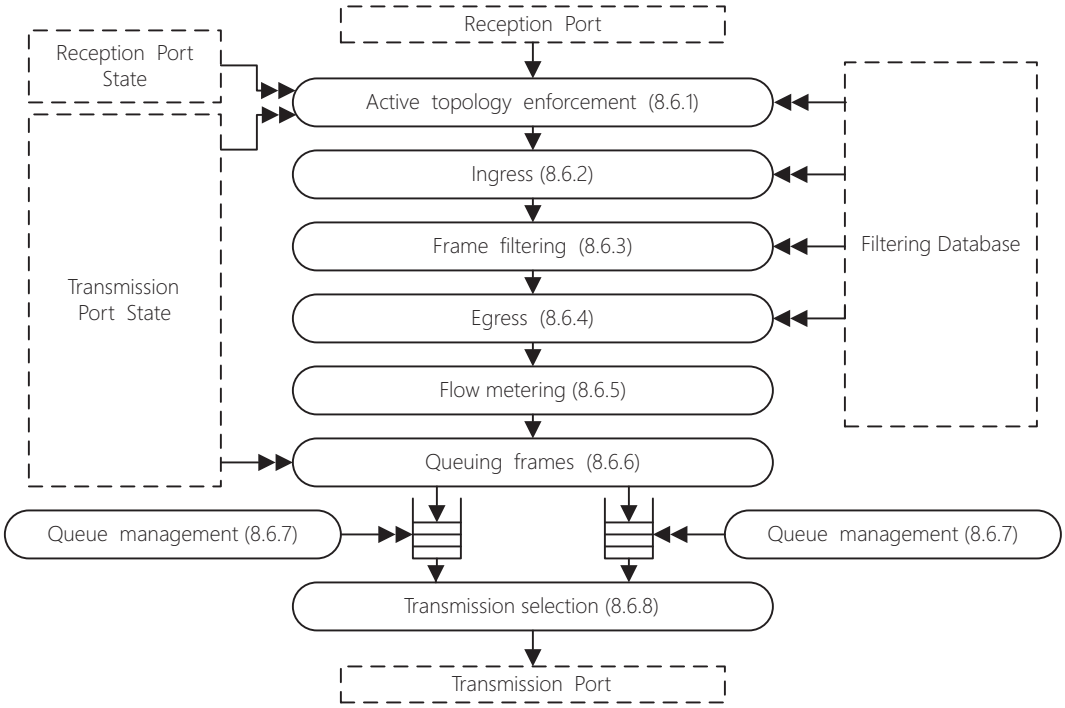


Figure 8-12—Forwarding process functions

Figure 8-4 illustrates the operation of the Forwarding Process in a single instance of frame relay between the Ports of a Bridge with two Ports.

8.6.1 Active topology enforcement

To prevent data loops and unwanted learning of source MAC addresses, the Forwarding Process determines the values (TRUE or FALSE) of the learning and forwarding controls (8.4) appropriate to each received frame and Bridge Port. If learning is TRUE for the reception Port and ingress filtering (8.6.2) would not cause the received frame to be discarded, the source address and VID are submitted to the Learning Process.

NOTE 1—VIDs are not applicable to MAC Bridges and only the source address is submitted to the Learning Process.

If forwarding is TRUE for the reception Port, and either the EVBMode parameter value (40.4) for the Port is not “EVB Bridge” or the value of the operReflectiveRelayControl parameter for the Port is FALSE, each Bridge Port, other than the reception Port, with forwarding TRUE is identified as a potential transmission Port. If forwarding is TRUE for the receiving Port and the EVBMode parameter value (40.4) for the Port is “EVB Bridge” and the operReflectiveRelayControl parameter value for the Port is TRUE, each Bridge Port, including the reception Port, with forwarding TRUE is identified as a potential transmission Port.

In an edge relay (ER), the forwarding process may set learning FALSE for all frames.

An SST Bridge supports a single active topology, the CST. For each Bridge Port, RSTP determines a single value for forwarding and a single value for learning (8.4) for all frames.

Bridges with MST, PBB-TE, or SPB capabilities use the VID of the received frame to determine forwarding and learning for that frame for each Bridge Port that is enabled, i.e., has MAC_Operational True and an Administrative Bridge Port State of Enabled, as follows:

If the Bridge supports PBB-TE, and the VID is an ESP-VID, forwarding is TRUE and learning is FALSE. Control over the active topology of each ESP is provided by configuration of Static Filtering Entries in the FDB (8.8.1, 25.10.1).

If the Bridge uses MSTP to configure the CIST, and the VID identifies a VLAN assigned to the CIST, forwarding and learning are as determined by MSTP (Clause 13) for the CIST.

If the Bridge uses MSTP to configure MSTIs, and the VID identifies a VLAN assigned to an MSTI calculated by MSTP, forwarding and learning are as determined by MSTP for that MSTI.

If the Bridge uses ISIS-SPB to configure the CIST, and the VID identifies a VLAN assigned to the CIST, forwarding and learning take the value of forwarding determined by ISIS-SPB (Clause 28) for the CIST.

If the Bridge uses ISIS-SPB, and the VID is used by SPBV as an SPVID, both forwarding and learning take the value of forwarding determined by ISIS-SPB for the SPT identified by that SPVID.

If the Bridge uses ISIS-SPB and the VID identifies a VLAN supported by SPBM, then for that VID:

— Learning is False for all Bridge Ports.
— Forwarding is True for the reception Port if and only if a Dynamic Filtering Entry for the frame's source address exists and specifies Forward for that Port or a MAC Address Registration Entry for the frame's individual destination address exists and specifies Forward for that Port.
— Forwarding is True for all other Bridge Ports.

NOTE 2—Effective control over the egress component of an SPT for VLANs supported by SPBM is provided by ISIS-SPB configuration of (a) a Dynamic Filtering Entry for the VLAN's VID and Root MAC address (for unicast frames); and (b) MAC Address Registration Entries for the VID- and SPT-specific group MAC addresses (for multicast frames); and (c) a MAC Address Registration Entry for the VID to filter "All Unregistered Group Addresses" at all Ports.

All Bridges other than SST Bridges implement the MST Configuration Table (8.9.1). The use of VIDs to determine learning and forwarding, as required by this clause, shall be consistent with that table as follows. VIDs allocated by the MST Configuration Table (8.9.1) of value:

— CIST-MSTID (0x000) are CIST VIDs.
— SPBM-MSTID (0xFFC) are Base VIDs supported by SPBM.
— SPBV-MSTID (0xFFD) are Base VIDs supported by SPBV.
— TE-MSTID (0xFFE) are ESP-VIDs supported by PBB-TE.
— SPVID-Pool-MSTID (0xFFF) are VIDs reserved for use by ISIS-SPB as SPVIDs.
— All VIDs allocated to other values of MSTID are assigned to the MSTI identified by that MSTID.

NOTE 3—While the MST Configuration Table is capable of detailing the configuration of each SPVID, it captures the allocation of Base VIDs only. Individual allocation of SPVIDs are captured in the ISIS-SPB database, the SPB ECT Static Entry (12.25.4), and in the port VID translation tables. By specifying only the type of VID and its allocation to SPB, backwards compatibility with STP, RSTP, and MSTP is maintained.

8.6.1.1 Requirements for the use of reflective relay

VEPA ERs (8.6.3.1) used in EVB (Clause 40) require reflective relay (40.4, 8.6.1) to be enabled on an attached EVB Bridge SBP in order to ensure that all VSIs connected to the VEPA ER are able to receive frames transmitted on one of the other VSIs. The following requirements ensure that a device operates correctly when using reflective relay:

a) The operation of the device shall be such that it prevents the establishment of loops, i.e., the device shall not both request and provide reflective relay on the same port.
b) The device shall ensure that any frame that it transmits on a given port, and that is reflected back to the device through the attached Bridge Port, is filtered by the device in order to prevent it being delivered to the originating port.

c) Any device requesting reflective relay is responsible for performing frame replication as necessary for delivery to multiple ports.

NOTE—Information that can be used to assist in meeting these requirements is the source MAC address and the FID derived from the VID.

8.6.2 Ingress filtering

Each Port may support an Enable Ingress Filtering parameter. A frame received on a Port that is not in the member set (8.8.10) associated with the frame's VID shall be discarded if this parameter is set. The default value for this parameter is reset, i.e., Disable Ingress Filtering, for all Ports. Any Port that supports setting this parameter shall also support resetting it. The parameter may be configured by the management operations defined in Clause 12.

This function is not applicable to VLAN-unaware MAC Relays.

8.6.3 Frame filtering

The Forwarding Process takes filtering decisions, i.e., reduces the set of potential transmission Ports (8.6.1), for each received frame on the basis of:

a) Destination MAC address
b) VID
c) Flow hash
d) The information contained in the FDB for that MAC address and VID
e) The default Group filtering behavior for the potential transmission Port (8.8.6)

in accordance with the definition of the FDB entry types (8.8.1, 8.8.3, and 8.8.4). The required behavior is summarized in 8.8.6, 8.8.9, Table 8-10, Table 8-11, and Table 8-12. Item b), specifying a VID value, is not applicable to VLAN-unaware MAC Relays. Flow hash is applicable only on Bridges supporting flow filtering (44.2).

Each of the reserved MAC addresses specified in Table 8-1 shall be permanently configured in the FDB in C-VLAN components and ERs. Each of the reserved MAC addresses specified in Table 8-2 shall be permanently configured in the FDB in S-VLAN components. Each of the reserved MAC addresses specified in Table 8-3 shall be permanently configured in the FDB in TPMR components. The FDB entries for reserved MAC addresses shall specify filtering for all Bridge Ports and all VIDs. Management shall not provide the capability to modify or remove entries for reserved MAC addresses.

The addresses in Table 8-1, Table 8-2, and Table 8-3 determine the scope of propagation of PDUs within a Bridged Network, as follows:

f) The ***Nearest Bridge*** group address is an address that no conformant TPMR component, S-VLAN component, C-VLAN component, or MAC Bridge can forward. PDUs transmitted using this destination address, or any of the other addresses that appear in all three tables, can therefore travel no further than those stations that can be reached via a single individual LAN from the originating station. Hence the Nearest Bridge group address is also known as the Individual LAN Scope group address.
g) The ***Nearest non-TPMR*** Bridge group address is an address that no conformant S-VLAN component, C-VLAN component, or MAC Bridge can forward; however, this address is relayed by a TPMR component. PDUs using this destination address, or any of the other addresses that appear in both Table 8-1 and Table 8-2 but not in Table 8-3, will be relayed by any TPMRs but will propagate no further than the nearest S-VLAN component, C-VLAN component, or MAC Bridge.
h) The ***Nearest Customer Bridge*** group address is an address that no conformant C-VLAN component or MAC Bridge can forward; however, it is relayed by TPMR components and S-VLAN components. PDUs using this destination address, or any of the other addresses that appear

in Table 8-1 but not in either Table 8-2 or Table 8-3, will be relayed by TPMR components and S-VLAN components but will propagate no further than the nearest C-VLAN component or MAC Bridge.

Table 8-1—C-VLAN and MAC Bridge component Reserved addresses

Assignment	Value
Bridge Group Address, Nearest Customer Bridge group address[a]	01-80-C2-00-00-00
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-01
IEEE 802.3 Slow_Protocols_Multicast address	01-80-C2-00-00-02
Nearest non-TPMR Bridge group address	01-80-C2-00-00-03
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-04
Reserved for future standardization	01-80-C2-00-00-05
Reserved for future standardization	01-80-C2-00-00-06
MEF Forum ELMI protocol group address[b]	01-80-C2-00-00-07
Provider Bridge Group Address	01-80-C2-00-00-08
Reserved for future standardization	01-80-C2-00-00-09
Reserved for future standardization	01-80-C2-00-00-0A
EDE-SS PEP Address (IEEE Std 802.1AE)	01-80-C2-00-00-0B
Reserved for future standardization	01-80-C2-00-00-0C
Provider Bridge MVRP Address	01-80-C2-00-00-0D
Individual LAN Scope group address[c], Nearest Bridge group address	01-80-C2-00-00-0E
Reserved for future standardization	01-80-C2-00-00-0F

[a] As stated in 13.41, in a Provider Edge Bridge, a C-VLAN component supporting a single service instance (i.e., with a single PEP) may forward (not filter) frames with the Nearest Customer Bridge Address as the destination address.
[b] This address is not exclusively reserved for this purpose; other uses are reserved for future standardization.
[c] It is intended that no IEEE 802.1 relay device will be defined that will forward frames that carry this destination address.

NOTE 1—The reserved MAC addresses specified in Table 8-1, Table 8-2, and Table 8-3 determine the span of connectivity for the protocol frames using the address; they do not identify the protocol. The protocols are identified by the EtherType field following the address fields.

NOTE 2—An instance of IEEE 802.1AX™ Link Aggregation Control Protocol (LACP) intended to operate between non-TPMR Bridges, even through a TPMR, can use the Nearest non-TPMR Bridge group address. See K.2 for discussion of the use of TPMRs in a link using LACP.

Table 8-2—S-VLAN component Reserved addresses

Assignment	Value
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-01
IEEE 802.3 Slow_Protocols_Multicast address	01-80-C2-00-00-02
Nearest non-TPMR Bridge group address	01-80-C2-00-00-03
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-04
Reserved for future standardization	01-80-C2-00-00-05
Reserved for future standardization	01-80-C2-00-00-06
MEF Forum ELMI protocol group address[a]	01-80-C2-00-00-07
Provider Bridge Group Address[b]	01-80-C2-00-00-08
Reserved for future standardization	01-80-C2-00-00-09
Reserved for future standardization	01-80-C2-00-00-0A
Individual LAN Scope group address[c], Nearest Bridge group address	01-80-C2-00-00-0E

[a] This address is not exclusively reserved for this purpose; other uses are reserved for future standardization.
[b] It is intended that no IEEE 802.1 protocol or device will be defined that will require the inclusion of this address in the FDB to prevent or restrict its use for communication between a port of a Provider Bridge's S-VLAN component and the S-VLAN component of the nearest Provider Bridge.
[c] It is intended that no IEEE 802.1 relay device will be defined that will forward frames that carry this destination address.

Table 8-3—TPMR component Reserved addresses

Assignment	Value
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-01
IEEE 802.3 Slow_Protocols_Multicast address	01-80-C2-00-00-02
IEEE MAC-specific Control Protocols group address	01-80-C2-00-00-04
Individual LAN Scope group address[a], Nearest Bridge group address	01-80-C2-00-00-0E

[a] It is intended that no IEEE 802.1 relay device will be defined that will forward frames that carry this destination address.

8.6.3.1 Virtual edge port aggregator (VEPA) filtering

A VEPA ER filters frames as follows.

If the receiving port is a DRP, then the URP shall be selected as the only transmission Port.

If the receiving port is a URP, then in addition to the filtering specified in 8.6.3, if there is a filtering entry that specifies forwarding for the source MAC address and VLAN of the frame for any DRP, then that DRP shall be removed from the list of potential transmission Ports.

8.6.4 Egress filtering

This function is not applicable to VLAN-unaware MAC Relays.

Any Port that is not in the member set (8.8.10) for the frame's VID is removed from the set of potential egress Ports.

8.6.5 Flow classification and metering

The Forwarding Process can apply flow classification and metering to frames that are received on a Bridge Port and have one or more potential transmission ports. Bridge Ports and end stations may support Per-Stream Filtering and Policing (PSFP), Asynchronous Traffic Shaping (ATS) filtering and eligibility time assignment, or the general flow classification rules specified in 8.6.5.1.

NOTE—The general flow classification and metering specification was added to this standard by IEEE Std 802.1Q-2005, PSFP by IEEE Std 802.1Qci-2017, and ATS by IEEE Std 802.1Qcr-2020.

PSFP and ATS share common per-stream classification and metering elements, as shown in Figure 8-13. The stream identification function specified in IEEE Std 802.1CB can be used to associate received frames with these elements.

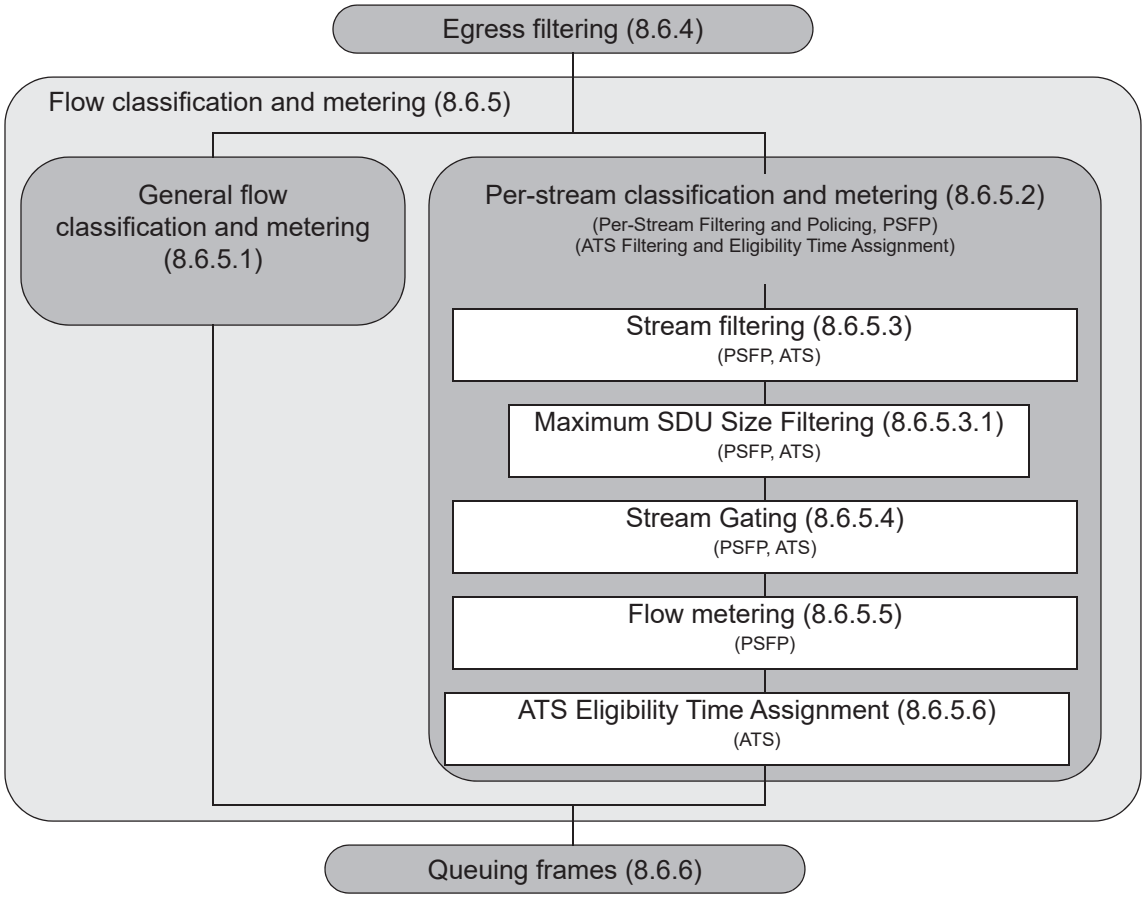


Figure 8-13—Flow classification and metering

8.6.5.1 General flow classification and metering

Bridges that implement general flow classification and metering can identify subsets of traffic (frames), each subject to the same flow metering and forwarding. Flow classification rules may be based on the following:

a) Destination MAC address
b) Source MAC address
c) VID
d) Priority

Item c), specifying a VID value, is not applicable to VLAN-unaware MAC Relays.

Frames classified using the same set of classification rules are subject to the same flow meter. The flow meter can change the drop_eligible parameter associated with each frame and can discard frames on the basis of the following parameters for each received frame and previously received frames, and the time elapsed since those frames were received:

e) The received value of the drop_eligible parameter
f) The mac_service_data_unit size

The flow meter shall not base its decision on the parameters of frames received on other Bridge Ports, or on any other parameters of those Ports. The bandwidth profile algorithm described in the MEF Forum Technical Specification 10.3 (MEF 10.3) should be used.

NOTE 1—The flow meter described here can encompass a number of meters, each with a simpler specification. However, given the breadth of implementation choice permitted, further structuring to specify, for example, that frames can bypass a meter or are subject only to one of a number of meters provides no additional information.

NOTE 2—Although flow metering is applied after egress (Figure 8-12), the meter(s) operate per reception Port, not per potential transmission Port(s).

8.6.5.2 Per-stream classification and metering

When Per-Stream Filtering and Policing (PSFP) or Asynchronous Traffic Shaping (ATS) is used, filtering and policing decisions for received frames are made, and subsequent queuing (8.6.6) and transmission selection decisions (8.6.8) supported, as follows:

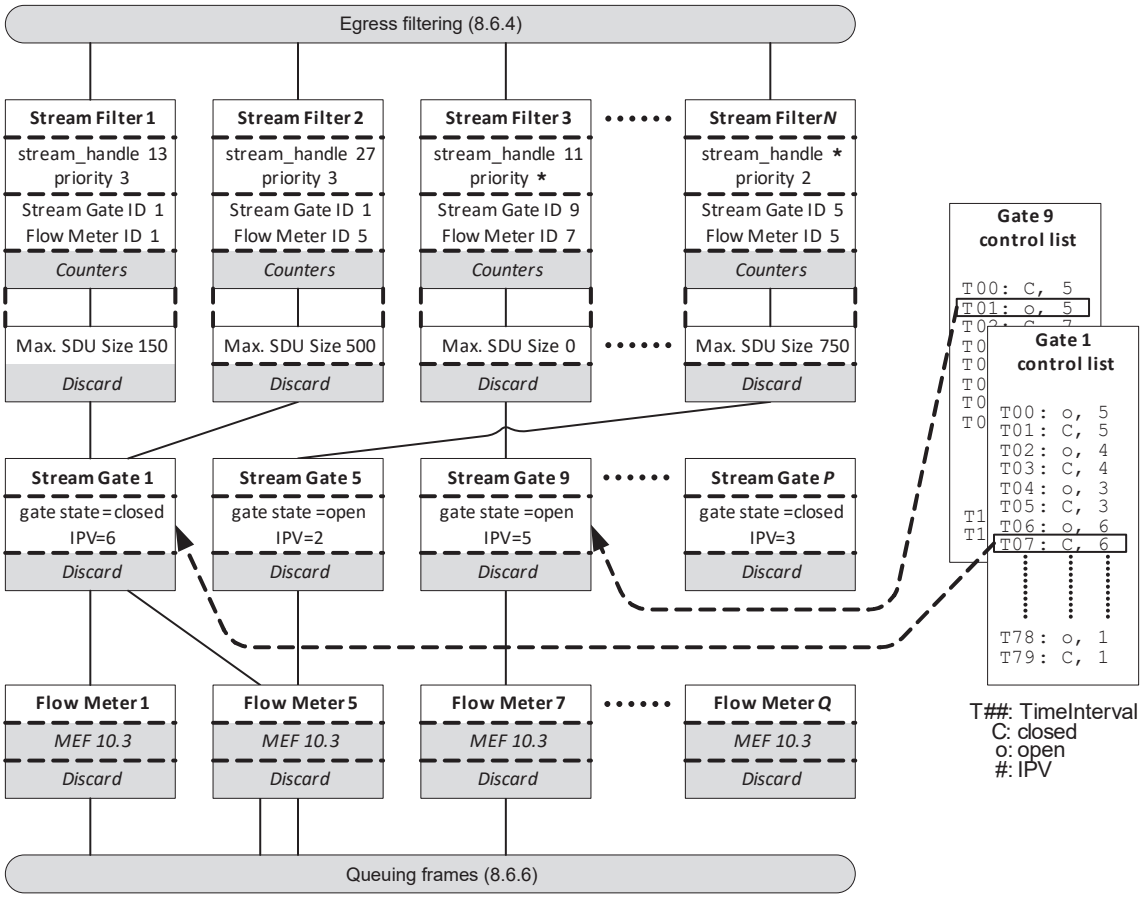
a) Each received frame can be associated with a stream filter, as specified in 8.6.5.3. If a matching stream filter is specified (8.6.5.3), that is used to process the frame. Wildcard stream filters can be configured to match and discard frames not associated with a specified stream. If no matching stream filter is found, the frame is queued for transmission as specified in 8.6.6.
b) If the stream filter specifies maximum SDU size filtering (8.6.5.3.1), that is used to process the frame. The frame can be discarded if a maximum SDU size is exceed. The ATS scheduler state machine operation (8.6.11) assumes that the sizes of frames that it processes are less than or equal to the associated CommittedBurstSize parameter (8.6.11.3.5).
c) The stream filter specifies a stream gate (8.6.5.4), that is used to process the frame. The frame can be discarded if it is received outside of permitted reception intervals or a given data limit within a reception interval is exceeded. The frame's priority can be mapped to an internal priority value (IPV) that can influence subsequent queuing decisions (8.6.6).
d) If the stream filter specifies a flow meter (8.6.5.5), that is used to process the frame. The frame can be discarded or marked as drop eligible if a traffic limit of a flow meter is exceeded. A given stream filter can be configured with flow meters and an ATS scheduler if both PSFP and ATS are supported.
e) If the stream filter specifies an ATS scheduler (8.6.5.6), that is used to process the frame. It computes an eligibility time for the frame for subsequent use by the ATS transmission selection algorithm (8.6.8.5). The frame can be discarded if a maximum eligibility time is exceeded (8.6.11.3.13).

8.6.5.2.1 PSFP support

Each Bridge component or end station that implements PSFP shall support stream filtering, maximum SDU size filtering, stream gating, and flow metering, with the following:

a) A single *Stream Filter Instance Table* (8.6.5.3).
b) A single *Stream Gate Instance Table* (8.6.5.4).
c) A single *Flow Meter Instance Table* (8.6.5.5).

The relationship between stream filters, stream gates, flow meters for streams subject to PSFP processing (as identified by the stream filter) is illustrated by Figure 8-14 for a number of streams.



KEY
Counters: Matching, passing, and discarded frame counters (8.6.5.3).
Discard: Frame discarding abilities and parameters (8.6.5.3.1, 8.6.5.4, 8.6.5.5).
MEF 10.3: Flow metering based on MEF 10.3 Bandwidth Profile parameters and algorithm as specified in 8.6.5.5.

Figure 8-14—Per-stream classification for PSFP

8.6.5.2.2 ATS support

Each Bridge component that implements ATS shall support stream filtering, maximum SDU size filtering, stream gates supporting IPV assignment, ATS schedulers, and ATS scheduler groups, with the following:

a) A single *Stream Filter Instance Table* (8.6.5.3).
b) A single *Stream Gate Instance Table* (8.6.5.4).
   If the Bridge component does not support PSFP in addition to ATS, each stream gate only supports IPV assignment (8.6.5.4). IPV can be used as part of adjusting per-hop delay bounds to meet specific networks' end-to-end delay requirements.
c) A single *ATS Scheduler Instance Table* (8.6.5.6).
d) A single *ATS Scheduler Group Instance Table* (8.6.5.6).
e) An *ATS Port Parameter Table* for each Bridge Port (8.6.5.6).

NOTE 1—The operation of ATS schedulers (8.6.11) provides policing capabilities similar to those provided by flow meters (8.6.5.5). This handling of improper traffic can be sufficient, such that no additional flow meters are required.

NOTE 2—For bridges with support for ATS, and without support for PSFP, stream gates of ATS traffic will never close. In this case, stream gates are only used for IPV assignment.

NOTE 3—In presence of state changes of stream gates associated with ATS traffic, the asynchronous nature of ATS traffic can require that state changes of multiple of these associated gates are executed simultaneously.

The relationship between stream filters, stream gates, and ATS schedulers for streams subject to ATS processing is illustrated by Figure 8-15.

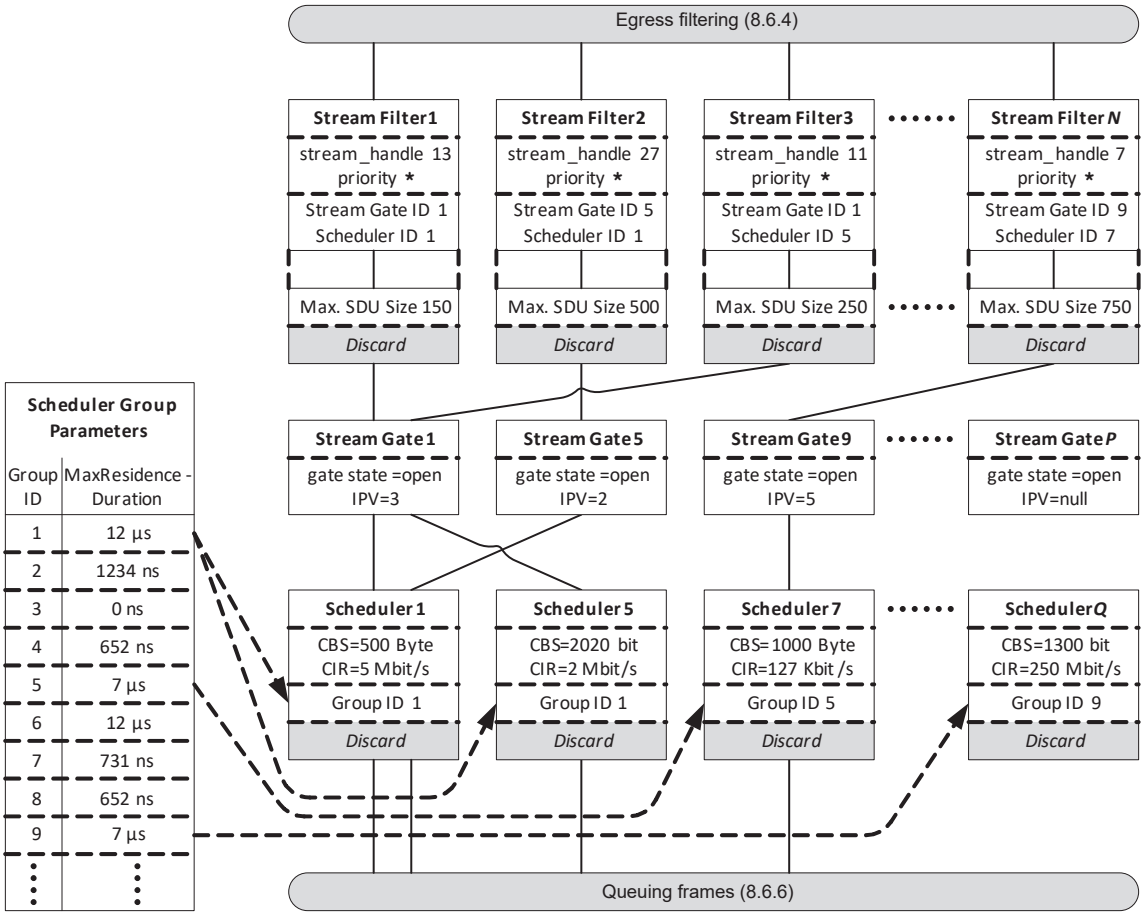
ATS support in end stations is provided by a modified variant of per-stream classification and metering for ATS, as specified in 47.1.

8.6.5.3 Stream filtering

A received frame can be associated with a stream filter using the frame's *stream_handle* and *priority* parameters. The *stream_handle* is a sub-parameter of the connection_identifier parameter of the ISS (6.6), provided by the stream identification function specified in IEEE Std 802.1CB.

Each stream filter comprises the following:

a) An integer *stream filter identifier*.
b) A *stream_handle* specification, either:
   1) A single value, as specified in IEEE Std 802.1CB.
   2) A wildcard, that matches any *stream_handle*.
c) A *priority* specification, either:
   1) A single priority value.
   2) A wildcard value that matches any priority value.
d) Maximum SDU size filtering (8.6.5.3.1) information, comprising:
   1) An integer *Maximum SDU size*, in octets. A value of 0 disables maximum SDU size filtering for this stream filter.
   2) A boolean *StreamBlockedDueToOversizeFrameEnable* parameter.
   3) A boolean *StreamBlockedDueToOversizeFrame* parameter.
e) An integer *stream gate identifier* (8.6.5.4).
f) An integer *flow meter instance identifier* (8.6.5.5).
   If this parameter is absent, frames associated with the stream filter are not subject to flow metering.
g) An integer ATS *scheduler instance identifier* (8.6.5.6).
   If this parameter is absent, frames associated with the stream filter are not subject to ATS scheduling and transmission selection.



KEY
Discard: Frame discarding abilities and parameters (Clause 8.6.5.3.1, Clause 8.6.5.4, 8.6.5.6).
CBS: CommittedBurstSize parameter (8.6.5.6, 8.6.11.3.5).
CIR: CommittedInformationRate parameter (8.6.5.6, 8.6.11.3.6).

Figure 8-15—Per-stream classification and metering for ATS

Each stream filter also comprises the following counters for frames associated with the stream filter:

h) *MatchingFramesCount*: all frames associated with that stream filter.
i) *PassingSDUCount*: frames passing the maximum SDU size filter (8.6.5.3.1).
j) *NotPassingSDUCount*: frames not passing the maximum SDU size filter (8.6.5.3.1).
k) *PassingFrameCount*: frames passing the associated stream gate (8.6.5.4).
l) *NotPassingFrameCount*: frames not passing the stream gate (8.6.5.4).
m) *RedFramesCount*: frames discarded by the flow meter (8.6.5.5).

The *stream filter identifier* uniquely identifies the stream filter, indexing a *Stream Filter Instance Table* of up to *MaxStreamFilterInstances* stream filters. Each received frame is associated with the stream filter with the lowest *stream filter identifier* whose *stream_handle* and *priority* specification match the frame's parameters, and the *MatchingFramesCount* is incremented for that filter.

NOTE 1—The use of stream_handle and priority, along with the wild-carding rules previously stated, allow configuration possibilities that go beyond the selection of individual streams, for example, per-priority filtering and policing, or per-priority per-reception Port filtering and policing can be configured using these rules.

NOTE 2—If it is desired to discard frames that do not match any other stream filter, rather than such frames being processed without filtering, a stream filter can be placed at the end of the table with stream_handle and priority specifications both wild-carded and the stream gate identifier of a permanently closed stream gate.

NOTE 3—A discarded frame is not processed or counted by subsequent elements of the forwarding process. As a consequence, implementations can internally represent all counters [items h) through m) above] by the four counters MatchingFramesCount [item h) above], NotPassingSDUCount [item j) above], NotPassingFrameCount [item l) above], and RedFramesCount [item m) above].

8.6.5.3.1 Maximum SDU Size Filtering

If the SDU size of a frame exceeds the value of the associated stream filter's Maximum SDU size parameter, the frame is discarded and that stream filter's NotPassingSDUCount is incremented. If the stream filter's StreamBlockedDueToOversizeFrameEnable parameter is configured to be TRUE, the StreamBlockedDueToOversizeFrame parameter is set to TRUE and all subsequent frames will be discarded until StreamBlockedDueToOversizeFrame is administratively reset to FALSE.

Otherwise, the stream filter's PassingSDUCount is incremented (see 8.6.5.3). The default configuration of both StreamBlockedDueToOversizeFrameEnable and StreamBlockedDueToOversizeFrame is FALSE.

NOTE—The Maximum SDU size is defined per stream filter and can therefore differ from the queueMaxSDU specified in 8.6.8.4.As queueMaxSDU is applied after the flow classification and metering, it is possible that a frame that passes the Maximum SDU size filter will later be discarded because its SDU size exceeds queueMaxSDU.

8.6.5.4 Stream gating

Stream gates can discard frames whose reception times contradict a given time schedule. Stream gates can also map the frame's priority to an internal priority value (IPV) that is used to make subsequent queuing decisions (8.6.6), while retaining the frame's original priority for transmission.

NOTE 1—The IPV facilitates ATS per-hop delay bound adjustment to satisfy specific networks' end-to-end delay requirements. Annex T (CQF) describes another IPV use case.

Each stream gate comprises the following:

a) An integer *stream gate instance identifier*.
b) An administrative and an operational *stream gate state* parameter. These parameters take the following values:
    1) Open: Frames are permitted to pass through the stream gate.
    2) Closed: Frames are not permitted to pass through the stream gate.
c) An administrative and an operational *internal priority value specification* parameter. These parameters take the following values:
    1) Null, in this case the received frame's priority parameter is used as the IPV.
    2) A specific IPV for the frame.

The *stream gate instance identifier* uniquely identifies the stream gate, indexing a *Stream Gate Instance Table* of up to *MaxStreamGateInstances* stream gates.

If PSFP are supported, each stream gate also includes the following:

d) An administrative and an operational *stream gate control list*.
e) A boolean *GateClosedDueToInvalidRxEnable* parameter.
f) A boolean *GateClosedDueToInvalidRx* parameter.
g) A boolean *GateClosedDueToOctetsExceededEnable* parameter.
h) A boolean *GateClosedDueToOctetsExceeded* parameter.

An instance of the stream gate control state machine (8.6.10) determines the operational values of the *stream gate state* and the *internal priority value specification* [items b) and c) above] by the cyclical execution of the control operations (see Table 8-4) specified in the stream gate's *stream gate control list* [item d) above]. The administrative *stream gate state* and *internal priority value specification* parameters are used to determine the initial values of the corresponding operational parameters, and the administrative *stream gate control list* parameter allows configuration of a new control list prior to enabling its use in a running system.

If a frame is passed by a stream gate, the *PassingFrameCount* of the stream filter (8.6.5.3) associated with that frame is incremented. The *NotPassingFrameCount* is incremented if the frame is discarded.

Table 8-4—Stream gate control operations

Operation name	Parameter(s)	Action
SetGateAndIPV	StreamGateState, IPV, TimeInterval, IntervalOctetMax	The StreamGateState parameter specifies a desired state, *open* or *closed*, for the stream gate, and the IPV parameter specifies a desired value of the IPV associated with the stream. On execution, the StreamGateState and IPV parameter values are used to set the operational values of the stream gate state and internal priority value specification parameters for the stream. After *TimeInterval* ticks (8.6.9.4.16) has elapsed since the completion of the previous stream gate control operation in the stream gate control list, control passes to the next stream gate control operation. The optional IntervalOctetMax parameter specifies the maximum number of MSDU octets that are permitted to pass the gate during the specified TimeInterval. If the IntervalOctetMax parameter is omitted, there is no limit on the number of octets that can pass the gate.

Stream gates are able to permanently discard frames and thus effectively override the operational gate state (i.e., the stream gate behaves as if the operational stream gate state is Closed). This capability is provided in case a frame is discarded due to a closed gate state [8.6.5.4 item b)], and in case a frame is discarded because there are insufficient octets left (i.e., the value of the IntervalOctetsLeft parameter, as specified in 8.6.10.8, is lower than the frame length).

i) Permanent frame discarding due to a frame received during a closed gate state is enabled if the GateClosedDueToInvalidRxEnable parameter is TRUE, and disabled if this parameter is FALSE. If enabled and any frame is discarded, then the GateClosedDueToInvalidRx parameter is set to TRUE, and all subsequent frames are discarded as long as the GateClosedDueToInvalidRxEnable and GateClosedDueToInvalidRx parameters are TRUE. Changes of the GateClosedDueToInvalidRxEnable parameter and transitions from TRUE to FALSE of the GateClosedDueToInvalidRx parameter are administrative actions.

j) Permanent frame discarding due to insufficient left octets is enabled if the GateClosedDueToOctetsExceededEnable parameter is TRUE, and disabled if this parameter is FALSE. If enabled and any frame is discarded because there are insufficient octets left, then the GateClosedDueToOctetsExceeded parameter is set to TRUE, and all subsequent frames are discarded as long as the GateClosedDueToOctetsExceededEnable and GateClosedDueToOctetsExceededEnable parameters are TRUE. Changes of the GateClosedDueToOctetsExceededEnable parameter and transitions from TRUE to FALSE of the GateClosedDueToOctetsExceeded parameter are administrative actions.

Per default, permanent frame discarding is disabled and all associated parameters have the default value FALSE.

NOTE 2—Permanent frame discarding allows the detection of incoming frames during time periods when the stream gate is in the closed state and exceptionally large ingress bursts to result in the stream gate behaving as it is in a permanently closed state, until such a time as management action is taken to reset the condition. The intent is to support

applications where the transmission and reception of frames across the network is coordinated such that frames are received only when the stream gate is open with a limited overall amount of ingress octets. Hence, frames received by the stream gate when it is in the closed state and unexpected amounts of ingress octets represent invalid receive conditions.

8.6.5.5 Flow metering

The flow meters specified by this subclause (8.6.5.5) implement the parameters and algorithm specified in *Bandwidth Profile Parameters and Algorithm* in MEF 10.3 with the additions described in this subclause.

Each flow meter comprises the following:

a) An integer *flow meter identifier.*
b) An integer *Committed information rate (CIR)*, in bits per second (MEF 10.3).
c) An integer *Committed burst size (CBS)*, in octets (MEF 10.3).
d) An integer *Excess Information Rate (EIR)*, in bits per second (MEF 10.3).
e) An integer *Excess burst size (EBS) per bandwidth profile flow*, in octets (MEF 10.3).
f) A *Coupling flag (CF)*, which takes the value 0 or 1 (MEF 10.3).
g) A *Color mode (CM)*, which takes the value *color-blind* or *color-aware* (MEF 10.3).
h) A boolean *DropOnYellow* parameter.
i) A boolean *MarkAllFramesRedEnable* parameter.
j) A boolean *MarkAllFramesRed* parameter.

NOTE 1—This standard specifies the relationship among frame length, media-dependent overhead, ATS scheduler operation, and the associated parameters in 8.6.11. In contrast, the operation and parameters of flow meters in 8.6.5.5 are as specified by MEF 10.3.

NOTE 2—Envelope and Rank, as defined in MEF 10.3, are not used by the flow meters described in this subclause; i.e., the reduced functionality algorithm described in 12.2 of MEF 10.3 is used.

The *flow meter identifier* uniquely identifies the flow meter instance, indexing a *Flow Meter Instance Table* of up to *MaxFlowMeterInstances* flow meters.

The DropOnYellow parameter indicates whether frames marked yellow by the MEF 10.3 algorithm are discarded or marked as drop eligible:

k) A value of TRUE indicates that yellow frames are discarded.
l) A value of FALSE indicates that the drop_eligible parameter of yellow frames is set to TRUE.

NOTE 3—Changing the value of the drop_eligible parameter may change the contents of the frame, depending on how the frame is tagged when transmitted, which may then require updating the frame_check_sequence. Mechanisms for conveying information from ingress to egress that the frame_check_sequence may require updating are implementation dependent.

Flow meters can permanently discard all frames after an initial frame has been discarded. This capability is enabled if the MarkAllFramesRedEnable parameter is TRUE, and disabled if this parameter is FALSE. If enabled and the flow meter discards a frame, then the MarkAllFramesRed parameter is set to TRUE, and all subsequent frames are discarded as long as the MarkAllFramesRedEnable and MarkAllFramesRed parameters are TRUE.

Changes of the MarkAllFramesRedEnable parameter and transitions from TRUE to FALSE of the MarkAllFramesRed parameter are administrative actions. Per default, permanent frame discarding is disabled and both associated parameters have the default value FALSE.

Each time a flow meter discards a frame, the RedFramesCount counter of the originating stream filter (8.6.5.3) is increased.

8.6.5.6 ATS eligibility time assignment

Asynchronous Traffic Shaping (ATS) schedulers assign eligibility times to frames which are then used for traffic regulation by the ATS transmission selection algorithm (8.6.8.5).

NOTE 1—ATS schedulers, as defined in this subclause (8.6.5.6), realize the computational part of the overall traffic shaping operation of ATS. The complete operation is provided in combination with the ATS transmission selection algorithm (8.6.8.5), which uses the assigned eligibility times to regulate the traffic for transmission.

Each ATS scheduler comprises the following:

a) An integer *scheduler identifier*.
b) An integer *scheduler group identifier*.
c) An integer *CommittedBurstSizeParameter* parameter, in bits (8.6.11.3.5).
d) An integer *CommittedInformationRate* parameter, in bits per second (8.6.11.3.6).
e) An internal *bucket empty time* state variable, in seconds (8.6.11.3.3).

ATS schedulers are organized in *ATS scheduler groups*. There is one ATS scheduler group per reception Port per upstream traffic class, where the latter refers to the transmitting traffic class in the device connected to the given reception Port. All ATS schedulers that process frames from a particular reception Port and a particular upstream traffic class are in the respective ATS scheduler group.

Each ATS scheduler group comprises the following:

f) An integer *scheduler group identifier*.
g) An integer *MaximumResidenceTime* parameter, shared by all ATS schedulers in a scheduler group, in nanoseconds (8.6.11.3.13).
h) An internal *group eligibility time* state variable, shared by all ATS schedulers in a scheduler group, in seconds (8.6.11.3.10).

NOTE 2—The organization of ATS schedulers into groups results in a non-decreasing ordering of eligibility times of successive frames associated with a single group. This permits frames of one group to be queued in FIFO order.

Each ATS scheduler assigns eligibility times to the associated frames, and discards frames in exceptional situations. The underlying operations are performed by an ATS scheduler state machine (8.6.11) associated with an ATS scheduler. This state machine updates the associated bucket empty time and group eligibility time state variables based on the CommittedBurstSize, the CommittedInformationRate, the MaxResidenceTime, the frame arrival times, and the frame lengths (including media-specific overhead).

Each Port is associated with the following variable for ATS schedulers:

i) An integer *DiscardedFramesCount* of frames discarded by the ATS schedulers associated with that reception Port.

Each Bridge component provides an *ATS Scheduler Instance Table* of up to *MaxSchedulerInstances* ATS schedulers, an *ATS Scheduler Group Instance Table* of up to *MaxSchedulerGroupInstances* ATS scheduler groups, and a *ATS Scheduler Port Parameter Table* shared by all ATS schedulers associated with a reception Port.

NOTE 3—Whether ATS scheduler instances, ATS scheduler group instances, the scheduler instance table, and the scheduler group instance table are located in reception ports or in transmission ports is implementation specific.

8.6.6 Queuing frames

The Forwarding Process shall queue each received frame to each of the potential transmission Ports (8.6.1, 8.6.3, 8.6.4).

NOTE 1—The Forwarding Process is modeled as receiving a frame as the parameters of a data indication and transmitting through supplying the parameters of a data request. Queuing a frame awaiting transmission amounts to placing the parameters of a data request on an outbound queue.

The Forwarding Process provides storage for queued frames, awaiting an opportunity to submit these for transmission. The order of frames received on the same Bridge Port shall be preserved for:

a) Unicast frames with a given VID, priority, flow hash, and destination address and source address combination.
b) Multicast frames with a given VID, priority, flow hash, and destination address.

Flow hash is applicable only on Bridges supporting flow filtering (44.2).

The Forwarding Process provides one or more queues for a given Bridge Port, each corresponding to a distinct traffic class. Each frame is mapped to a traffic class using the Traffic Class Table for the Port. The priority value used for this mapping is determined as follows:

c) If stream gates are unsupported (8.6.5.4), the frame's priority is used.
d) If stream gates are supported and the IPV specification assigned to the frame is the null value, the frame's priority is used.
e) If stream gates are supported and the IPV specification assigned to the frame is an IPV, this IPV is used.

Traffic class tables may be managed. Table 8-5 shows the recommended mapping for the number of classes implemented, in implementations that do not support the credit-based shaper transmission selection algorithm (8.6.8.2). The requirements for priority to traffic class mappings in implementations that support the credit-based shaper transmission selection algorithm are defined in 34.5. Up to eight traffic classes may be supported, allowing separate queues for each priority.

Table 8-5—Recommended priority to traffic class mappings

		Number of available traffic classes							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Priority	0 (Default)	0	0	0	0	0	1	1	1
	1	0	0	0	0	0	0	0	0
	2	0	0	0	1	1	2	2	2
	3	0	0	0	1	1	2	3	3
	4	0	1	1	2	2	3	4	4
	5	0	1	1	2	2	3	4	5
	6	0	1	2	3	3	4	5	6
	7	0	1	2	3	4	5	6	7
NOTE—The rationale for these mappings is discussed in Annex I.									

NOTE 2—Different Ports can use different numbers of traffic classes. Ports with media access methods that support a single transmission priority, such as Ethernet, can support more than one traffic class.

NOTE 3—A queue in this context is not necessarily a single FIFO data structure. A queue is a record of all frames of a given traffic class awaiting transmission on a given Bridge Port. The transmission selection algorithm (8.6.8) determines which traffic class, among those classes with frames available for transmission, provides the next frame for transmission. A variety of queue structures such as a single FIFO, or a set of FIFOs with one for each VLAN or priority, is allowed.

In a congestion-aware Bridge (Clause 30), the act of queuing a frame for transmission on a Bridge Port can result in the Forwarding Process generating a CNM. The CNM is injected back into the Forwarding Process (8.6.1) as if it had been received on that Bridge Port.

If PSFP is supported (8.6.5.2), and the IPV associated with the stream filter that passed the frame is anything other than the null value, then that IPV is used to determine the traffic class of the frame, in place of the frame's priority, via the Traffic Class Table specified in 8.6.6. In all other respects, the queuing actions specified in 8.6.6 are unchanged.

The IPV is used only to determine the traffic class associated with a frame, and hence select an outbound queue; for all other purposes, the received priority is used.

8.6.7 Queue management

A frame queued for transmission on a Port shall be removed from that queue:

a) Following a transmit data request. No further attempt shall be made to transmit the frame on that Port even if the transmission is known to have failed.
b) If that is necessary to ensure that the maximum Bridge transit delay (6.5.6) will not be exceeded at the time at which the frame would subsequently be transmitted.
c) If the transmission Port is no longer forwarding for that frame (8.4, 8.6.1). Frames entering the queue subsequent to the transition out of the Forwarding state (e.g., CFM frames from Down MPs, as described in 22.1, Figure 22-4, and Figure 22-7) are not discarded.

NOTE—CFM frames may be excepted, and not removed from the queue, on a transition out of the Forwarding state (see 22.1.3).

The frame can be removed from the queue, and not subsequently transmitted:

d) If the time for which buffering is guaranteed has been exceeded for that frame
e) By a queue management algorithm that attempts to improve the QoS provided by deterministically or probabilistically managing the queue depth based on the current and past queue depths.

Removal of a frame from a queue for any particular Port does not affect queuing of that frame for transmission on any other Port.

The probability of removing a frame with drop_eligible set shall not be less than that of removing a frame with drop_eligible False, all other conditions being equal. If a queue management algorithm is implemented, it should preferentially discard frames with drop_eligible True. If a Bridge supports encoding or decoding of drop_eligible from the PCP field of a VLAN tag (6.9.3) on any of its Ports, then it shall implement a boolean parameter Require Drop Encoding on each of its Ports with default value FALSE. If Require Drop Encoding is True and the Bridge Port cannot encode particular priorities with drop_eligible, then frames queued with those priorities and drop_eligible True shall be discarded and not transmitted.

8.6.8 Transmission selection

For each Port, frames are selected for transmission on the basis of the traffic classes that the Port supports and the operation of the transmission selection algorithms supported by the corresponding queues on that Port. For a given Port and traffic class, frames are selected from the corresponding queue for transmission if and only if:

a) The operation of the transmission selection algorithm supported by that queue determines that there is a frame available for transmission; and
b) For each queue corresponding to a numerically higher value of traffic class supported by the Port, the operation of the transmission selection algorithm supported by that queue determines that there is no frame available for transmission.

In a port of a Bridge or station that supports PFC, a frame of priority n is not available for transmission if that priority is paused, i.e., if Priority_Paused[n] is TRUE (see 36.1.3.2) on that port. When Transmission Selection is running above Link Aggregation, a frame of priority n is not available for transmission if that priority is paused on the physical port to which the frame is to be distributed.

NOTE 1—Two or more priorities can be combined in a single queue. In this case if one or more of the priorities in the queue are paused, it is possible for frames in that queue not belonging to the paused priority to not be scheduled for transmission.

NOTE 2—Mixing PFC and non-PFC priorities in the same queue results in non-PFC traffic being paused causing congestion spreading, and therefore is not recommended.

In a port of a Bridge or station that supports frame preemption, a frame of priority *n* is not available for transmission if that priority is identified in the frame preemption status table (6.7.2) as preemptable and either the holdRequest object (12.30.1.5) is set to the value *hold*, or the transmission of a prior preemptable frame has yet to complete because it has been interrupted to allow the transmission of an express frame.

The strict priority transmission selection algorithm defined in 8.6.8.1 shall be supported by all Bridges as the default algorithm for selecting frames for transmission. The credit-based shaper transmission selection algorithm defined in 8.6.8.2, the ETS algorithm defined in 8.6.8.3, and the ATS transmission selection algorithm defined in 8.6.8.5 may be supported in addition to the strict priority algorithm. Further transmission selection algorithms, selectable by management means, may be supported as an implementation option so long as the requirements of 8.6.6 are met.

The Transmission Selection Algorithm Table for a given Port assigns, for each traffic class that the Port supports, the transmission selection algorithm that is to be used to select frames for transmission from the corresponding queue. Transmission Selection Algorithm Tables may be managed, and allow the identification of vendor-specific transmission selection algorithms. The transmission selection algorithms are identified in the Transmission Selection Algorithm Table by means of integer identifiers, as defined in Table 8-6.

A recommended configuration of the Transmission Selection Algorithm Tables for use with the credit-based shaper transmission selection algorithms is specified in 34.5. When the enhancements for scheduled traffic are supported, additional requirements to determine whether a frame is available for transmission apply, as specified in 8.6.8.4.

Table 8-6—Transmission selection algorithm identifiers

Transmission selection algorithm	Identifier
Strict priority (8.6.8.1)	0
Credit-based shaper (8.6.8.2)	1
Enhanced Transmission Selection (ETS) (8.6.8.3)	2
ATS Transmission Selection (8.6.8.5)	3
Reserved for future standardization	4–254
Vendor-specific Transmission Selection algorithm value for use with DCBX (D.2.8.8)	255
Vendor-specific	A four-octet integer, where the most significant 3 octets hold an OUI or CID value, and the least significant octet holds an integer value in the range 0–255 assigned by the owner of the OUI or CID.

8.6.8.1 Strict priority algorithm

For a given queue that supports strict priority transmission selection, the algorithm determines that there is a frame available for transmission if the queue contains one or more frames. The order in which frames are selected for transmission from the queue shall maintain the ordering requirement specified in 8.6.6.

8.6.8.2 Credit-based shaper algorithm

For a given queue that supports credit-based shaper transmission selection, the algorithm determines that a frame is available for transmission if the following conditions are all true:

a) The queue contains one or more frames.
b) The *transmitAllowed* signal for the queue is TRUE.

The order in which frames are selected for transmission from the queue shall maintain the ordering requirement specified in 8.6.6.

The following external parameters are associated with each queue that supports the operation of the credit-based shaper algorithm:

c) ***portTransmitRate.*** The transmission rate, in bits per second, that the underlying MAC Service that supports transmission through the Port provides. The value of this parameter is determined by the operation of the MAC.
d) ***idleSlope***. The rate of change of *credit*, in bits per second, when the value of *credit* is increasing (i.e., while *transmit* is FALSE and the transmission gate for the queue is open [8.6.8.4]). The value of *idleSlope* can never exceed *portTransmitRate*. If the enhancements for scheduled traffic (8.6.8.4) are not supported, or if GateEnabled is FALSE (8.6.9.4.14), the value of *idleSlope* for a given queue is equal to the value of the *operIdleSlope(N)* parameter for that queue, as defined in 34.3. If the enhancements for scheduled traffic (8.6.8.4) are supported, and GateEnabled is TRUE (8.6.9.4.14), then:

$$idleSlope = (operIdleSlope(N) \times \text{OperCycleTime} / \text{GateOpenTime})$$

where OperCycleTime is as defined in 8.6.9.4.19 and GateOpenTime is equal to the total amount of time during the gating cycle that the gate state for the queue is Open.

NOTE 1—When scheduled traffic operation is enabled, *credit* is accumulated only while the gate is open; therefore, the effective data rate of the *idleSlope* is increased to reflect the duty cycle for the transmission gate associated with the queue; however, the value of *operIdleSlope(N)* for the queue remains unchanged.

The following internal parameters are associated with each queue that supports the credit-based shaper algorithm:

e) ***transmit***. Takes the value TRUE for the duration of a frame transmission from the queue; FALSE when any frame transmission from the queue has completed. If the credit-based shaper algorithm is used in combination with frame preemption (6.7.2), transmit only takes the value TRUE while the frame is actually being transmitted by the MAC. If the frame transmission is delayed or interrupted (e.g., the frame is a preemptable frame and its transmission is interrupted to allow the transmission of an express frame from a different queue, or the frame is an express frame and there is a delay before transmission can start because a preemptable frame was being transmitted) transmit takes the value FALSE until transmission of the frame commences or is resumed. Transmit also takes the value FALSE during the transmission of any overhead that is a consequence of frame preemption; i.e., any additional frame overhead that is added to the preemptable frame when preemption occurs.

NOTE 2—The consequence of this is that any overhead associated with preemption does not come out of the reserved bandwidth for the credit-based shaper.

f) ***credit***. The transmission credit, in bits, that is currently available to the queue. If, at any time, there are no frames in the queue, and the *transmit* parameter is FALSE, and *credit* is positive, and the transmission gate for the queue is open (8.6.8.4), and there is no preemptable frame from this queue for which transmission is in progress but has been interrupted, then *credit* is set to zero.

NOTE 3—The condition that the transmit parameter is FALSE and a preemptable frame or part-frame is waiting in the MAC for transmission can only occur if the credit-based shaper algorithm is used in combination with Preemption.

g) ***sendSlope***. The rate of change of *credit*, in bits per second, when the value of *credit* is decreasing (i.e., while *transmit* is TRUE). The value of *sendSlope* is defined as follows:

$$sendSlope = (idleSlope - portTransmitRate)$$

h) ***transmitAllowed***. Takes the value TRUE when the *credit* parameter is zero or positive; FALSE when the *credit* parameter is negative.

NOTE 4—The value of *credit* is naturally constrained by the operating parameters for the algorithm, and also by the operation of any higher priority queues that use this algorithm. The lowest value that *credit* can reach depends on *sendSlope* and the largest frame that will be transmitted from the queue. This largest frame size is a consequence of the type of traffic that is being transmitted using the queue, rather than a limit imposed by the algorithm or by management. The highest value that can be accumulated in *credit* depends on *idleSlope* and the length of time that the algorithm may have to wait when the queue is not empty and there is other traffic being transmitted through the Port; for any given queue, that length of time is bounded, as discussed in Annex L, which also illustrates how the algorithm operates under varying conditions, and how its operation affects the maximum latency that can be experienced by SR traffic.

NOTE 5—In order for the credit-based shaper algorithm to operate as intended, it is necessary for all traffic classes that support the algorithm to be numerically higher than any traffic classes that support the strict priority algorithm defined in 8.6.8.1. The mapping of priorities onto traffic classes, and the choice of traffic classes that support particular transmission selection algorithms, is defined in 34.5.

Traffic classes using the credit-based shaper algorithm shall not use PFC and shall ignore the setting of the bits related to such classes in the PFC Enable bit vector (see D.2.10.6)

8.6.8.3 ETS algorithm

If ETS is enabled for a traffic class, transmission selection is performed based on the allocation of bandwidth to that traffic class. Bandwidth is distributed among ETS traffic classes that support ETS algorithm such that each traffic class is allocated available bandwidth in proportion to its TCBandwidth (see Clause 37).

For a given queue that supports ETS, the algorithm determines that there is a frame available for transmission if the following conditions are all true:

a) The queue contains one or more frames.
b) The ETS algorithm (37.3) determines that a frame should be transmitted from the queue.
c) There are no frames available for transmission for any queues running strict priority or credit-based shaper algorithms.

The order in which frames are selected for transmission from the queue shall maintain the ordering requirement specified in 8.6.6.

8.6.8.4 Enhancements for scheduled traffic

A Bridge or an end station may support enhancements that allow transmission from each queue to be scheduled relative to a known timescale. In order to achieve this, a transmission gate is associated with each queue; the state of the transmission gate determines whether or not queued frames can be selected for transmission (see Figure 8-16). For a given queue, the transmission gate can be in one of two states:

a) *Open*: Queued frames are selected for transmission, in accordance with the definition of the transmission selection algorithm associated with the queue.
b) *Closed*: Queued frames are not selected for transmission.

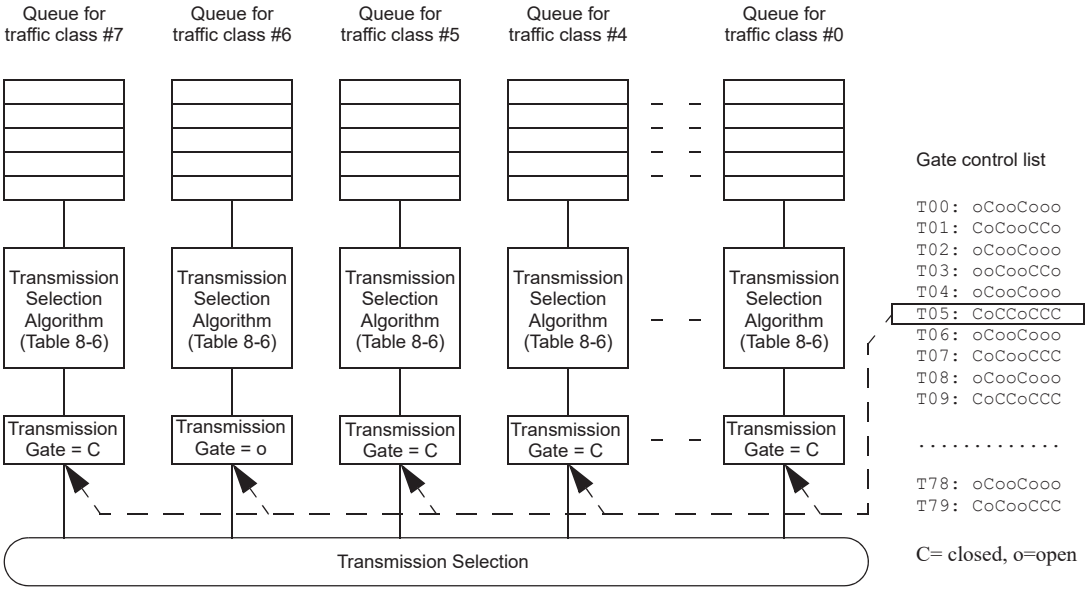


Figure 8-16—Transmission selection with gates

A *gate control list* associated with each Port contains an ordered list of gate operations. Each gate operation changes the transmission gate state for the gate associated with each of the Port's traffic class queues and allows associated control operations to be scheduled. In an implementation that does not support enhancements for scheduled traffic, all gates are assumed to be permanently in the *open* state. Table 8-7 identifies the gate operation types, their parameters, and the actions that result from their execution. The state machines that control the execution of the gate control list, along with their variables and procedures, are specified in 8.6.9.

Table 8-7—Gate operations

Operation name	Parameter(s)	Action
SetGateStates	GateState, TimeInterval	The *GateState* parameter indicates a value, *open* or *closed*, for each of the Port's queues. The gates are immediately set to the states indicated in the GateState parameter. This causes gate-close events (3.99) and/or gate-open events (3.100) to occur for any queue where the new GateState represents a change of state relative to the current state of the gate. After *TimeInterval* ticks (8.6.9.4.16) have elapsed since the completion of the previous gate operation in the gate control list, control passes to the next gate operation.
Set-And-Hold-MAC	GateState, TimeInterval	Performs all of the actions defined for the SetGateStates operation; in addition, the start of this operation marks the point in the sequence of gate operations at which the MAC associated with the port is to have stopped transmitting preemptable frames. This is achieved by setting the holdRequest managed object to the value *hold (1)*, at holdAdvance (Table 12-33) nanoseconds in advance of this point for the hold to have taken effect at this point. If frame preemption is not supported or not enabled (preemptionActive is FALSE), this operation behaves the same as SetGateStates.
Set-And-Release-MAC	GateState, TimeInterval	Performs all of the actions defined for the SetGateStates operation; in addition, the start of this operation marks the point in the sequence of gate operations at which the MAC associated with the port is permitted to resume transmitting preemptable frames; if an express frame is currently being transmitted by the MAC, the release takes effect at the end of that transmission. This is achieved by setting the holdRequest managed object to the value *release (2)*, at releaseAdvance (Table 12-33) nanoseconds in advance of this point for the release to have taken effect at this point.[a] If frame preemption is not supported or not enabled (preemptionActive is FALSE), this operation behaves the same as SetGateStates.

[a] The releaseAdvance parameter allows the timing of when the release command is issued to vary depending upon the constraints of a particular implementation. Its value should be less than the minimum frame size so that release does not occur too early and interfere with transmission of the last express frame.

In addition to the other checks carried out by the transmission selection algorithm, a frame on a traffic class queue is not available for transmission [as required for tests (a) and (b) in 8.6.8] if the transmission gate is in the closed state or if there is insufficient time available to transmit the entirety of that frame, plus the media-dependent overhead specified in 12.4.2.2, before the next gate-close event (3.99) associated with that queue (Figure 8-17). .

NOTE 1—For example, in the case of IEEE 802.3 media, the media-dependent overhead prior to the gate-close event includes the preamble of a potentially following frame from a different traffic class.

A per-traffic class counter, TransmissionOverrun (12.29.1.1.2), is incremented if the implementation detects that a frame from a given queue is still being transmitted by the MAC when the gate-close event for that queue occurs.

NOTE 2—There can be reasons why the frame size, and therefore the length of time needed for its transmission, is unknown. For example, where frame preemption is supported and there is no way of telling in advance how many times a given frame will be preempted before its transmission is complete. It is desirable that the schedule for such traffic is designed to accommodate the intended pattern of transmission without overrunning the next gate-close event for the traffic classes concerned.

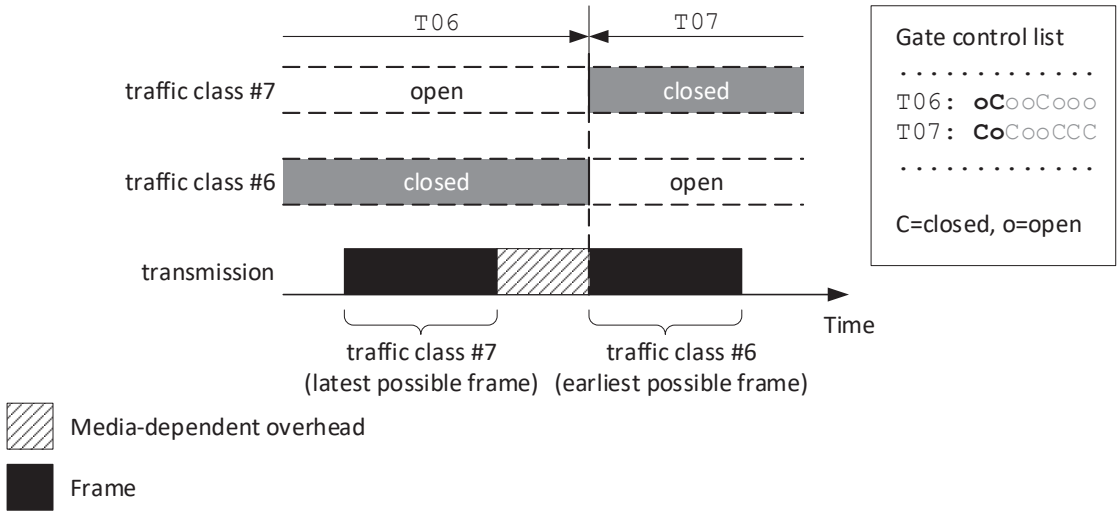


Figure 8-17—Frame timing at gate-close events

NOTE 3— It is assumed that the implementation can determine the time at which the next gate-close event will occur from the sequence of gate events. In the normal case, this can be achieved by inspecting the sequence of gate operations in OperControlList (8.6.9.4.18) and associated variables. However, when a new configuration is about to be installed, it would be necessary to inspect the contents of both the OperControlList and the AdminControlList (8.6.9.4.2) and associated variables in order to determine the time of the next gate-close event, as the gating cycle for the new configuration may differ in size and phasing from the old cycle.

A per-traffic class queue queueMaxSDU parameter defines the maximum service data unit size for each queue; frames that exceed queueMaxSDU are discarded [item b8) in 6.5.2]. The value of queueMaxSDU for each queue is configurable by management (12.29); its default value is the maximum SDU size supported by the MAC procedures employed on the LAN to which the frame is to be relayed [item b3) in 6.5.2].

NOTE 3—The use of PFC is likely to interfere with a traffic schedule, because PFC is transmitted by a higher layer entity (see Clause 36).

In order for an end station to support the scheduled transmission of frames, it is necessary for its behavior to be compatible with the operation of the forwarding and queuing mechanisms employed in the Bridges to which it connects. In effect, the requirements for an end station are for its transmission selection to operate as if it is a single outbound Port of a Bridge that supports scheduled traffic. There are no particular requirements for end station support for the reception of scheduled traffic; only for the transmission of scheduled traffic.

8.6.8.5 ATS transmission selection algorithm

For a given queue that supports ATS transmission selection, a frame is eligible for transmission if the assigned eligibility time (8.6.5.6, 8.6.11.3.2) is earlier than or at the current time.

The current time is determined by the TransmissionSelection Clock, which is an implementation specific local system clock function.

Frames are selected for transmission in ascending order of the assigned eligibility times. Transmission selection of frames with identical assigned eligibility times shall maintain the ordering requirement specified in 8.6.6.

NOTE—In the case of frames with non-identical eligibility times, the ordering requirement from 8.6.6 is automatically satisfied due the operation of the ATS scheduler state machines (8.6.11), which assign eligibility times in a non-decreasing order.

8.6.9 Scheduled traffic state machines

The execution of the gate operations in a Port's gate control list (8.6.8.4) is controlled by three state machines:

a) The Cycle Timer state machine (8.6.9.1)
b) The List Execute state machine (8.6.9.2)
c) The List Config state machine (8.6.9.3)

One instance of each state machine is instantiated for each Port that supports the enhancements for scheduled traffic.

The Cycle Timer state machine initiates the execution of the gate control list and ensures that the gating cycle time defined for the Port is maintained.

The List Execute state machine executes the gate operations in the gate control list, in sequence, and establishes the appropriate time delay between each operation.

The List Config state machine manages the process of updating the current active schedule, interrupting the operation of the other two state machines while the update process is performed, and restarting them once the new schedule has been installed.

The state machine notation is specified in Annex E.

An overview of the state machines, showing their relationships and the variables that are used by them, can be seen in Figure 8-18.

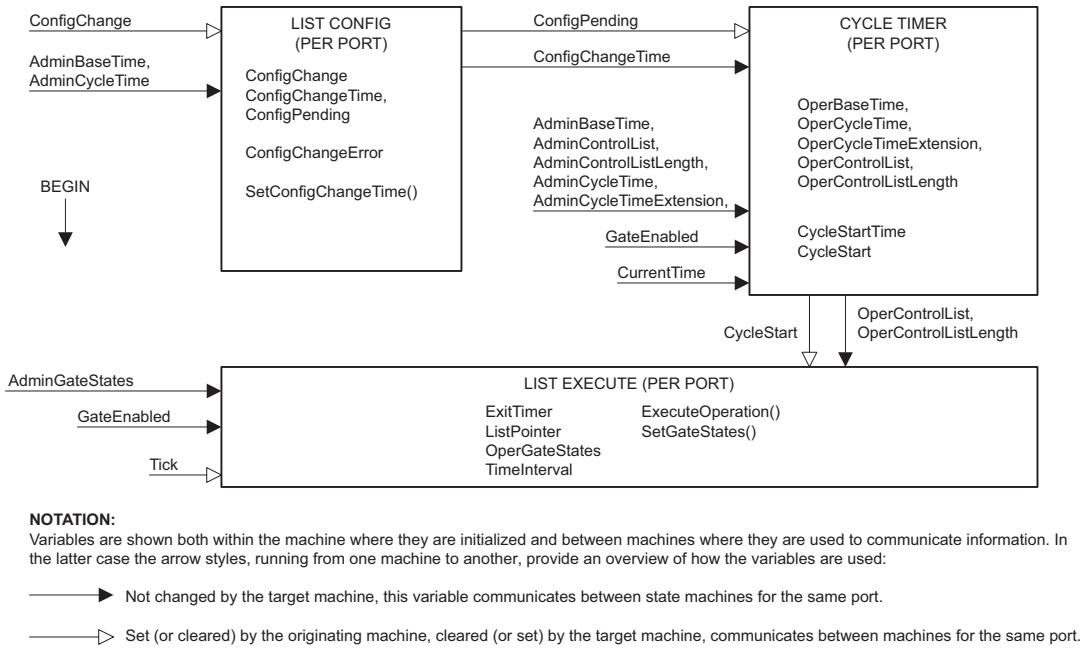


Figure 8-18—Scheduled traffic state machines—overview and relationships

8.6.9.1 Cycle Timer state machine

The Cycle Timer state machine shall implement the function specified by the state diagram in Figure 8-19 and the attendant definitions in 8.6.9.4.

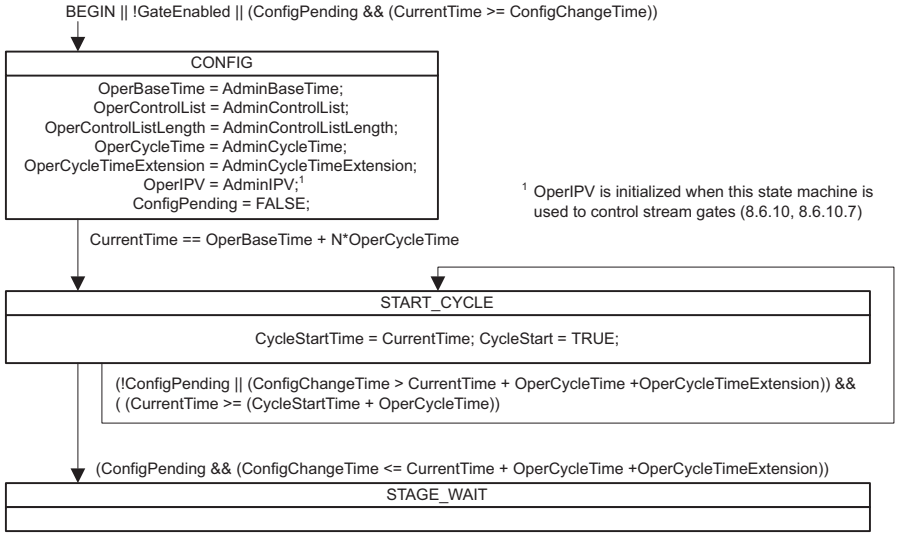


Figure 8-19—Cycle Timer state machine

NOTE 1—Since the origin of the PTP timescale is 1 January 1970 00:00:00 TAI, CycleStartTime will be larger than 1.3×10^{18} ns. If sufficient precision is not maintained when computing N, CycleStartTime will not be an integer multiple of OperCycleTime, which could result in misalignment of the cycles at ports on different bridges.

NOTE 2—If AdminBaseTime is set to the same time in the past in all bridges and end stations, OperBaseTime is always in the past, and all cycles start synchronized. Using AdminBaseTime in the past is appropriate when you can start schedules prior to starting the application that uses the schedules. Use of AdminBaseTime in the future is intended to change a currently running schedule in all bridges and end stations to a new schedule at a future time. Using AdminBaseTime in the future is appropriate when schedules must be changed without stopping the application.

8.6.9.2 List Execute state machine

The List Execute state machine shall implement the function specified by the state diagram in Figure 8-20 and the attendant definitions in 8.6.9.2.1, 8.6.9.2.2, and 8.6.9.4.

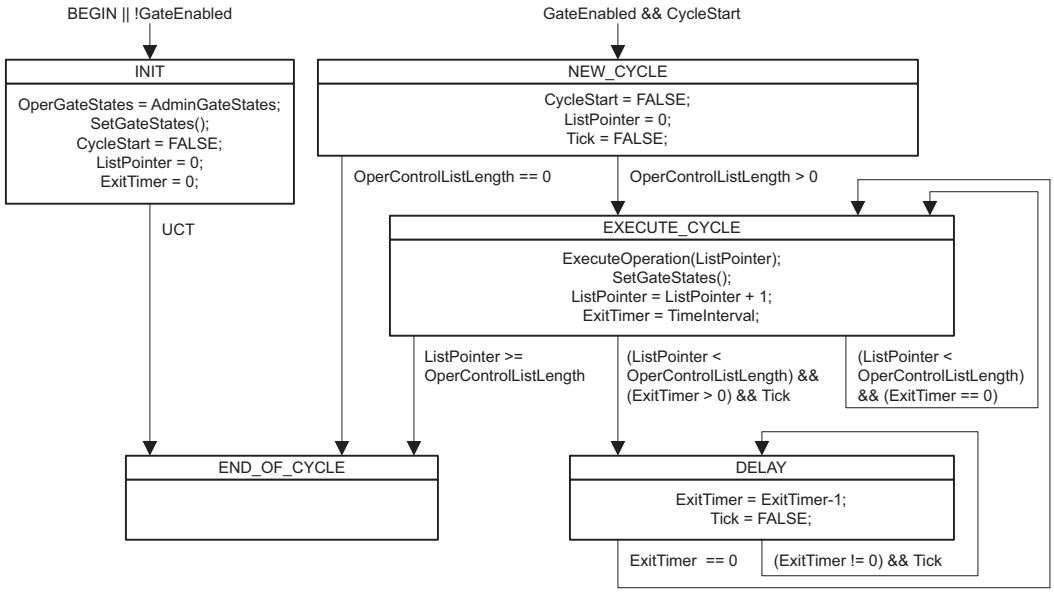


Figure 8-20—List Execute state machine

8.6.9.2.1 ExecuteOperation()

The ExecuteOperation() procedure is responsible for fetching the next gate operation from the OperControlList, along with any parameters associated with it, and performing actions based upon the gate operation that has been fetched. The value of the ListPointer variable (8.6.9.4.15) is used as an index into OperControlList. The procedure processes the operation according to its operation name (Table 8-7) as follows:

a) If the operation name is SetGateStates, then the GateState parameter value associated with the operation is assigned to the OperGateStates variable (8.6.9.4.21), and the TimeInterval parameter value associated with the operation is assigned to the TimeInterval variable (8.6.9.4.23). If the TimeInterval parameter value associated with the operation was 0, the TimeInterval variable is assigned the value 1.
b) If the operation name is unrecognized, then the ListPointer variable (8.6.9.4.15) is assigned the value of the OperControlListLength variable (8.6.9.4.22) and the TimeInterval variable (8.6.9.4.23) is assigned the value 0.
c) If there is no TimeInterval parameter associated with the operation, then the TimeInterval variable is assigned the value 0.

8.6.9.2.2 SetGateStates()

This procedure sets the gate state for each of the Port's queues as specified by the value of the OperGateStates variable (8.6.9.4.21).

NOTE—If the OperGateStates value differs from the previous gate states, the SetGateStates() procedure causes gate-open and/or gate-close events to occur (3.99, 3.100). It is possible that, on a given queue, the maximum time interval between any gate-open event and a subsequent gate-close event is smaller than the value of queueMaxSDU, in

which case, frames that are too long to transmit but are shorter than queueMaxSDU could be queued on that queue. Such frames would never be transmitted, but would eventually be discarded because they exceed the maximum frame lifetime (6.5.2, 6.5.6). It should also be noted that a Bridge is allowed to discard frames that could never be transmitted [item b8) in 6.5.2].

8.6.9.3 List Config state machine

The List Config state machine shall implement the function specified by the state diagram in Figure 8-21 and the attendant definitions in 8.6.9.3.1 and 8.6.9.4.

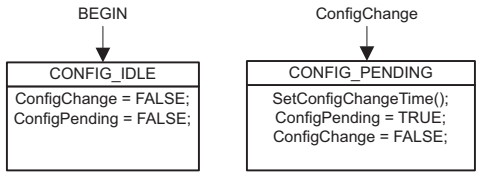


Figure 8-21—List Config state machine

8.6.9.3.1 SetConfigChangeTime()

The SetConfigChangeTime() procedure determines the time at which the administrative values of the cycle configuration variables are to be copied across to the operational variables. The procedure sets the ConfigChangeTime variable (8.6.9.4.9) to the start time, based upon the values of AdminBaseTime (8.6.9.4.1) and AdminCycleTime (8.6.9.4.3), according to the following rules:

a) If:
AdminBaseTime >= CurrentTime (8.6.9.4.10)
(i.e., AdminBaseTime specifies the current time or a future time)
Then:
ConfigChangeTime = AdminBaseTime

b) If:
(AdminBaseTime < CurrentTime) and (GateEnabled = FALSE)
(i.e., AdminBaseTime specifies a time in the past, and the current schedule is stopped)
Then:
ConfigChangeTime = (AdminBaseTime + N*AdminCycleTime)
where N is the smallest integer for which the relation
ConfigChangeTime >= CurrentTime
would be TRUE.

c) If:
(AdminBaseTime < CurrentTime) and (GateEnabled = TRUE)
(i.e., AdminBaseTime specifies a time in the past, and the current schedule is running)
Then:
Increment ConfigChangeError counter (12.29.1)
ConfigChangeTime = (AdminBaseTime + N*AdminCycleTime)
where N is the smallest integer for which the relation
ConfigChangeTime >= CurrentTime
would be TRUE.

8.6.9.4 State machine variables

8.6.9.4.1 AdminBaseTime

The administrative value of base time, expressed as an IEEE 1588 precision time protocol (PTP) [B15] timescale (see IEEE Std 802.1AS™). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperBaseTime (8.6.9.4.17).

NOTE—Time is expressed in the PTP timescale as the number of seconds, nanoseconds, and fractional nanoseconds that have elapsed since 1 January 1970 00:00:00 TAI.

8.6.9.4.2 AdminControlList

The administrative version of the gate control list for the Port. This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperControlList (8.6.9.4.18).

8.6.9.4.3 AdminCycleTime

The administrative value of the duration of the gating cycle for the Port (3.101). This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperCycleTime (8.6.9.4.19). The AdminCycleTime variable is a rational number of seconds, defined by an integer numerator and an integer denominator.

8.6.9.4.4 AdminCycleTimeExtension

An integer number of nanoseconds, defining the maximum amount of time by which the gating cycle for the Port (3.101) is permitted to be extended when a new cycle configuration is being installed. This administrative value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperCycleTimeExtension (8.6.9.4.20).

8.6.9.4.5 AdminGateStates

The initial state of the gate associated with each queue for the Port is set by the List Execute state machine (8.6.9.2), and is determined by the value of the AdminGateStates variable. The default value of AdminGateStates is *open* for all queues. The value of AdminGateStates can be changed by management.

8.6.9.4.6 AdminControlListLength

This value can be changed by management, and is used by the List Config state machine (8.6.9.3) to set the value of OperControlListLength (8.6.9.4.22).

8.6.9.4.7 ConfigChange

A Boolean variable that acts as a start signal to the List Config state machine (8.6.9.3) that the administrative variable values for the Port are ready to be copied into their corresponding operational variables. This variable is set TRUE by management and is set FALSE by the List Config state machine.

8.6.9.4.8 ConfigPending

A Boolean variable, set TRUE by the List Config state machine (8.6.9.3) to signal that there is a new cycle configuration awaiting installation. The variable is set FALSE when the List Config state machine has installed the new configuration. The variable is used by the Cycle Timer state machine (8.6.9.1) to control the length of the cycle that immediately precedes the first cycle that uses the new configuration values. This value can be read by management, as specified in 12.29.1.

8.6.9.4.9 ConfigChangeTime

The time at which the administrative variables that determine the cycle are to be copied across to the corresponding operational variables, expressed as a PTP timescale. The value of this variable is set by the SetConfigChangeTime() procedure (8.6.9.3.1) in the List Config state machine (8.6.9.3).

8.6.9.4.10 CurrentTime

The current time maintained by the local system, expressed as a PTP timescale (see IEEE Std 802.1AS).

NOTE 1—Other sources of times can be used to provide a value for the time. The implementation has to ensure that the same view of time is shared by the implementation and whatever entity is responsible for establishing the time schedule. The described mechanisms will work also with other formats of time.

NOTE 2—A discontinuity in time will have a predictable effect upon the operation of the state machines, as a consequence of their definitions. The implementer and/or user is advised to understand what those effects could be, and either limit such discontinuities or ensure that the results will not adversely affect the application.

8.6.9.4.11 CycleStart

A Boolean variable used as a signal from the Cycle Timer state machine (8.6.9.1) to the List Execute state machine to start executing the gate control list. Set TRUE by the Cycle Timer state machine and set FALSE by the List Execute state machine (8.6.9.2).

8.6.9.4.12 CycleStartTime

The time at which the next gate control list execution cycle is to start, expressed as a PTP timescale. The value of this parameter is set by the Cycle Timer state machine (8.6.9.1).

8.6.9.4.13 ExitTimer

A timer that implements the delay associated with the currently executing gate operation, expressed as an integer number of nanoseconds. The value is set by the operation of the List Execute state machine (8.6.9.2).

8.6.9.4.14 GateEnabled

A Boolean variable that indicates whether the operation of the state machines is enabled (TRUE) or disabled (FALSE). This variable is set by management. The default value of this variable is FALSE.

8.6.9.4.15 ListPointer

An integer used as a pointer to entries in the OperControlList (8.6.9.4.18), each entry consisting of a gate operation with its associated parameters (Table 8-7). A value of zero points at the first entry in the list; a value of (OperControlListLength – 1) points at the last entry.

8.6.9.4.16 Tick

A Boolean variable, set to TRUE by an implementation-specific system clock function at one nanosecond intervals, that controls the decrementing of the ExitTimer variable (8.6.9.4.13). This variable is set FALSE by the operation of the List Execute state machine (8.6.9.2).

NOTE—While the state machine is documented on the basis of a nanosecond clock "tick," it is anticipated that real implementations will use a wide variety of clocks that differ in frequency accuracy and granularity. Hence, the management parameters specified in 12.29 allow a management station to discover the characteristics of an implementation's cycle timer clock (TickGranularity) and to set the parameters for the gating cycle accordingly.

8.6.9.4.17 OperBaseTime

The operational value of base time, expressed as a PTP timescale (see IEEE Std 802.1AS). This variable is used by the List Config state machine (8.6.9.3).

8.6.9.4.18 OperControlList

The active Gate Control List for the Port; the List Execute state machine executes this list. This list is populated dynamically from the AdminControlList (8.6.9.4.2) under the control of the List Config state machine (8.6.9.3).

8.6.9.4.19 OperCycleTime

The operational value of the duration of the gating cycle for the Port (3.101). This variable is set dynamically from the AdminCycleTime variable (8.6.9.4.3) under the control of the List Config state machine (8.6.9.3). OperCycleTime is used by the Cycle Timer state machine (8.6.9.1) to enforce the cycle time for the Port. The OperCycleTime variable is a rational number of seconds, defined by an integer numerator and an integer denominator.

8.6.9.4.20 OperCycleTimeExtension

An integer number of nanoseconds, defining the maximum amount of time by which the gating cycle for the Port (3.101) is permitted to be extended when a new cycle configuration is installed. This operational value is set by the List Config state machine (8.6.9.3) to the value of AdminCycleTimeExtension (8.6.9.4.4). The value of OperCycleTimeExtension is used by the Cycle Timer state machine (8.6.9.1).

8.6.9.4.21 OperGateStates

The current state of the gate associated with each queue for the Port. OperGateStates is set by the List Execute state machine (8.6.9.2), and its initial value is determined by the value of the AdminGateStates variable (8.6.9.4.5).

8.6.9.4.22 OperControlListLength

This variable is set dynamically from the AdminControlListLength parameter (8.6.9.4.6) under the control of the List Config state machine (8.6.9.3). OperControlListLength indicates the number of entries in the OperControlList and is used by the List Execute state machine (8.6.9.2) to determine when the end of the list has been reached.

8.6.9.4.23 TimeInterval

Set to the value of the TimeInterval parameter associated with the currently executing gate operation. Used in the operation of the List Execute state machine (8.6.9.2).

8.6.10 Stream gate control state machines

The execution of the gate operations in a stream gate control list (8.6.5.4) is controlled by the three state machines specified in 8.6.9:

a) The Cycle Timer state machine (8.6.9.1)
b) The List Execute state machine (8.6.9.2)
c) The List Config state machine (8.6.9.3)

One instance of each state machine is instantiated for each stream gate control list associated with instances of stream gates in a Bridge component that supports stream gates. An overview of the operation of these state machines can be found in Figure 8-18.

The operation of these state machines is as defined in 8.6.9, with the exception of the definitions of the ExecuteOperation() procedure, the SetGateStates() procedure, the ListPointer variable, the AdminGateStates variable, and the OperGateStates variable; amended versions of these definitions appear in 8.6.10.1 through 8.6.10.5. Table 8-8 shows the correspondence between the procedures/variables used in 8.6.9 and the stream gate versions of these procedures/variables.

Three additional variables needed by the ExecuteStreamGateOperation procedure are defined in 8.6.10.6 and 8.6.10.7.

Table 8-8—Scheduled Traffic and Stream Gate procedures/variables

Procedure/variable name in 8.6.9	StreamGate procedure/variable name
ExecuteOperation() (8.6.9.2.1)	ExecuteStreamGateOperation() (8.6.10.1)
SetGateStates() (8.6.9.2.2)	SetStreamGateStates() (8.6.10.2)
ListPointer (8.6.9.4.15)	StreamGateListPointer (8.6.10.3)
AdminGateStates (8.6.9.4.5)	StreamGateAdminGateStates (8.6.10.4)
OperGateStates (8.6.9.4.21)	StreamGateOperGateStates (8.6.10.5)

8.6.10.1 ExecuteStreamGateOperation()

The ExecuteStreamGateOperation() procedure is responsible for fetching the next gate operation from the OperControlList, along with any parameters associated with it, and performing actions based upon the gate operation that has been fetched. The value of the StreamGateListPointer variable (8.6.9.2.2) is used as an index into OperControlList. The procedure processes the operation according to its operation name (Table 8-4) as follows:

a) If the operation name is SetGateAndIPV, then the StreamGateState parameter value associated with the operation is assigned to the StreamGateOperGateStates variable (8.6.10.5), the IPV parameter value is assigned to the OperIPV variable (8.6.10.7), and the TimeInterval parameter value associated with the operation is assigned to the TimeInterval variable (8.6.9.4.23). If the TimeInterval parameter value associated with the operation was 0, the TimeInterval variable is assigned the value 1. If there is an IntervalOctetMax parameter associated with the gate operation, then that parameter value is used to set the value of the IntervalOctetsLeft variable (8.6.10.8); otherwise, the IntervalOctetsLeft variable is set to a value greater than the maximum possible number of octets that the gate could pass during TimeInterval.
b) If the operation name is unrecognized, then the StreamGateListPointer variable (8.6.9.4.15) is assigned the value of the OperControlListLength variable (8.6.9.4.22) and the TimeInterval variable (8.6.9.4.23) is assigned the value 0.
c) If there is no TimeInterval parameter associated with the operation, then the TimeInterval variable is assigned the value 0.

8.6.10.2 SetStreamGateStates()

This procedure sets the stream gate state as specified by the value of the StreamGateOperGateStates variable (8.6.9.4.21).

8.6.10.3 StreamGateListPointer

An integer used as a pointer to entries in the OperControlList (8.6.9.4.18), each entry consisting of a stream gate control operation with its associated parameters (Table 8-4). A value of zero points at the first entry in the list; a value of (OperControlListLength – 1) points at the last entry.

8.6.10.4 StreamGateAdminGateStates

The initial state of the gate associated with the stream gate is set by the List Execute state machine (8.6.9.2) and is determined by the value of the StreamGateAdminGateStates variable. The default value of StreamGateAdminGateStates is open. The value of StreamGateAdminGateStates can be changed by management.

8.6.10.5 StreamGateOperGateStates

The current state of the gate associated with the stream gate. StreamGateOperGateStates is set by the List Execute state machine (8.6.9.2), and its initial value is determined by the value of the StreamGateAdminGateStates variable (8.6.10.4).

8.6.10.6 AdminIPV

The initial value of the OperIPV variable (8.6.10.7) associated with the stream gate is determined by the value of the AdminIPV variable. The default value of AdminIPV variable is the null value. The value of the AdminIPV variable can be changed by management.

8.6.10.7 OperIPV

The current value of the IPV associated with the stream gate. The initial value of OperIPV is set equal to the value of the AdminIPV variable (8.6.10.6) by the Cycle Timer state machine (8.6.9.1) with the operational cycle configuration variables when the state machines are initialized, when GateEnabled (8.6.9.4.14) is FALSE, and at ConfigChange Time (8.6.9.4.9). Subsequently, if there is a stream gate control list associated with the stream gate instance, its value is controlled by the contents of the operational stream gate control list and the operation of the List Execute state machine (8.6.9.2).

8.6.10.8 IntervalOctetsLeft

The current value of the IntervalOctetsLeft parameter indicates how many more MSDU octets can be passed by the stream gate during the current TimeInterval. This variable is initialized by the ExecuteStreamGateOperation() procedure (8.6.10.1). If a frame that would otherwise pass the gate is larger than the current value of IntervalOctetsLeft, it is treated as if the gate is in the *closed* state; i.e., it is discarded. If a frame that would otherwise pass the gate is smaller than the current value of IntervalOctetsLeft, the number of MSDU octets is subtracted from the value of IntervalOctetsLeft.

8.6.11 ATS Scheduler state machines

The ATS scheduler state machine operation is based on the ATS scheduler clocks (8.6.11.1), which is in relationship to transmission selection clocks (8.6.8.5). The state machine operation is specified by the ProcessFrame(frame) procedure (8.6.11.3) and the therein used state variables (8.6.11.3.3, 8.6.11.3.10). Parameters used by the ProcessFrame(frame) procedure are as defined in 8.6.5.6. Each arriving frame causes invocation of the ProcessFrame(frame) procedure.

8.6.11.1 ATS Scheduler Clocks

An ATS scheduler clock is an implementation specific local system clock function. It is used to determine the arrival time of frames (8.6.11.3.1). A Bridge component may utilize one or more ATS scheduler clock instances. In the case of multiple scheduler clock instances, all ATS scheduler instances associated with the same reception Port share the same ATS scheduler clock instance (i.e., the arrival time of all frames received from a particular reception port is determined by the same ATS scheduler clock instance).

8.6.11.2 Relationship between ATS Scheduler Clocks and Transmission Selection Clocks

ATS scheduler clocks and transmission selection clocks (8.6.8.5) run at the same long term rate with bounded offset variation. A difference between an arbitrary instant of time t_{FA}, as recognized by an ATS scheduler clock instance, and the same instant of time t_{TS}, as recognized by a transmission selection clock instance, may be observed during the processing of a frame. The time difference may vary over a sequence of frames, which is characterized by the following equation:

$$\text{ClockOffsetMin} \leq t_{TS} - t_{FA} \leq \text{ClockOffsetMax}$$

where ClockOffsetMin and ClockOffsetMax are implementation specific constants that limit the variation. The range is characterized by ClockOffsetVariationMax (12.31.8.3) as follows:

$$\text{ClockOffsetVariationMax} = \text{ClockOffsetMax} - \text{ClockOffsetMin}$$

NOTE 1—ClockOffsetMin and ClockOffsetMax capture implementation specific properties such as the resolution of the associated clocks, associated rounding errors, constant offsets between clocks, Bridge-internal synchronization inaccuracies in presence of different underlying oscillators, and similar.

A pair of a scheduler clock instance and a transmission selection clock instance has an implementation specific nominal rate, and a maximal absolute deviation from this nominal rate during operation, as characterized by the ClockRateDeviationMax parameter (Clause 12.31.8.4).

NOTE 2—ClockRateDeviationMax captures implementation specific properties such as oscillator rate deviation, numeric resolution for the operations specified in 8.6.11.3, and similar.

NOTE 3—ATS scheduler clocks and transmission selection clocks provide a model to express different sources of delay, delay variation, and inaccuracy. It is not required to implement different multiple physical oscillators/clocks (i.e., ATS scheduler clocks and transmission selection clocks can actually be the same physical clock or can be generated from the same oscillator), but the model captures the properties of implementations with and without different physical oscillators/clocks in a unified manner.

8.6.11.3 ProcessFrame(frame)

This procedure computes eligibility time, assigns the eligibility times to frames, and updates the ATS scheduler state machine variables.

The procedure is described by the following pseudo-code in a neutral manner: The arithmetic precision, and the resolution of variables, are implementation specific, unless externally visible by management (12.31). The impact of the associated inaccuracies is discussed in Annex V.

```
ProcessFrame(frame) {
       lengthRecoveryDuration     = length(frame)/
                                    CommittedInformationRate;
       emptyToFullDuration        = CommittedBurstSize/
                                    CommittedInformationRate;
       schedulerEligibilityTime   = BucketEmptyTime +
                                    lengthRecoveryDuration;
       bucketFullTime             = BucketEmptyTime +
                                    emptyToFullDuration;
       eligibilityTime            = max(arrivalTime(frame),
                                        GroupEligibilityTime,
                                        schedulerEligibilityTime);

       if (eligibilityTime <= (arrivalTime(frame) + MaxResidenceTime/1.0e9)){
              // The frame is valid
              GroupEligibilityTime = eligibilityTime;
              BucketEmptyTime      = (eligibilityTime < bucketFullTime) ?
                     schedulerEligibilityTime :
                     schedulerEligibilityTime + eligibilityTime – bucketFullTime;
              AssignAndProceed(frame,eligibilityTime);
       } else {
              // The frame is invalid
              Discard(frame);
       }
}
```

8.6.11.3.1 arrivalTime(frame)

The arrival time of the frame, in seconds. The arrival time refers to the instant of time at which the associated ATS scheduler clock instance recognizes the arrival of the entire frame.

The point at which this recognition happens on the path between reception Ports and transmission Ports is implementation dependent. The earliest option is when the frame passes the boundary between the network physical medium and a reception Port, the latest option is during invocation of the ProcessFrame procedure.

For all frames arriving at all reception Ports, the arrival time is determined relative to the frame end. The maximum delay between the time a frame passes the boundary between the network physical medium and its subsequent recognition by the associated ATS scheduler clock instance is implementation specific, and is characterized by the ArrivalRecognitionDelayMax parameter (12.31.8.5).

The order of all frames associated with one ATS scheduler group at the boundary between the network physical medium and a reception Port is the same as the order of the arrival times determined for these frames.

NOTE—For example, the arrival time of frames may be determined based on invocation of the M_UNITDATA.indication service primitive of the ISS (6.6), as specified in IEEE Std 802.1AC.

8.6.11.3.2 AssignAndProceed(frame,eligibilityTime)

This procedure calculates an assigned eligibility time parameter (assignedEligibilityTime) that is used by the ATS transmission selection algorithm (8.6.8.5).

The assignedEligibilityTime is derived from the eligibilityTime parameter. Its calculation accounts for variations between the associated ATS scheduler clock and transmission selection clock instances, and for processing delays through the forwarding process, as detailed in the following.

Any frame may experience an additional, non-negative, processing delay, between its arrival time recognition by the associated ATS scheduler clock instance and the time at which it is queued and becomes available for transmission selection (8.6.8.5). This delay may vary per frame, thus that there is a delay variation over a sequence of frames. The processing delay is characterized by the following equation:

$$\text{ProcessingDelayMin} \leq \text{processingDelay(frame)} \leq \text{ProcessingDelayMax}$$

where ProcessingDelayMin (12.31.8.6) and ProcessingDelayMax (12.31.8.7) are implementation specific parameters, and processingDelay(frame) denotes the processing delay of an actual frame, including any potential delay introduced by the operation of the associated ATS scheduler state machine instance.

The assigned eligibility time is calculated as follows:

$$\text{assignedEligibilityTime} = \text{eligibilityTime} + \text{ClockOffsetMin} + \text{ProcessingDelayMax}$$

8.6.11.3.3 BucketEmptyTime

A variable that embodies the current state of the ATS scheduler instance.This variable is initialized with a time earlier than CommittedBurstSize/CommittedInformationRate in the past, as perceived by the ATS Scheduler Clock.

8.6.11.3.4 bucketFullTime

A temporary variable used when updating BucketEmptyTime after determining a frame’s schedulerEligibilityTime. The prior value of BucketEmptyTime plus the emptyToFullDuration.

8.6.11.3.5 CommittedBurstSize

The committed burst size of the ATS scheduler instance, in bits (8.6.5.6).

8.6.11.3.6 CommittedInformationRate

The committed information rate of the ATS scheduler instance, in bits per second (8.6.5.6).

8.6.11.3.7 Discard(frame)

This procedure discards the frame and increases the DiscardedFramesCount counter of the associated reception port (8.6.5.6). The procedure is called in exceptional situations only (e.g., misbehavior of the connected upstream system).

8.6.11.3.8 eligibilityTime

The eligibility time of the frame, without taking the implementation specific device-internal timing properties of the forwarding process into account. These timing properties are taken into account by the AssignAndProceed(frame) procedure (8.6.11.3.2).

8.6.11.3.9 emptyToFullDuration

The duration CommittedBurstSize/CommittedInformationRate.

8.6.11.3.10 GroupEligibilityTime

A state variable that contains the most recent value of the eligibilityTime variable from the previous frame, as processed by any ATS scheduler instance in the same ATS scheduler group, in seconds.

The GroupEligibilityTime variable is initialized with a time earlier or equal to the current time, as perceived by the ATS scheduler clock.

8.6.11.3.11 length(frame)

The length of the frame, including all media-dependent overhead (12.4.2.2), in bits.

8.6.11.3.12 lengthRecoveryDuration

The duration length(frame)/CommittedInformationRate.

8.6.11.3.13 MaxResidenceTime

The MaximumResidenceTime parameter of the ATS scheduler group instance associated with the ATS scheduler instance, in nanoseconds (8.6.5.6). The parameter limits the duration for which frames can reside in a Bridge.

NOTE—A consistent setup of MaxResidenceTime parameter can be determined by the per hop delay bound, which is a result of the timing analysis (Annex V).

8.6.11.3.14 schedulerEligibilityTime

A temporary variable used in the calculation of a frame’s eligibilityTime. The prior value of BucketEmptyTime plus the lengthRecoveryDuration for the frame.

8.7 The Learning Process

The Learning Process receives the source MAC addresses and VIDs, or only the source MAC addresses in the case of VLAN-unaware MAC Relays, of received frames from the Forwarding Process, subject to active topology enforcement (8.6.1) and the application of ingress filtering (8.6.2). The Learning Process is not invoked (8.6.1) for frames whose VID is an ESP-VID or identifies a VLAN supported by SPBM.

When invoked, the Learning Process shall create or update a Dynamic Filtering Entry (8.8.3) that specifies the reception Port for the frame's source address and, in the case of VLAN Bridge components, the frame's VID, if and only if the source address is an individual address, i.e., is not a group address, the resulting number of entries would not exceed the capacity of the FDB, and the filtering utility criteria for the receiving Bridge Port are met, as specified below.

If the FDB is already filled to capacity, but a new entry would otherwise be made, then an existing entry may be removed to make room for the new entry.

The purpose of filtering utility criteria is to reduce the capacity requirements of the FDB and to reduce the time for which service can be denied (6.5.1) by retaining filtering information learned prior to a change in the physical topology of the network. Filtering utility criteria shall be applied to the learning and retention of information for each FID (8.8.8). In Bridges other than EVB Bridges (5.23), enhanced filtering utility criteria may be implemented for any Bridge Port as specified below (8.7.2); if implemented, both the default (8.7.1) and the enhanced criteria shall be selectable by management. In EVB Bridges, the enhanced filtering utility criteria shall be implemented for all Bridge Ports, and the default filtering utility criteria shall not be implemented.

Figure 8-5 illustrates the operation of the Learning Process in the inclusion of station location information carried by a single frame, received on one of the Ports of a Bridge, in the FDB.

8.7.1 Default filtering utility criteria

The default for a VLAN Bridge is that the member set (8.8.10) for the frame's VID includes at least one Port.

NOTE—If the member set for a given VID is empty, that VID is not currently active, and the Bridge will filter all frames destined for that VID, regardless of their destination address.

The default filtering utility criteria are always met for MAC Bridges.

8.7.2 Enhanced filtering utility criteria

For a VLAN Bridge, the enhanced criteria are satisfied if at least one VID that uses the FID includes the reception Port and at least one other Port with a Port State of Learning or Forwarding in its member set, and:

a) The operPointToPointMAC parameter is FALSE for the reception Port, or
b) Ingress for the VID is permitted through a third Port, or
c) The reception Port has reflective relay enabled (40.4.2).

NOTE—The third port can, but is not required to, be in the member set.

For a MAC Bridge, the enhanced criteria are satisfied if there exists at least one Port different than the reception Port with a Port State of Learning or Forwarding, and:

d) The operPointToPointMAC parameter is FALSE for the reception Port, or
e) There exists third Port with a Port State of Learning or Forward, or
f) The reception Port has reflective relay enabled (40.4.2).

8.7.3 Ageing of Dynamic Filtering Entries

Dynamic Filtering Entries shall be automatically removed after a specified time, the Ageing Time, has elapsed since the entry was created or last updated by the Learning Process.

The ageing out of Dynamic Filtering Entries ensures that end stations that have been moved to a different part of the network will not be permanently prevented from receiving frames. It also takes account of changes in the active topology of the network that can cause end stations to appear to move from the point of view of the Bridge; i.e., the path to those end stations subsequently lies through a different Bridge Port.

The Ageing Time may be set by management (Clause 12). A range of applicable values and a recommended default is specified in Table 8-9; this is suggested to remove the need for explicit configuration in most cases. If the value of Ageing Time can be set by management, the Bridge shall have the capability to use values in the range specified, with a granularity of 1 s.

Table 8-9—Ageing time parameter value

Parameter	Recommended default value	Range
Ageing time	300.0 s	10.0–1 000 000.0 s

NOTE—The granularity is specified in order to establish a common basis for the granularity expressed in the management operations defined in Clause 12, not to constrain the granularity of the actual timer supported by a conformant implementation. If the implementation supports a granularity other than 1 s, then it is possible that the value read back by management following a Set operation will not match the actual value expressed in the Set.

The STP specified in Clause 8 of IEEE Std 802.1D, 1998 Edition [B11], includes a procedure for notifying all Bridges in the network of topology change. It specifies a short value for the Ageing Timer, to be enforced for a period after any topology change (8.3.5 of IEEE Std 802.1D, 1998 Edition [B11]). While the topology is not changing, this procedure allows normal ageing to accommodate extended periods during which addressed end stations do not generate frames themselves, perhaps through being powered down, without sacrificing the ability of the network to continue to provide service after automatic configuration.

8.8 The Filtering Database (FDB)

The FDB supports queries by the Forwarding Process to determine whether received frames, with given values of, destination MAC address, and for VLAN Bridge components, VID, are to be forwarded through a given potential transmission Port (8.6.1, 8.6.3, 8.6.4). It can also be used, by SPBM (8.6.1), to determine whether received frames with given values of source B-MAC address and B-VID, are to be forwarded from a given reception Port. The FDB contains filtering information in the form of filtering entries that are either:

a) Static, and explicitly configured by management action; or
b) Dynamic, and automatically entered into the FDB by the normal operation of the Bridge and the protocols it supports.

Two entry types are used to represent static filtering information. The Static Filtering Entry represents static information in the FDB for individual and for group MAC addresses. It allows administrative control of:

c) Forwarding of frames with particular destination addresses.
d) The inclusion in the FDB of dynamic filtering information associated with Extended Filtering Services, and use of this information.

The FDB shall contain entries of the Static Filtering Entry type.

The Static VLAN Registration Entry represents all static information in the FDB for VLANs. It allows administrative control of:

e) Forwarding of frames with particular VIDs.
f) The inclusion/removal of tag headers in forwarded frames.
g) The inclusion in the FDB of dynamic VLAN membership information, and use of this information.

The FDB associated with VLAN Bridge components may contain entries of the Static VLAN Registration Entry type. The Static VLAN Registration Entry type is not applicable to MAC Bridge components.

Static filtering information is added to, modified, and removed from the FDB only under explicit management control except when PBB-TE IPS is deployed, in which case the static filtering information for traffic associated with IPGs configured on the Bridge is added to, modified, and removed from the FDB only under the direction of IPS Control (26.11.3). It shall not be automatically removed by any ageing mechanism. Management of static filtering information may be carried out by use of the remote management capability provided by Bridge Management (8.12) using the operations specified in Clause 12.

Four entry types are used to represent dynamic filtering information:

h) Each Dynamic Filtering Entry specifies the Port through which a frame with a given individual MAC address, and in the case of VLAN Bridge components, VID, has been or can be received. Dynamic Filtering Entries can be created and updated by the Learning Process (8.7) and by ISIS-SPB. Entries that are updated by the Learning Process are subject to ageing and removal by the FDB.

NOTE 1—ISIS-SPB has to create the Dynamic Filtering Entries for VLANs supported by SPBM, since learning is not used. Initial creation of these entries does no harm for VLANs supported by SPBV (when learning is used) as it can reduce flooding of frames to unknown destinations.

i) MAC Address Registration Entries support the registration of MAC addresses. They are created, updated, and removed by MMRP in support of Extended Filtering Services (8.8.4 and Clause 10) and by ISIS-SPB. If the Restricted_MAC_Address_Registration management control (10.12.2.3) is TRUE, then the creation of a MAC Address Registration Entry by MMRP is not permitted unless a Static Filtering Entry exists that permits dynamic registration for the Group concerned.
j) Dynamic VLAN Registration Entries are used to specify the Ports on which VLAN membership has been dynamically registered. They are not applicable to MAC Bridge components. They are created, updated, and removed by MVRP, MIRP, and ISIS-SPB, in support of automatic VLAN membership configuration (Clause 11 and Clause 39). The MVRP controlled Dynamic VLAN Registration Entries are subject to the state of the Restricted_VLAN_Registration management control (11.2.3.2.3). If the value of this control is TRUE, then the creation of a Dynamic VLAN Registration Entry is not permitted unless a Static VLAN Registration Entry exists that permits dynamic registration for the VID concerned.
k) Dynamic Reservation Entries are used to specify the Ports on which stream reservations have been made. They are created, updated, and removed by the operation of SRP defined in Clause 35.

Static Filtering Entries and MAC Address Registration Entries comprise:

l) A MAC address specification.
m) A VID.
n) A Port Map, with a control element for each outbound Port to specify filtering for, that MAC address specification, and in the case of VLAN Bridge components, that VID.

Item m), and any reference to VIDs, are not applicable to MAC Bridge components.

Dynamic Filtering Entries comprise:

o) A MAC address specification.
p) A locally significant FID (see 8.8.8).
q) A Port Map, with a control element for each outbound Port to specify filtering for, that MAC address specification, and in the case of VLAN Bridge components, for the VID(s) allocated to that FID.

Item p) and any reference to VIDs and FIDs are not applicable to MAC Bridge components.

The Port Map in Static and Dynamic Filtering Entries may contain a **connection_identifier** (8.8.12) for each outbound Port.

Static and Dynamic VLAN Registration Entries comprise:

r) A VID.
s) A Port Map, with a control element for each outbound Port to specify filtering for the VID.

Static and Dynamic VLAN Registration Entries are not applicable to MAC Bridge components.

Dynamic Reservation Entries comprise:

t) A MAC address specification.
u) A VID.
v) A Port Map, with a control element for each outbound Port to specify filtering for that MAC address specification, and in the case of VLAN Bridge components, in the VLAN specified by the VID.

Dynamic filtering information may be read by use of the remote management capability provided by Bridge Management (8.12) using the operations specified in Clause 12.

The Filtering Services supported by a Bridge (Basic and Extended Filtering Services) determine the default behavior of the Bridge with respect to the forwarding of frames destined for group MAC addresses. In Bridges that support Extended Filtering Services, the default forwarding behavior for group MAC addresses, for each Port, and for each VID, can be configured both statically and dynamically by means of Static Filtering Entries and/or MAC Address Registration Entries that can carry the following MAC address specifications:

w) All Group Addresses, for which no more specific Static Filtering Entry exists.
x) All Unregistered Group Addresses (i.e., all group MAC addresses for which no MAC Address Registration Entry exists), for which no more specific Static Filtering Entry exists.

NOTE 2—The All Group Addresses specification in item w), when used in a Static Filtering Entry with an appropriate control specification, provides the ability to configure a Bridge that supports Extended Filtering Services to behave as a Bridge that supports only Basic Filtering Services on some or all of its Ports. This might be done for the following reasons:

— The Ports concerned serve “legacy” devices that wish to receive multicast traffic, but are unable to register Group membership.
— The Ports concerned serve devices that need to receive all multicast traffic, such as routers or diagnostic devices.

The FDB shall support the creation, updating, and removal of Dynamic Filtering Entries by the Learning Process (8.7). In Bridges that support Extended Filtering Services, the FDB shall support the creation, updating, and removal of MAC Address Registration Entries by MMRP (Clause 10). In Bridges that support SPBM, Dynamic Filtering Entries are populated by ISIS-SPB (Clause 28). In Bridges that support SPBV the Dynamic Filtering Entries are created and updated by the Learning Process (8.7) and the use of ISIS-SPB for this operation is optional (28.12.9).

SPB (27.10) allocates SPVIDs dynamically to support shortest path bridging of frames assigned to one or more VLANs, each identified by a Base VID (Clause 3). A Static Filtering Entry should not be created for an SPVID, irrespective of whether that SPVID is currently used, and SPVIDs should not be used in registration protocols that create MAC Address Registration Entries or Dynamic VLAN Registration

Entries. In an SPT Bridge, configuration or registration of an FDB entry with the Base VID of a VLAN supported by SPBV shall cause the Bridge to filter frames as if that entry was also present for every one of the SPVIDs for that Base VID.

In Bridges that support SRP, the FDB shall support the creation, updating, and removal of Dynamic Reservation Entries by SRP (Clause 35).

Figure 8-4 illustrates use of the FDB by the Forwarding Process in a single instance of frame relay between the Ports of a Bridge with two Ports.

Figure 8-5 illustrates the creation or update of a dynamic entry in the FDB by the Learning Process. The entries in the FDB, associated with VLAN Bridge components, allow MAC address information to be learned independently for each VID or set of VIDs, by relating a MAC address to the VID or set of VIDs on which that address was learned.

NOTE 3—The ability to create VLAN-dependent FDB entries allows a VLAN Bridge to support multiple end stations with the same individual MAC address residing on different VLANs. It also supports end stations with multiple interfaces, each using the same individual MAC address, as long as not more than one end station or interface that uses a given MAC address resides in a given VLAN.

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity (8.10), which operates STP, and its notification of the FDB of changes in active topology signaled by that protocol.

There are no standardized constraints on the size of the FDB in an implementation for which conformance to this standard is claimed. The PICS proforma in Annex A requires the following to be specified for a given implementation:

y) The total number of entries (Static Filtering Entries, Dynamic Filtering Entries, MAC Address Registration Entries, Static VLAN Registration Entries, Dynamic VLAN Registration Entries, and Dynamic Reservation Entries) that the implementation of the FDB can support.
z) Of that total number, the total number of VLAN Registration Entries (static and dynamic) that the FDB can support.

8.8.1 Static Filtering Entries

A Static Filtering Entry specifies:

a) A MAC address specification, comprising
    1) An individual MAC address, or
    2) A group MAC address, or
    3) All Individual Addresses, for which no more specific Filtering Entry exists, or
    4) All Group Addresses, for which no more specific Static Filtering Entry exists, or
    5) All Unregistered Group Addresses, for which no more specific Static Filtering Entry exists.
b) A VID specification, comprising:
    1) The VID of a specific VLAN to which the static filtering information applies, or
    2) The wildcard VID (Table 9-2), indicating that the static filtering information applies to all VIDs for which no specific Static Filtering Entry exists.
c) A Port Map, containing a control element for each outbound Port, specifying that a frame with a destination MAC address, and in the case of VLAN Bridge components, VID that meets this specification is to be:
    1) Forwarded, independently of any dynamic filtering information held by the FDB, or
    2) Filtered, independently of any dynamic filtering information, or
    3) Forwarded or filtered on the basis of dynamic filtering information, or on the basis of the default Group filtering behavior for the outbound Port (8.8.6) if no dynamic filtering information is present specifically for the MAC address.

The Port Map may contain a connection_identifier (8.8.12) for each outbound Port.

MAC Bridges shall have the capability to support the first two values for the MAC address specification, and all three values for each control element for all Static Filtering Entries [i.e., shall have the capability to support item a1), item a2), item c1), item c2), and item c3)]. All VLAN Bridges shall have the capability to support the first two values for the MAC address specification, both values of the VID specification, and all three values for each control element for all Static Filtering Entries [i.e., shall have the capability to support item a1), item a2), item b1), item b2), item c1), item c2), and item c3)]. All Bridges supporting PBB-TE or SPT Bridges shall, in addition, support item a3) and item a4) for ESP-VIDs (8.9) or VIDs identifying VLANs supported by SPBM, respectively, and shall always have in their FDBs Static Filtering Entries specifying item a3) and item a4), and a Port Map specifying filtering for each outbound port, for every ESP-VID or SPBM VID, respectively.

A Bridge that supports Extended Filtering Services shall have the capability to support item a1), item a2), item a4), and item a5) for the MAC address specification and all three control element values for all Static Filtering Entries.

For a given MAC address specification, a separate Static Filtering Entry with a distinct Port Map may be created for each VID from which frames are received by the Forwarding Process.

In addition to controlling the forwarding of frames, Static Filtering Entries provide the Registrar Administrative Control values for MMRP (Clause 10). Static configuration of forwarding of a specific destination MAC address to an outbound port indicates Registration Fixed on that port, which indicates a desire to receive the specific frames even in the absence of dynamic information. Static configuration of filtering of frames that might otherwise be sent to an outbound port indicates Registration Forbidden. The absence of a Static Filtering Entry for a MAC address, or the configuration of forwarding or filtering on the basis of dynamic filtering information, indicates Normal Registration.

8.8.2 Static VLAN Registration Entries

A Static VLAN Registration Entry specifies:

a) The VID to which the static filtering information applies.
b) A Port Map, consisting of a control element for each outbound Port, specifying:
    1) The Registrar Administrative Control values for MVRP (Clause 11) and MIRP (Clause 39) for the VID. In addition to providing control over the operation of MVRP and MIRP, these values can also directly affect the forwarding behavior of the Bridge, as described in 8.8.10. The values that can be represented are:
        i) Registration Fixed (New ignored), or
        ii) Registration Fixed (New propagated), or
        iii) Registration Forbidden, or
        iv) Normal Registration.
    2) Whether frames are to be VLAN-tagged or untagged when transmitted. The entries in the Port Map that specify untagged transmission compose the untagged set for the VID. The untagged set is empty if no Static VLAN Registration Entry exists for the VID.

Static VLAN Registration Entries are not applicable to MAC Bridge components.

A separate Static VLAN Registration Entry with a distinct Port Map may be created for each VID. All Bridges shall be capable of supporting all values for each control element for all Static VLAN Registration Entries; however, the ability to support more than one untagged VID on egress on any given Port is optional (see 5.4).

NOTE 1—In other words, it is possible to configure any VID as untagged on egress, but it is not necessarily possible to configure more than one VID as untagged on egress. It is an implementation option about whether only a single

untagged VID per Port on egress is supported or whether multiple untagged VIDs per Port on egress are supported. When a single untagged VID per Port is supported, that VID is not necessarily the same as the PVID.

The initial state of the Permanent Database contains a Static VLAN Registration Entry for the VID corresponding to the Default PVID (Table 9-2). The Port Map in this entry specifies Registration Fixed and forwarding untagged for all Ports of the Bridge. This entry may be modified or removed from the Permanent Database by means of the management operations defined in Clause 12 if the implementation supports these operations.

NOTE 2—This initial state causes the default tagging state for the PVID to be untagged, and for all other VIDs to be tagged, unless otherwise configured; however, the management configuration mechanisms allow any VID (including the PVID) to be specified as VLAN-tagged or untagged on any Port.

NOTE 3—For VLANs supported by SPBV the Filtering specified by a static VLAN registration entry for the Base VID is applied for all SPVIDs associated with that Base VID.

8.8.3 Dynamic Filtering Entries

A Dynamic Filtering Entry specifies:

a) An individual MAC address.
b) The FID, an identifier assigned by the MAC Bridge (8.8.8) to identify a set of VIDs for which no more than one Dynamic Filtering Entry can exist for any individual MAC address.

   NOTE 1—An FID identifies a set of VIDs among which Shared VLAN Learning (SVL) (3.238) takes place. Any pair of FIDs identifies two sets of VIDs between which Independent VLAN Learning (IVL) (3.111) takes place. The allocation of FIDs by a Bridge is described in 8.8.8.

c) A Port Map specifying forwarding for the destination MAC address and FID to a single Port or, in the case of ECMP with flow filtering (44.1, 44.2), to a set of Ports from which one must be selected.

Item b), and any reference to FIDs and VIDs in the list above, are not applicable to MAC Bridge components.

The Port Map may contain a **connection_identifier** (8.8.12) for each outbound Port.

Dynamic Filtering Entries can be created, updated, and removed by the Learning Process (8.7). They shall be automatically removed after a specified time, the Ageing Time (8.7.3), has elapsed since the entry was created or last updated.

Dynamic Filtering Entries can also be created and updated by SPB (Clause 27). ISIS-SPB (Clause 28) refreshes these entries, so they are not aged out by the normal operation of the Learning Process. These entries are used by SPBM (Clause 27) to support both unicast loop mitigation (6.5.4.2) and multicast loop prevention (6.5.4.1) for active topology enforcement (8.6.1) as well as to locate end stations. Entries indicating a set of potential forwarding ports from which one must be selected are used by ECMP with flow filtering. SPBV updates Dynamic Filtering Entries by the normal Learning Process, but they may also be controlled by ISIS-SPB. This allows entries for the higher layer entities in a Bridge (see Figure 8-12) to be populated rapidly after any topology change.

No more than one Dynamic Filtering Entry shall be created in the FDB for a given combination of MAC address and FID. Dynamic Filtering Entries cannot be created or updated by management.

NOTE 2—Dynamic Filtering Entries may be read by management (Clause 12). In the case of VLAN Bridge components, the FID is represented in the management Read operation by any one of the VIDs that it represents. For a given VID, the set of VIDs that share the same FID may also be determined by management.

8.8.4 MAC Address Registration Entries

A MAC Address Registration Entry specifies:

a) A MAC address specification, comprising:
   1) An individual MAC address, or
   2) A group MAC address, or
   3) All Group Addresses, for which no more specific Static Filtering Entry exists, or
   4) All Unregistered Group Addresses, for which no more specific Static Filtering Entry exists.
b) The VID for which the dynamic filtering information was registered.
c) A Port Map, consisting of a control element for each outbound Port, which specifies forwarding (Registered) or filtering (Not registered) of frames destined to the MAC address and, in the case of VLAN Bridge components, the VID.

Item b) and any reference to VIDs, in the list above, are not applicable to MAC Bridge components.

MAC Address Registration Entries are created, modified, and deleted by the operation of MMRP (Clause 10) or by ISIS-SPB. No more than one MAC Address Registration Entry shall be created in the FDB for a given combination of MAC address specification and VID.

NOTE—It is possible to have a Static Filtering Entry that has values of Forward or Filter on some or all Ports that mask the dynamic values held in a corresponding MAC Address Registration Entry. The values in the MAC Address Registration Entry will continue to be updated by MMRP; hence, subsequent modification of that entry to allow the use of dynamic filtering information on one or more Ports immediately activates the true MMRP registration state that was hitherto masked by the static information.

The creation of MAC Address Registration Entries by MMRP is subject to the Restricted_MAC_Address_Registration management control (10.12.2.3). If the value of this control is TRUE, a dynamic entry for a given MAC address may only be created if a Static Filtering Entry already exists for that MAC address, in which the Registrar Administrative Control value is Normal Registration.

8.8.5 Dynamic VLAN Registration Entries

A Dynamic VLAN Registration Entry specifies:

a) The VID to which the dynamic filtering information applies.
b) A Port Map with a control element for each outbound Port specifying whether the VID is registered on that Port.

NOTE—Dynamic VLAN Registration Entries can be accessed by ingress ports or egress ports.

Dynamic VLAN Registration Entries are not applicable to MAC Bridge components.

A separate Dynamic VLAN Registration Entry with a distinct Port Map may be created for each VID from which frames are received by the Forwarding Process.

The creation of Dynamic VLAN Registration Entries is subject to the Restricted_VLAN_Registration management control (11.2.3.2.3). If the value of this control is TRUE, a dynamic entry for a given VID may only be created if a Static VLAN Registration Entry already exists for that VID, in which the Registrar Administrative Control value is Normal Registration.

8.8.6 Default Group filtering behavior

Forwarding and filtering of group-addressed frames may be managed by specifying defaults for each VID and outbound Port, or just outbound Ports in the case of MAC Bridges. The behavior of each of these defaults, as modified by the control elements of more explicit FDB entries applicable to a given frame's MAC address, VID, and outbound Port, is as follows:

NOTE 1—As stated in 8.8.1 for VLAN Bridge components, for a given MAC address, there may be separate Static Filtering Entries with a distinct Port Map for each VID.

a) *Forward All Groups.* The frame is forwarded, unless an explicit Static Filtering Entry specifies filtering independent of any dynamic filtering information.
b) *Forward Unregistered Groups.* The frame is forwarded, unless:
    1) An explicit Static Filtering Entry specifies filtering independent of any dynamic filtering information; or
    2) An explicit Static Filtering Entry specifies forwarding or filtering on the basis of dynamic filtering information, and an applicable explicit MAC Address Registration Entry exists specifying filtering; or
    3) An applicable explicit Static Filtering Entry does not exist, but an applicable MAC Address Registration Entry specifies filtering.
c) *Filter Unregistered Groups.* The frame is filtered unless:
    1) An explicit Static Filtering Entry specifies forwarding independent of any dynamic filtering information; or
    2) An explicit Static Filtering Entry specifies forwarding or filtering on the basis of dynamic filtering information, and an applicable explicit MAC Address Registration Entry exists specifying forwarding; or
    3) An applicable explicit Static Filtering Entry does not exist, but an applicable MAC Address Registration Entry specifies forwarding.

In Bridges that support only Basic Filtering Services, the default Group filtering behavior is Forward All Groups for all Ports of the Bridge, for all VIDs.

NOTE 2—Forward All Groups corresponds directly to the behavior specified in IEEE Std 802.1D, 1993 Edition [B10] when forwarding group MAC addressed frames for which no static filtering information exists in the FDB. Forward All Groups makes use of information contained in Static Filtering Entries for specific group MAC addresses, but overrides any information contained in MAC Address Registration Entries. Forward Unregistered Groups is analogous to the forwarding behavior of a Bridge with respect to individual MAC addresses. If there is no static or dynamic information for a specific group MAC address, then the frame is forwarded; otherwise, the frame is forwarded in accordance with the statically configured or dynamically learned information.

In Bridges that support Extended Filtering Services, the default Group filtering behavior for each outbound Port, and in the case of VLAN Bridge components, for each VID, is determined by the following information contained in the FDB:

d) Any Static Filtering Entries that are applicable to that VID in the case of VLAN Bridge components, with a MAC address specification of All Group Addresses or All Unregistered Group Addresses.
e) Any MAC Address Registration Entries that are applicable to that VID in the case of VLAN Bridge components, with a MAC address specification of All Group Addresses or All Unregistered Group Addresses.

The means whereby this information determines the default Group filtering behavior is specified in 8.8.9, Table 8-11, and Table 8-12.

NOTE 3—The result is that the default Group filtering behavior, applicable in the case of VLAN Bridge components for each VID, can be configured for each Port of the Bridge via Static Filtering Entries, determined dynamically via MAC Address Registration Entries created/updated by MMRP (Clause 10), or both. For example, in the absence of any static or dynamic information in the FDB for All Group Addresses or All Unregistered Group Addresses, the default Group filtering behavior will be Filter Unregistered Groups on all Ports, for all VIDs. Subsequently, the creation of a Dynamic MAC Address Registration Entry for All Unregistered Group Addresses indicating "Registered", for a given VID in the

case of VLAN Bridge components, on a given Port would cause that Port to exhibit Forward Unregistered Groups behavior, for that VID in the case of VLAN Bridge components. Similarly, creating a Static Filtering Entry for All Group Addresses indicating "Registration Fixed" on a given Port, in the case of VLAN Bridge components for that VID, would cause that Port to exhibit Forward All Groups behavior.

Hence, by using appropriate combinations of "Registration Fixed," "Registration Forbidden," and "Normal Registration" in the Port Maps of Static Filtering Entries for the All Group Addresses and All Unregistered Group Addresses address specifications, it is possible, for a given Port, and in the case of VLAN Bridge components, VID, to:

— Fix the default Group filtering behavior to be just one of the three behaviors described above; or
— Restrict the choice of behaviors to a subset of the three, and allow MMRP registrations (or their absence) to determine the final choice; or
— Allow any one of the three behaviors to be adopted, in accordance with any registrations received via MMRP.

8.8.7 Dynamic Reservation Entries

A Dynamic Reservation Entry specifies the following:

a) A group MAC address or an individual MAC address.
b) The VID for which the dynamic reservation information was registered.
c) A Reservation Port Map, consisting of a control element for each outbound Port that specifies forwarding (reservation information exists for this Port) or filtering (reservation information does not exist for this Port) of frames for this Port. The initial value shall be filtering.

Dynamic Reservation Entries are created, modified, and deleted by the operation of SRP. No more than one Dynamic Reservation Entry shall be created in the FDB for a given combination of MAC address and VID.

8.8.8 Allocation of VIDs to FIDs

The allocation of VIDs to FIDs within a VLAN Bridge determines how learned individual MAC address information is used in forwarding and filtering decisions. If two VIDs are allocated to the same FID learned information is shared, i.e., an individual MAC address learned following receipt of a frame affects the forwarding or filtering of a subsequent frame with the same address as its destination address if either of the two VIDs have been assigned to each of the two frames. If two VIDs are allocated to different FIDs learned information is independent, i.e., an individual MAC address for frames that have one of the VIDs assigned does not affect forwarding or filtering of frames with the other VID. IVL can allow two separate stations to use the same MAC address, provided they use different VLANs, and also allows frames transmitted by a single station to be assigned to independent active topologies. SVL allows support of a single VLAN by multiple VIDs, enabling further control over the filtering of frames for that VLAN, and allowing SPB to support the VLAN with a set of symmetric trees while still using learning. Further considerations for the use of IVL and/or SVL are described in Annex F (informative).

A VLAN Bridge shall support either SVL or IVL, and may support both. If IVL is not supported the Bridge shall support a single FID. If IVL is supported, the number of FIDs shall be the same as the maximum number of VLANs supported by the implementation. For the purposes of the management operations, FIDs are numbered from 1 through N, where N is the maximum number of FIDs supported by the implementation. A Bridge that supports both SVL and IVL shall be capable of allocating any VID to any FID, through configuration of the VID to FID allocation table. Following any set of management operations designed to change the allocation of VIDs to FIDs, whether initiated by an administrative request or as a consequence of other aspects of the Bridge's operation, the value of any FID that is in use should be the same as that of one of the VIDs allocated to that FID. One exception to this rule is the allocation of SPVIDs to FIDs for SPBV (Clause 27). SPVIDs that are allocated are associated with a Base VID's FID. The learning behavior of SPVIDs assigned to a FID is determined by the learning behavior of the associated Base VID's FID (27.11).

The VID to FID allocation table may be read and modified by means of the management operations defined in Clause 12. For each VID supported by the implementation, the allocation table indicates one of the following:

a) The VID is currently not allocated to any FID, or
b) A fixed allocation has been defined (via management), allocating this VID to a specific FID, or
c) A dynamic allocation has been defined, allocating this VID to a specific FID.

An SPT Bridge can dynamically allocate VIDs, that have been reserved for use as SPVIDs, to FIDs.

An MST Bridge shall support IVL and may support SVL. An MST Bridge shall be capable of allocating any FID to any MSTID through configuration of the FID to MSTID Allocation Table (12.12.2). An SPT Bridge supports both IVL and SVL.

8.8.9 Querying the FDB

If a frame is assigned to a VLAN supported by SPBM, then the Filtering Database is queried upon reception of the frame by the ingress port for ingress checking and the frame is forwarded or filtered. If single port admittance ingress checking (6.5.4.2) is applied, then the frame is forwarded only if a Dynamic Filtering Entry for that VID, source address tuple specifies forward for the ingress port; otherwise, the frame is filtered. If relaxed ingress checking (45.3.1) is applied, then the frame is forwarded only if the ingress port is in the Port Map of the MAC Address Registration Entry for that VID, individual destination address tuple; otherwise, the frame is filtered.

If the VID assigned to a relayed frame identifies a VID or an ESP with a given outbound Bridge Port in its member set (8.8.10), the FDB entries that are applicable to the frame's destination MAC address and VID determine whether the frame is filtered or forwarded through that Bridge Port. More than one entry can apply to a given frame. This subclause (8.8.9) specifies the effect of combining applicable entries, and of the absence of certain types of entries (not all possible entries are necessarily present). For an overview of the different types of entries, see the introductory text of 8.8.

The FDB entries associated with a VLAN Bridge component, applicable to a frame whose destination MAC address is a specific individual MAC address are the Dynamic Filtering Entry (if present) with that MAC address and the FID to which the frame's VID is allocated (8.8.8), and all Static Filtering Entries (if any) with that MAC address, or with "All Individual MAC Address," as their MAC address specification and a VID that is also allocated to that FID, as their VID specification. An entry with a wildcard VID applies only if there is no applicable Static Filtering Entry for a specific VID. Table 8-10 specifies the result of combining this information for an individual MAC address and a given outbound Bridge Port, and can be summarized as follows:

— IF any static entry for a VID allocated to the FID specifies Forward, THEN Forward.
— ELSE IF any static entry for a VID allocated to the FID specifies Filter, THEN Filter.
— ELSE IF a static entry for the wildcard VID specifies Forward, THEN Forward.
— ELSE IF a static entry for the wildcard VID specifies Filter, THEN Filter.
— ELSE IF dynamic (learned filtering information) entry for the FID specifies Filter, THEN Filter
— ELSE Forward.

Table 8-10 is also applicable to MAC Bridge components but in this case there is no specific qualification on FIDs in the FDB entries and the result of combining this information for an individual MAC address and a given outbound Bridge Port can be summarized as follows:

— IF any static entry specifies Forward, THEN Forward.
— ELSE IF any static entry specifies Filter, THEN Filter.
— ELSE IF dynamic (learned filtering information) entry specifies Filter, THEN Filter.
— ELSE Forward.

Table 8-10—Combining Static and Dynamic Filtering Entries for an individual MAC address

Filtering Information	Control Elements in any Static Filtering Entry or Entries for this individual MAC address, FID, and outbound Port specify:				
	Forward (Any Static Filtering Entry for this Address/FID/Port specifies Forward)	Filter (No Static Filtering Entry for this Address/FID/Port specifies Forward)	Use Dynamic Filtering Information (No Static Filtering Entry for this Address/FID/Port specifies Forward or Filter), or no Static Filtering Entry present. Dynamic Filtering Entry Control Element for this individual MAC address, FID, and outbound Port specifies:		
			Forward	Filter	No Dynamic Filtering Entry present
Result	Forward	Filter	Forward	Filter	Forward

The FDB entries applicable (if present) to a frame whose destination MAC address is a specific group MAC address are the Static Filtering Entries and MAC Address Registration Entries (for the frame's VID and for the wildcard VID) whose address specification is that group MAC address or "All Group Addresses" or "All Unregistered Group Addresses." A Static Filtering Entry for a wildcard VID applies only if there is no applicable Static Filtering Entry for a specific VID, MAC Address Registration Entries do not use wildcard VIDs. Table 8-11 specifies the results, Registered or Not Registered for a given outbound Bridge Port, of combining the entries for the "All Group Addresses" and for combining the entries for "All Unregistered Group Addresses." Table 8-12 combines these results with the entries for the specific group MAC address. The result of Table 8-11 for "All Group Addresses" can be summarized as follows:

— IF a static entry for "All Group Addresses" and the frame's VID specifies Forward (Registration Fixed), THEN "All Group Addresses" is Registered.
— ELSE IF a static entry for "All Group Addresses" and the frame's VID specifies Filter (Registration Forbidden), THEN "All Group Addresses" is Not Registered.
— ELSE IF a dynamic (MAC Address Registration) entry for "All Group Addresses" and the frame's VID specifies Forward (Registered), THEN "All Group Addresses" is Registered.
— ELSE "All Group Addresses" is NOT Registered.

NOTE 1—The result for "All Unregistered Group Addresses" is given by substituting that address specification for "All Group Address" throughout the summary.

The result of Table 8-12 can be summarized as follows:

— IF a static entry for the specific group address and the frame's VID specifies Forward, THEN Forward.
— ELSE IF a static entry for the specific group address and the frame's VID specifies Filter, THEN Filter.
— ELSE IF a static entry for the specific group address and the wildcard VID specifies Forward, THEN Forward.
— ELSE IF a static entry for the specific group address and the wildcard VID specifies Filter, THEN Filter.
— ELSE IF the Table 8-11 result for "All Group Addresses" is Registered, THEN Forward.
— ELSE IF the Table 8-11 result for "All Unregistered Group Addresses" is Registered, THEN Forward.
— ELSE IF a dynamic (MAC Address Registration) entry for the specific group address and the frame's VID specifies Forward, THEN Forward.
— ELSE Filter.

Table 8-11—Combining Static Filtering Entry and MAC Address Registration Entry for "All Group Addresses" and "All Unregistered Group Addresses"

Filtering Information	Static Filtering Entry Control Element for this group MAC address, VID, and outbound Port specifies:				
	Registration Fixed (Forward)	Registration Forbidden (Filter)	Use MAC Address Registration Information, or no Static Filtering Entry present. MAC Address Registration Entry Control Element for this group MAC address, VID, and outbound Port specifies:		
			Registered (Forward)	Not Registered (Filter)	No MAC Address Registration Entry present
Result	Registered	Not Registered	Registered	Not Registered	Not Registered

Table 8-12—Forwarding or Filtering for specific group MAC addresses

All Group Addresses control elements for this VID and Port specify (Table 8-11):	All Unregistered Group Addresses control elements for this VID and Port specify (Table 8-11):	Static Filtering Entry Control Element for this group MAC address, VID, and outbound Port specifies:				
		Registration Fixed (Forward)	Registration Forbidden (Filter)	Use MAC Address Registration Information, or no Static Filtering Entry present. MAC Address Registration Entry Control Element for this group MAC address, VID, and outbound Port specifies:		
				Registered (Forward)	Not Registered (Filter)	No MAC Address Registration Entry present
Not Registered	Not Registered	Forward	Filter	Forward	Filter (Filter Unregistered Groups)	Filter (Filter Unregistered Groups)
	Registered	Forward	Filter	Forward	Forward (Forward Unregistered Groups)	Forward (Forward Unregistered Groups)
Registered		Forward	Filter	Forward (Forward All Groups)	Forward (Forward All Groups)	Forward (Forward All Groups)

Table 8-11 and Table 8-12 are also applicable to MAC Bridge components but in this case there is no specific qualification on VIDs in the FDB entries and the result of combining this information for an individual MAC address and a given outbound Bridge Port can be summarized as follows:

— IF a static entry for the specific group address specifies Forward, THEN Forward.
— ELSE IF a static entry for the specific group address specifies Filter, THEN Filter.
— ELSE IF a static entry for the specific group address specifies Forward, THEN Forward.
— ELSE IF a static entry for the specific group address specifies Filter, THEN Filter.
— ELSE IF the Table 8-11 result for "All Group Addresses" is Registered, THEN Forward.
— ELSE IF the Table 8-11 result for "All Unregistered Group Addresses" is Registered, THEN Forward.
— ELSE IF a dynamic (MAC Address Registration) entry for the specific group address specifies Forward, THEN Forward.
— ELSE Filter.

When forwarding or filtering a frame with a destination group MAC address, a VLAN Bridge may:

a) Ignore the allocation of VIDs to FID, and use Table 8-12 directly for the frame's VID; or
b) Take the same decision for all VIDs allocated to any given FID, forwarding if Table 8-12 specifies Forward for any VID allocated to the same FID as the frame's VID, and filtering otherwise.

For a given destination MAC address and VID, a Dynamic Reservation Entry (8.8.7) may be present in the FDB, indicating, by means of its port map, which Ports have valid bandwidth reservations. If a Dynamic Reservation Entry exists in the FDB for that MAC address and VID, the port map in the Dynamic Reservation Entry is used to prevent frames being forwarded on Ports where no reservation exists. Table 8-13 combines the output of Table 8-10 (for an individual MAC address) or Table 8-12 (for a group MAC address) with a Dynamic Reservation Entry to specify forwarding, or filtering, of a frame with that destination MAC address and VID through an outbound Port.

Table 8-13—Forwarding or Filtering with Dynamic Reservation Entries

		Dynamic Reservation Entry Control Element for this individual or group MAC address, VID, and outbound Port specifies:	
		Forward	**Filter**
Output of Table 8-10 (individual MAC address) or Table 8-12 (group MAC address) for this group or individual MAC address, VID, and outbound Port specifies:	**Forward**	Forward	Filter
	Filter	Filter	Filter

NOTE 2—Where a group MAC address is used as the destination address for reserved traffic, the reservation mechanisms used by SRP will prevent reservations being made for multiple streams using the same combination of MAC address and VID. The Dynamic Reservation Entry can then control which Port(s) the stream associated with the MAC address and VID is permitted to be transmitted through. The restriction preventing multiple streams from using the same group MAC address/VID is necessary because those different streams may be destined for different destination Ports; if the restriction was not imposed, it would not be possible to distinguish which frames belong to which streams and therefore through which Ports they should be transmitted.

8.8.10 Determination of the member set for a VID

The VLAN configuration information contained in the FDB of a VLAN Bridge component for a given VID may include a Static VLAN Registration Entry (8.8.2) and/or a Dynamic VLAN Registration Entry (8.8.5). This information defines the member set, the Ports through which members of the VLAN identified by that VID can be reached.

For a given VID, the FDB can contain a Static VLAN Registration Entry, a Dynamic VLAN Registration Entry, both, or neither. Table 8-14 combines Static VLAN Registration Entry and Dynamic VLAN Registration Entry information for a VID and Port to give a result *member*, or *not member*, for the Port. The member set for a given VID consists of all Ports for which the result is member.

Table 8-14—Determination of whether a Port is in a VID's member set

Filtering Information	Static VLAN Registration Entry Control Element for this VID and Port specifies:				
	Registration Fixed	Registration Forbidden	Normal Registration, or no Static VLAN Registration Entry present. Dynamic VLAN Registration Entry Control Element for this VID and Port specifies:		
			Registered	Not Registered	No Dynamic VLAN Registration Entry present
Result	Member	Not member	Member	Not member	Not member

The Forwarding Process uses the member set to apply ingress (8.6.2) and egress rules (8.6.4) for the VID.

8.8.11 Permanent Database

The Permanent Database provides fixed storage for a number of Static Filtering Entries and Static VLAN Registration Entries. The FDB shall be initialized with the FDB entries contained in this fixed data store.

Entries may be added to and removed from the Permanent Database under explicit management control, using the management functionality defined in Clause 12. Changes to the contents of Static Filtering Entries or Static VLAN Registration Entries in the Permanent Database do not affect forwarding and filtering decisions taken by the Forwarding Process or the egress rules until such a time as the FDB is reinitialized.

NOTE 1—This aspect of the Permanent Database can be viewed as providing a "boot image" for the FDB, defining the contents of all initial entries, before any dynamic filtering information is added.

NOTE 2—Subclause 10.12.2.3 defines an initial state for the contents of the Permanent Database, required for the purposes of MMRP operation.

8.8.12 Connection_Identifier

A connection_identifier may be associated with the Bridge Port value maintained in a Dynamic Filtering Entry of the FDB for Bridge Ports that generate EM_UNITDATA.indications with a non-null connection_identifier parameter (e.g., a VIP as specified in 6.10). The connection_identifier has no effect on the Bridge operation specified in this clause other than being stored in the FDB and conveyed across the EISS as a parameter in an EM_UNITDATA.request or EM_UNITDATA.indication (6.8.1).

When the result of an FDB query (8.8.9) for a particular frame is that the frame will be forwarded, and the FDB entry determining that result has a connection_identifier, then that connection_identifier is included in the EM_UNITDATA.request. For a given VID and MAC address, a connection_identifier can be included in a Dynamic Filtering Entry of the FDB. The FDB entry that determines a filtering or forwarding result is

specified in Table 8-10. If there are no entries for that MAC address and VID in the FDB, then a null value for the connection_identifier is used in the EM_UNITDATA.request.

When an EM_UNITDATA.indication with a non-null connection_identifier is received from an ingress port, and the Learning Process identifies or creates a Dynamic Filtering Entry for that frame's source address and VID, the connection_identifier is included in the entry created for that port in the FDB.

8.9 MST, SPB, and ESP configuration information

In order to support multiple spanning trees, and SPB, all the Bridges in an MST or SPT Region have to be configured with assignments of VIDs to spanning trees.

The combination of the VID to FID allocations (8.8.8) and the FID to MSTI allocations (8.9.3) defines a mapping of VIDs to spanning trees, MSTIDs, represented by the MST Configuration Table (8.9.1). If an MSTID is included in the MSTI List (12.12.1), frames with VIDs allocated to that MSTID will be supported by an MSTI calculated by MSTP (Clause 13). If the MSTID is not included in the MSTI List, and is not a reserved MSTID, those frames will be supported by the IST.

A Bridge supporting PBB-TE can assign specific VID values to ESPs but can also support any of the spanning tree protocols. This is achieved by allocating the VIDs associated with the PBB-TE ESPs to a special MSTID, the TE-MSTID.

An SPT Bridge can allocate any given VLAN to the CIST, or to the reserved MSTIs, as well as supporting SPB for other VLANs within an SPT Region. The assignment of VLANs and VIDs to MSTIs is subject to similar considerations and constraints as for MST Bridges. In addition to the Base VID used to identify frames for the VLAN when transmitted on the CST outside the region, each VLAN supported by SPBV uses a number of dynamically allocated shortest path VIDs (SPVIDs), one for each SPT Bridge participating in the VLAN within the region.

The network administrator allocates enough SPVIDs for SPBV to avoid unintentionally excluding Bridges from the topology. The details of SPVID allocation, including mitigation of the consequences of not allocating enough SPVIDs, are specified in 27.10.

Administratively, by not translating from Base VID to SPVID, an SPBV VLAN can be forced to the IST. When there is no shortage of SPVIDs and the MST Configuration Identifiers (MCIDs) match but the Base VID algorithms disagree the algorithm defaults to the spanning tree. This behavior allows SPBV to change the Equal Cost Tree (ECT) Algorithms.

Dynamic SPVID allocation is supported by ISIS-SPB and allows the addition of Bridges to existing SPT Regions without disruptive configuration changes, as well as allowing supporting auto configuration of SPB in simple networks where all user data is assigned to a VLAN identified by the default PVID of 1 (Table 9-2). However, prior to SPVID allocation, all Bridges in an SPT Region have to agree which VLANs are to be shortest path bridged, and which SPT Set (ECT Algorithm) is to be used for each of those VLANs. By default, all VLANs whose Base VID is allocated to MSTID 0xFFD will be supported by SPBV using the SPB default ECT Algorithm. The SPT configuration information can also specify that frames for SPBV and SPBM be supported by another specified SPB ECT Algorithm as specified by configuration (12.25.4, Table 28-1).

NOTE—The use of MSTIDs to support allocation of Base VIDs to SPB allows the per VLAN components of the necessary information to be conveyed in the MST Configuration Digest, thus avoiding any need for a separate digest. However, the digest is not specific about how the VIDs are mapped to specific SPTs, just that they are allocated to SPBV, SPBM, or SPVIDs.

8.9.1 MST Configuration Table

The MST Configuration Table specifies an MSTID for each possible VID.

In an MST Bridge, each MSTID identifies the MSTI to which the VID is allocated and an MSTID of zero identifies the CIST.

The combination of the VID to FID allocations (8.8.8) and the FID to MSTID allocations (8.9.3) define a mapping of VIDs to MSTIDs summarized in the MST Configuration Table (8.9.1).

8.9.2 MST configuration identification

For two or more MST Bridges to be members of the same MST Region (3.165), it is necessary for those Bridges to support the same MST Region configuration and to be interconnected only by means of LANs, with all intervening Bridges being members of the region or being transparent to the BPDUs of the members of the region. Two MST Region configurations are considered to be the same if the correspondence between VIDs and MSTIDs is identical in both configurations and they use the same information to identify the configuration, including the same Configuration Name.

NOTE 1—If two adjacent MST Bridges consider themselves to be in the same MST Region despite having different mappings of VIDs to MSTIDs, then the possibility exists of undetectable loops arising within the MST Region.

In order to ensure that adjacent MST Bridges are able to determine whether they are part of the same MST Region, the MST BPDU supports the communication of an MCID (13.8).

NOTE 2—As the MCID is smaller than the mapping information that it summarizes, there is a small but finite possibility that two MST Bridges will assume that they have the same MST Region Configuration when this is not actually the case. However, given the size of the identifier, this standard assumes that this possibility is sufficiently small that it can safely be ignored. Appropriate use of the Configuration Name and Revision Level portions of the identifier can remove the possibility of an accidental match between MCIDs that are derived from different configurations within a single administrative domain (see 13.8).

8.9.3 FID to MSTI Allocation Table

The FID to MSTI Allocation Table defines, for all FIDs that the Bridge supports, the MSTID to which the FID is allocated.

a) The IST is identified by the reserved MSTID value 0.
b) The use of PBB-TE is identified by the reserved MSTID value TE-MSTID (0xFFE).
c) Each MSTID in the MSTI List identifies an MSTI.
   The reserved MSTID values 0 and TE-MSTID, SPBV-MSTID, SPBM-MSTID and SPVID-Pool-MSTID are never used in the MSTI List.
d) The following MSTID values identify the method used to support the VLANs identified by the Base VIDs allocated to those MSTIDs:
   1) 0xFFC—SPBM-MSTID.
   2) 0xFFD—SPBV-MSTID.
   3) 0xFFF—SPVID-Pool-MSTID: Allocated to FIDs that are not used to filter frames including SPVIDs for SPBV.

NOTE—MSTIDs that are present in the MSTI List (12.12) identify spanning tree instances supported by MSTP. MSTIDs identify (indirectly) VLANs that are supported by SPB.

8.9.4 SPT Configuration Identification

For two or more SPT Bridges to be members of the same SPT Region (Clause 3), it is necessary for those Bridges to support the same SPT Region configuration and to be interconnected only by means of LANs, with all intervening Bridges being members of the region or being transparent to the BPDUs and/or SPB

Hello PDUs of the members of the region. This requirement is identical to that for MST Regions: a given SPT Region can support selected MSTIs as well as SPTs. MCIDs only specify the VIDs that are configured.

Two SPT Region configurations are considered to be the same if they have the same MST Region configuration or alternate MST Region configuration, they agree on the VLANs that are to be shortest path bridged and they use the same ISIS-SPB. Furthermore by using ISIS-SPB they agree on which SPT Set is to be used for each of these VLANs (Clause 27).

The MST Region information captures the VIDs for SPB but it does not capture the operational state of the VIDs for SPB. This allows allocation of SPVIDs and upgrade of multiple ECT Algorithms without change to the MST Region when sufficient pre-allocation of VIDs has been configured. However, in situations where the network grows beyond the current allocation of VIDs, the options are to temporarily create a region boundary as the new configuration is deployed or allow in-service upgrades by making changes that are compatible with the current MST region configuration.

To support in-service upgrade from one set of VID to MSTID allocations to another, SPT Bridges support a second (auxiliary) MCID (28.9). Two such Bridges consider themselves to be in the same MST Region provided that at least one of their MCIDs matches with one of their neighbors. In this way, a new configuration can be incrementally introduced without time constraints, and put into operation, all the while maintaining operation as a single SPT Region.

8.10 Spanning Tree Protocol Entity

Figure 8-6 illustrates the operation of the Spanning Tree Protocol Entity, including the reception and transmission of frames containing BPDUs, the modification of the state information associated with individual Bridge Ports, and the notification of the FDB of changes in active topology.

A given MST Bridge is not required to support all of the spanning trees that exist within the MST bridged network. That is, the number of spanning trees operated by the Spanning Tree Protocol Entity in a given Bridge may be different from the number operated by that in another Bridge. However, as a direct consequence of the conditions stated in 8.9.2, the number of instances of the spanning tree protocol operated by a given MST Bridge is the same for all Bridges that are members of a given MST Region.

The ISIS-SPB Entity comprises an instance of IS-IS with SPB extensions as specified in Clause 28. The ISIS-SPB Entity is described, for the purposes of management, as distinct from the Spanning Tree Protocol Entity. Nonetheless, the ISIS-SPB and Spanning Tree Protocol Entities that calculate active topologies for the same Bridge Port use the same ISS SAP (ISS-SAP, 8.5, 27.2), and the same individual MAC address. However, ISIS-SPB uses one of the group MAC addresses in Table 8-15 and does not use the group MAC addresses used by the spanning tree protocol specified in Table 8-1. The ISIS-SPB Entity uses the state machines and state machine variables supported by the Spanning Tree Protocol Entity (Clause 27, 13.6) and calculates the Agreement Digest that the Spanning Tree Protocol Entity transmits in SPT BPDUs and/or SPB Hello PDUs.

8.11 MRP entities

The MRP entities operate the algorithms and protocols associated with the MRP Applications supported by the Bridge and consist of the set of MRP Participants for those MRP Applications (Clause 10).

Figure 8-7 illustrates the operation of an MRP entity, including the reception and transmission of frames containing MRPDUs, the use of control information contained in the FDB, and the notification of the FDB of changes in filtering information.

8.12 Bridge Management Entity

Remote management capabilities (as opposed to management via a console or other device attached directly to a Bridge) are modeled as performed by a Bridge Management Entity supported by a protocol stack as described in 8.13.7. To facilitate interoperable remote management, the Bridge Management Entity should use either the SMIv2 MIB modules specified in Clause 17 with SNMP or the YANG modules specified in Clause 48 with a network configuration protocol, e.g., NETCONF, RESTCONF.

8.13 Addressing

All MAC Entities communicating across a bridged network use 48-bit MAC addresses (IEEE Std 802). These can be universally administered addresses or a combination of universally administered and locally administered addresses.

8.13.1 End stations

Frames transmitted between end stations using the MAC Service carry the MAC address of the source and destination peer end stations in the source and destination address fields of the frames, respectively. The address, or other means of identification, of a Bridge is not carried in frames transmitted between peer users for the purpose of frame relay in the network.

In the absence of explicit filters configured via management as Static Filtering Entries, or via MMRP as MAC Address Registration Entries (8.8, Clause 10), frames with a destination address of the broadcast address or any other group address that is not a Reserved Address (8.6.3) are assigned by a VLAN Bridge component a VID and relayed throughout the VLAN identified by that VID.

8.13.2 Bridge Ports

A separate individual MAC address is associated with each instance of the MAC Service provided to an LLC Entity. That MAC address is used as the source address of frames transmitted by the LLC Entity.

Media access method-specific procedures can require the transmission and reception of frames that use an individual MAC address associated with the Bridge Port, but neither originate from nor are delivered to a MAC Service user. Where an individual MAC address is associated with the provision of an instance of the MAC Service by the Port, that address can be used as the source and/or the destination address of such frames, unless the specification of the media access method-specific procedures requires otherwise.

8.13.3 Use of LLC by Spanning Tree Protocol Entities

Spanning Tree Protocol Entities use the DL_UNITDATA.request and DL_UNITDATA.indication primitives (ISO/IEC 8802-2) provided by individual LLC Entities associated with each Bridge Port to transmit and receive BPDUs (Clause 14). The source_address and destination_address parameters of the DL_UNITDATA.request shall both denote the standard LLC address assigned to the Bridge spanning tree protocol (Table 8-15). Each DL_UNITDATA request primitive gives rise to the transmission of an LLC UI command PDU, which conveys the BPDU in its information field.[25]

Table 8-15—Standard LLC address assignment

Assignment	Value
Bridge spanning tree protocol	01000010
IS-IS PDUs	11111110
NOTE—Code Representation: The least significant bit (LSB) of the value shown is the right-most. The bits increase in significance from right to left. It should be noted that the code representation used here has been chosen in order to maintain consistency with the representation used elsewhere in this standard.	

A Protocol Identifier field, present in all BPDUs (Clause 14), serves to identify different protocols supported within the scope of the LLC address assignment. Further values of this field are reserved for future standardization. A Spanning Tree Protocol Entity that receives a BPDU with an unknown PID shall discard that PDU.

IS-IS PDUs are LLC (encoded with a DSAP and SSAP of 0xFE (section 7.5 of ISO/IEC 10589:2002), then a single byte indicating Control 0x03 (see ISO/IEC/IEEE 8802-2) immediately followed by a IS-IS PDU starting with an Interdomain Routeing Protocol Discriminator equal to 0x83 (section 5.3 of ISO/IEC 9577:1999).

8.13.4 Reserved MAC addresses

Any frame with a destination address that is a reserved MAC address shall not be forwarded by a Bridge. Reserved MAC addresses for MAC Bridge components and C-VLAN components, for S-VLAN components, and for TPMR components are specified in Table 8-1, Table 8-2, and Table 8-3, respectively. These group MAC addresses are reserved for assignment to standard protocols, according to the criteria for such assignments.[26]

8.13.5 Group MAC addresses for spanning tree entity

A Spanning Tree Protocol Entity uses an instance of the MAC Service provided by each of the Bridge's Ports to transmit frames addressed to the Spanning Tree Protocol Entities of all the other Bridges attached to the same LAN as that Port.

[25] Administration of LLC address assignments is the responsibility of the IEEE Registration Authority (IEEE RA). A full list of standard LLC address assignments, and the criteria for assignment, can be found on the IEEE RA Website at https://standards.ieee.org/regauth/index.html.

[26] Administration of standard group MAC address assignments is the responsibility of the IEEE Registration Authority (IEEE RA). A full list of standard group MAC address assignments, and the criteria for assignment, can be found on the IEEE RA Website at https://standards.ieee.org/regauth/index.html.

8.13.5.1 Group MAC addresses for spanning tree protocols

Spanning tree protocols use a reserved address for peer to peer communication between entities of the same type.

A universally administered standard group MAC address, known as the Bridge Group Address, has been assigned (Table 8-1) for use by C-VLAN components for this purpose.

It is essential to the operation of the spanning tree protocols that frames with this destination address both reach all peer protocol entities attached to the same LAN and do not reach protocol entities attached to other LANs. The Bridge Group Address is therefore included in the block of MAC Bridge and C-VLAN components reserved MAC addresses and is always filtered by Customer Bridges and C-VLAN components of Provider Edge Bridges (8.6.3).

As a network of Provider Bridges needs to appear to attached Customer Bridges as if it was a single LAN, frames addressed to the Bridge Group Address are forwarded by S-VLAN components. Provider Bridges also use a spanning tree protocol to provide one or more loop-free active topologies, so a distinct universally administered standard group MAC address, the Provider Bridge Group Address, which can be confined to the LANs that their Bridge Ports attach, has been assigned (Table 8-2). The Provider Bridge Group Address is included in both the C-VLAN component and the S-VLAN component reserved MAC addresses and is always filtered by all Bridges (8.6.3).

The source MAC address field of frames transmitted by Spanning Tree Protocol Entities contains the individual MAC address for the Bridge Port used to transmit the frame.

8.13.5.2 Group MAC addresses for SPB

ISIS-SPB use a group address for ISIS-SPB peer to peer communication. ISIS-SPB is configured to use only one of the addresses listed in Table 8-16. All other addresses in this table will be ignored by IS-IS and will not be filtered by the MAC Relay. The choice of which address is used depends on the environment.

Table 8-16 lists the various addresses that may be configured for ISIS-SPB. Table 8-17 lists the deployment environments for SPB. The usage of ISIS-SPB is described in Clause 28. These addresses are from a reserved address space. These addresses have the property that:

a) Where a given address in the set is used by a Bridge component to support ISIS-SPB, frames destined for that address shall not be forwarded by that Bridge component; i.e., a Static Filtering Entry for that address is maintained for that group MAC address in order to prevent the forwarding of frames destined for that address.
b) Where a given address in the set is not used by a Bridge component to support ISIS-SPB, frames destined for that address received on any Port that is part of a given active topology shall be forwarded by that Bridge component on all other Ports that are part of that active topology.

An SPT Bridge, whether it is running SPBV, or SPBM, or both, uses a single group MAC address. Table 8-17 provides the reference for the possible environments.

In Provider Bridge only environments, for SPBV the address should be the allocated All Provider Bridge Intermediate Systems address.

In Customer Bridge only environments where only SPBV is supported the address should be the All Customer Bridge Intermediate Systems address.

Table 8-16—ISIS-SPB reserved addresses

Assignment	Value
All Level 1 Intermediate Systems	01-80-C2-00-00-14[a]
All Level 2 Intermediate Systems	01-80-C2-00-00-15[a]
All Intermediate Systems	09-00-2B-00-00-05[a]
All Provider Bridge Intermediate Systems	01-80-C2-00-00-2E
All Customer Bridge Intermediate Systems	01-80-C2-00-00-2F

[a] The first three addresses are existing IS-IS addresses (Table 9 of ISO/IEC 10589:2002).

In SPBM or SPBV deployments where only Provider backbone components are configured the use of addresses is flexible as indicated in Table 8-17. To allow peering with other systems capable of using IS-IS for IP, the existing IS-IS addresses may be used.

Table 8-17—ISIS-SPB Recommended Address Usage

Network Deployment	Level 1	Level 2	All Levels
SPT Bridges Peering with other IS-IS-capable systems	01-80-C2-00-00-14	01-80-C2-00-00-15	09-00-2B-00-00-05
SPT Bridges PBBs only	01-80-C2-00-00-14	01-80-C2-00-00-15	09-00-2B-00-00-05 or 01-80-C2-00-00-2E
SPT Bridges in SPBV mode for S-VLANs Provider Bridge	01-80-C2-00-00-2E		
SPT Bridges in SPBV mode for C-VLANs Customer Bridge	01-80-C2-00-00-2F		

8.13.6 Group MAC addresses for MRP Applications

An MRP Entity that supports a given MRP Application transmits frames addressed to all other MRP Entities that implement the same MRP Application. The peers of each such entity bound a region of the network that contains no peers, commonly a single LAN in the case where all Bridges attached to the LAN implement the application.

Universally administered standard group MAC addresses are assigned to MRP applications, from a set of universally administered group MAC addresses, known as MRP application addresses, as shown in Table 10-1; these addresses are for use by VLAN components that support the MRP applications concerned. FDB entries for each MRP application address assigned to an application that is supported by a VLAN component should be configured in the FDB so frames for that application are confined to the peer region, while addresses for applications that are not supported should not be included. These group MAC addresses are reserved for assignment to standard protocols, according to the criteria for such assignments (see 8.13.4).

When an MRP Application operates among both Customer and Provider Bridges, a distinct universally administered group MAC address is assigned for use by both C-VLAN components and S-VLAN components. MMRP is such an application, and uses the Customer and Provider Bridge MMRP Address assigned in Table 10-1. When an MRP application operates separately among Customer Bridges or among

Provider Bridges, different distinct universally administered group MAC addresses are assigned for use by C-VLAN components and for use by S-VLAN components. MVRP is such an application; C-VLAN components use the Customer Bridge MVRP address assigned in Table 10-1, while S-VLAN components use the Provider Bridge MVRP address assigned in Table 8-1. Note that because the Provider Bridge MVRP address is selected from the set of addresses that appear in Table 8-1 but not Table 8-2, it will always be filtered by C-VLAN components. Although the Provider Bridge MVRP Address is not selected from Table 10-1, an S-VLAN component should treat this as an MRP Application Address and configure an FDB entry to filter frames with this address.

An MRP Entity that supports a given MRP Application uses the individual MAC address for the Bridge Port through which the PDU is transmitted (8.13.2) as the source_address field of MAC frames conveying MRPDUs for that application.

8.13.7 Bridge Management Entities

Network configuration and management protocols typically use IP as a network layer protocol. SNMP can also be supported directly over an IEEE 802 LAN, as specified in IETF RFC 4789. The management protocol stack and address used shall be supported by a single LLC Entity attached to a Bridge Port. The Port should be a Management Port for the Bridge, as described in 8.3 and Figure 8-8, but may be a Port attached to a LAN, as described in 8.13.9, Figure 8-24, and Figure 8-25.

NOTE—A universally administered standard group MAC address, known as the All LANs Bridge Management Group Address with a value of 01-80-C2-00-00-10 was assigned and recorded in the 1990 Edition of this standard. That address should not be used for Bridge management or for any other purpose.

8.13.8 Unique identification of a Bridge

A unique EUI-48 Universally Administered MAC address, termed the Bridge Address, shall be assigned to each Bridge. The Bridge Address may be the individual MAC address of a Bridge Port; in which case, use of the address of the lowest numbered Bridge Port (Port 1) is recommended.

NOTE—RSTP (Clause 13) and MSTP (Clause 13) require that a single unique identifier be associated with each Bridge. That identifier is derived from the Bridge Address as specified in 14.2.5.

8.13.9 Points of attachment and connectivity for Higher Layer Entities

The Higher Layer Entities in a Bridge, such as the Spanning Tree Protocol Entity (8.10), MRP entities (8.11), the ISIS-SPB Entity (Clause 28), and Bridge Management (8.12), are modeled as attaching directly to one or more individual LANs connected by the Bridge's Ports, in the same way that any distinct end station is attached to the network. While these entities and the relay function of the Bridge use the same individual MAC entities to transmit and receive frames, the addressing and connectivity to and from these entities is the same as if they were attached as separate end stations "outside" the Port or Ports where they are actually attached. Figure 8-22 is functionally equivalent to Figure 8-2 but illustrates this logical separation between the points of attachment used by the Higher Layer Entities and those used by the MAC Relay Entity.

Figure 8-23 depicts the information used to control the forwarding of frames from one Bridge Port to another (the Port States and the content of the FDB) as a series of switches (shown in the open, disconnected state) inserted in the path provided by the MAC Relay Entity. For the Bridge to forward a given frame between two Ports, all three switches must be in the closed state. While showing Higher Layer Entities sharing the point of attachment to each LAN used by each Bridge Port to forward frames, this figure further illustrates a point made by Figure 8-22. Controls placed in the forwarding path have no effect on the ability of a Higher Layer Entity to transmit and receive frames to or from a given LAN using a direct attachment to that LAN (e.g., from entity A to LAN A); they only affect the path taken by any indirect transmission or reception (e.g., from entity A to or from LAN B).

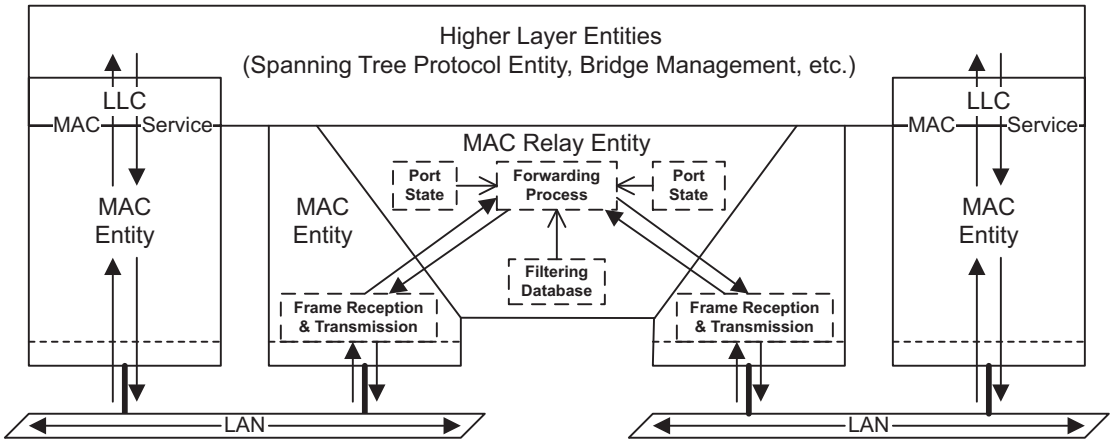


Figure 8-22—Logical points of attachment of the Higher Layer and Relay Entities

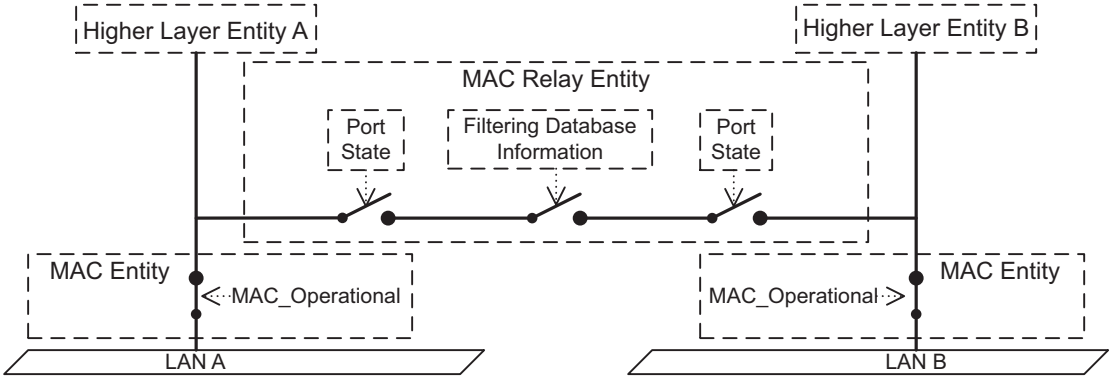


Figure 8-23—Effect of control information on the forwarding path

The functions provided by Higher Layer Entities can be categorized as requiring either:

a) A single point of attachment to the Bridged Network, providing connectivity to stations attached to the network at any point (subject to administrative control), as does Bridge Management; or
b) A distinct point of attachment to each individual LAN attached by a Bridge Port, providing connectivity only to peer entities connected directly to that LAN, as do the Spanning Tree Protocol Entity and the MRP entity.

In the latter case, it is essential that the function associate each received and transmitted frame with a point of attachment. Frames transmitted or received via one point of attachment are not to be relayed to and from other Ports and attached LANs, so the MAC addresses (8.13.4) used to reach these functions are permanently configured in the FDB.

NOTE 1—Addresses used to reach functions with distinct points of attachment are generally group MAC addresses.

NOTE 2—A single higher layer entity can incorporate both a function requiring a single point of attachment and a function requiring distinct points of attachment. The two functions are reached using different MAC addresses.

Figure 8-24 illustrates forwarding path connectivity for frames destined for Higher Layer Entities requiring per-Port points of attachment. Configuration of the Permanent Database in all Bridges to prevent relay of frames addressed to these entities means that they receive frames only via their direct points of attachment (i.e., from LAN A to entity A, and from LAN B to entity B), regardless of Port states.

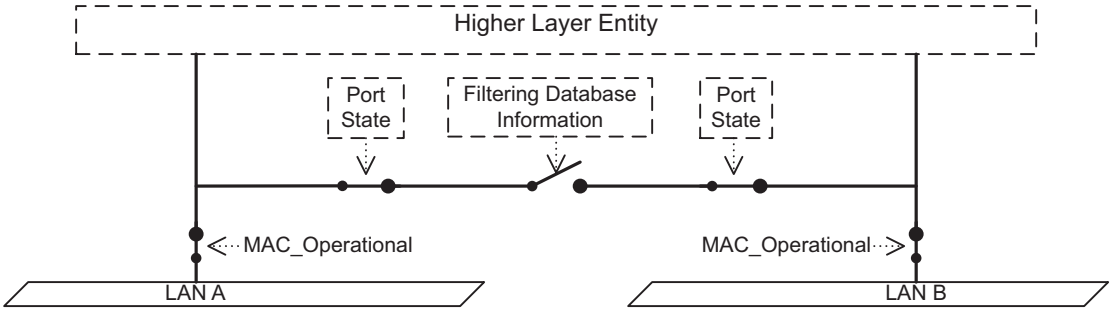


Figure 8-24—Per-Port points of attachment

Figure 8-25 and Figure 8-26 illustrate forwarding path connectivity for frames destined for a Higher Layer Entity requiring a single point of attachment. In both figures, the FDB permits relay of frames, as do the Port states in Figure 8-25 where frames received from LAN B are relayed by the Bridge to the entity and to LAN A.

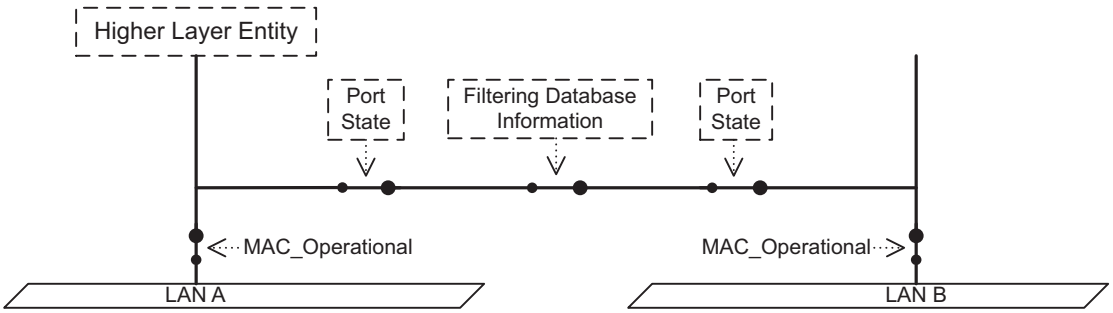


Figure 8-25—Single point of attachment—relay permitted

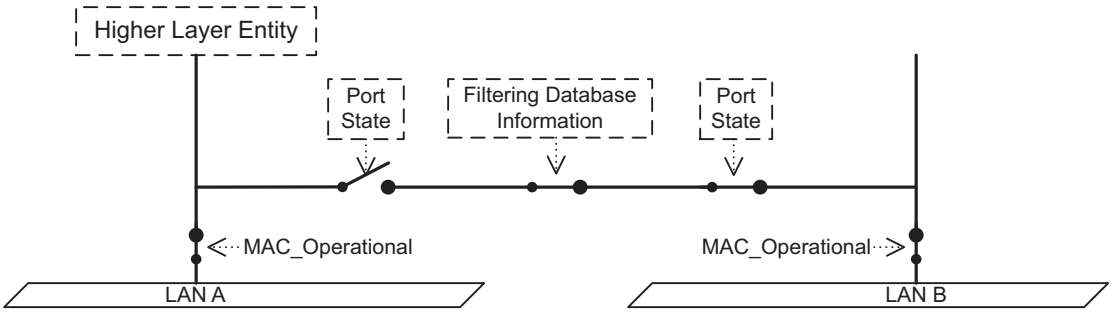


Figure 8-26—Single point of attachment—relay not permitted

In Figure 8-26, frames received from LAN A are received by the entity directly, but frames received from LAN B are not relayed by the Bridge and will only be received by the entity if another forwarding path is provided between LANs A and B. If the Discarding Port state shown resulted from spanning tree computation (and not from disabling the Administrative Bridge Port State), such a path will exist via one or more Bridges. If there is no active spanning tree path from B to A, the network has partitioned into two separate Bridged Networks, and the Higher Layer Entity shown is reachable only via LAN A.

Specific Higher Layer Entities can take notice of the Administrative Bridge Port State, as required by their specification. The Spanning Tree Protocol Entity is one such example—BPDUs are never transmitted or received on Ports with an Administrative Bridge Port State of Disabled.

If a Bridge Port's MAC Entity is not operational, a Higher Layer Entity directly attached at the Port will not be reachable, as Figure 8-27 illustrates. The Spanning Tree Protocol Entity ensures that the Port State is Discarding if the MAC_Operational (IEEE Std 802.1AC) is FALSE even if the Administrative Bridge Port State is Enabled.

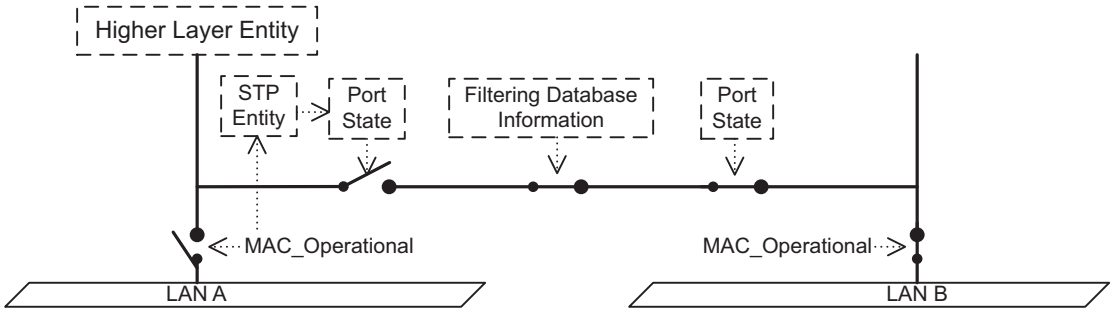


Figure 8-27—Effect of Port State

Port-based network access control (IEEE Std 802.1X) and MAC Security (IEEE Std 802.1AE) can be used to provide a further level of control over the connectivity provided by a Bridge Port to the MAC Relay Entity and the Higher Layer Entities within a Bridge. Port-based network access control creates two distinct SAPs for the LAN: the Controlled Port and the Uncontrolled Port. MAC_Operational is TRUE for the Controlled Port only when criteria for authentication, authorization, and secure connectivity have been satisfied; while MAC_Operational for the Uncontrolled Port is the same as that for direct access to the LAN. Both the Spanning Tree Protocol Entity and the MAC Relay Entity attach to the Controlled Port, thus ensuring that the connectivity seen by each of those entities is the same. If MAC_Operational for the Controlled Port is FALSE, the Spanning Tree Protocol Entity will ensure that both forwarding and learning (8.4) will be FALSE for that Port (i.e., the Port State will be Discarding). The Uncontrolled Port supports the operation of protocol entities such as the Port Access Entity (PAE) specified by IEEE Std 802.1X, that participate in the authentication exchanges necessary before Controlled Port connectivity is permitted or that distribute other unsecured information.

Figure 8-28 illustrates the connectivity provided to Higher Layer Entities if the MAC entity is physically capable of transmitting and receiving frames but MAC_Operational is FALSE for the Controlled Port. Higher Layer Entity A and the PAE are connected to an Uncontrolled Port and can transmit and receive frames using the MAC entity associated with the Port for LAN A, which Higher Layer Entity B cannot. None of the three entities can transmit or receive to or from LAN B.

NOTE 3—Reference should be made to IEEE Std 802.1X-2010 or later.

NOTE 4—The administrative and operational state values associated with the MAC, the Port's authorization state, and the Bridge Port State equate to the ifAdminStatus and ifOperStatus parameters associated with the corresponding interface definitions; see IETF RFC 2863.

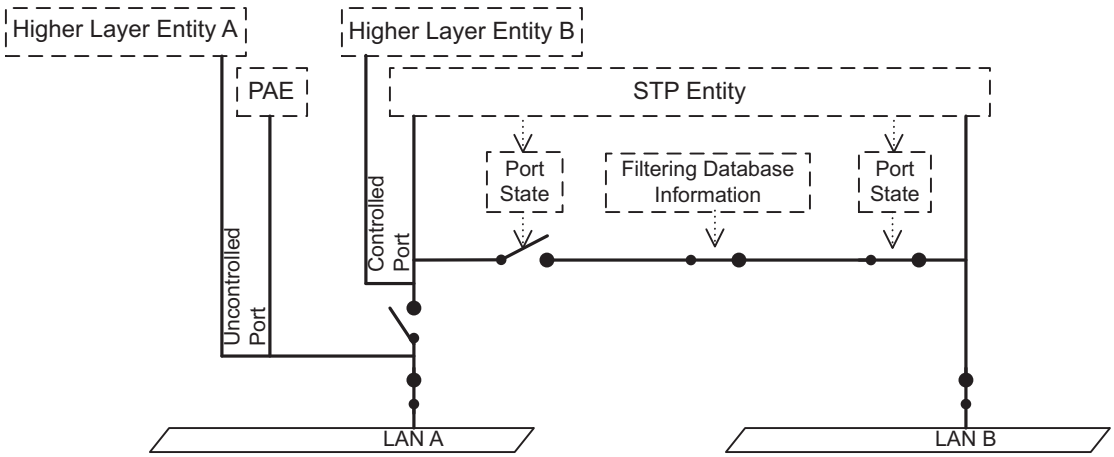


Figure 8-28—Controlled and Uncontrolled Port connectivity

8.13.10 VLAN attachment and connectivity for Higher Layer Entities

In VLAN Bridges, two more switches appear in the forwarding path, corresponding to the actions taken by the Forwarding Process (8.6) in applying the ingress and egress rules (8.6.2 and 8.6.4), as illustrated in Figure 8-29.

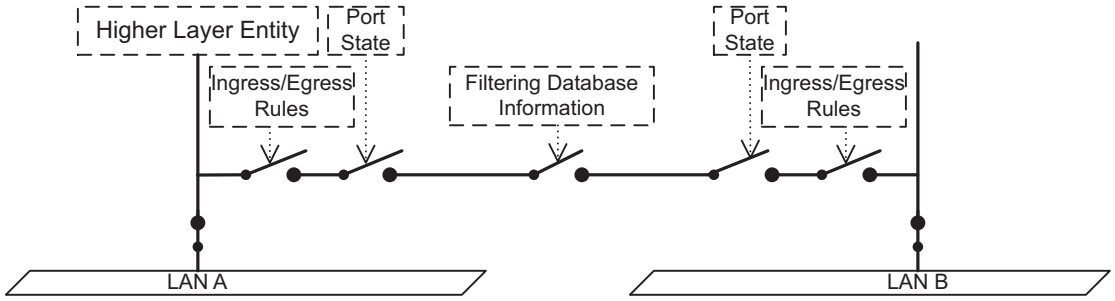


Figure 8-29—Ingress/egress control information in the forwarding path

As with Port state information, the configuration of the ingress and egress rules does not affect the reception of frames received on the same LAN as a Higher Layer Entity's point of attachment. For example, the reception of a frame by Higher Layer Entity A that was transmitted on LAN A is unaffected by the ingress or egress configuration of either Port. However, for Higher Layer Entities that require only a single point of attachment, the ingress and egress configuration affects the forwarding path. For example, frames destined for Higher Layer Entity A that are transmitted on LAN B would be subjected to the ingress rules that apply to Port B and the egress rules that apply to Port A.

The decision about whether frames transmitted by Higher Layer Entities are VLAN-tagged or untagged depends on the Higher Layer Entity concerned and the connectivity that it requires:

a) Spanning Tree Bridge Protocol Data Units (ST BPDUs) transmitted by the Spanning Tree Protocol Entity are not forwarded by Bridges and must be visible to all other Spanning Tree Protocol Entities attached to the same LAN. Such frames shall be transmitted untagged.

   NOTE—Any BPDUs or MVRPDUs that carry a tag header are not recognized as well-formed BPDUs or MVRPDUs and are not forwarded by the Bridge.

b) The definition of the MVRP application (11.2.3) calls for all MVRP frames to be transmitted untagged for similar reasons.

c) The definition of the MMRP application (Clause 10) calls for all MMRP frames originating from VLAN devices to be transmitted VLAN-tagged, in order for the VID in the tag to be used to identify the VLAN context in which the registration applies.

d) It may be necessary for PDUs transmitted for Bridge Management (8.12) to be VLAN-tagged in order to achieve the necessary connectivity for management in a Virtual Bridged Network. This is normally achieved by routing a packet containing the PDU to the routed subnet associated with the VLAN. Transmission of the packet through the router interface to that VLAN and subsequent forwarding of the resulting frame by VLAN Bridges ensures that the frame is correctly VLAN-tagged, as required.

8.13.11 CFM entities

CFM entities reside in shims. The entities in a CFM shim inspect every frame that passes through either of the shim's two SAPs, and decides whether to pass that frame through to the other SAP, process it, or both. The decision whether pass it through is not dependent on the destination_address, but the decision whether to process the frame is dependent on the destination_address (see Clause 19). A CFM entity shall discard any frame, directed to it by reason of its VID and MD Level, whose destination_address parameter does not correspond to a MAC address recognized by that CFM entity.

Any given CFM entity is configured to recognize one or more individual MAC addresses, and one or more group MAC addresses, in received frames, and to use one or more individual MAC address or one or more group MAC addresses for transmitted frames. The individual MAC address is unique, within a bridged network, to a specific Bridge, though not necessarily to a single Bridge Port (J.6). For VLAN-based and backbone service instances, the group MAC addresses are selected from Table 8-18 and Table 8-19 according to the MD Level and OpCode fields in the CFM PDU header. For these service instances, Loopback Messages (LBMs, 20.2), Loopback Replies (LBRs, 20.2), and Linktrace Replies (LTRs, 20.3) are carried in unicast frames while Continuity Check Messages (CCMs, 20.1) use addresses from Table 8-18, and Linktrace Messages (LTMs, 20.3) use addresses from Table 8-19. In the case of TESI, all CFM messages use the individual MAC addresses or the group MAC addresses that are associated with the monitored service (20.1, 20.2, 20.3).

NOTE—The group destination MAC addresses in Table 8-18 are there primarily to make it possible for Bridges built prior to this standard to process CFM. This restriction on the choice of group destination MAC addresses to be used on a CFM PDU is relaxed for ESP-VIDs. See 22.8.

Table 8-18—CCM group destination MAC addresses

01-80-C2-00-00-3y	
MD Level of CCM	**Four address bits "y"**
7	7
6	6
5	5
4	4
3	3
2	2
1	1
0	0

Table 8-19—LTM group destination MAC addresses

01-80-C2-00-00-3y	
MD Level of LTM	**Four address bits "y"**
7	F
6	E
5	D
4	C
3	B
2	A
1	9
0	8

9. Tagged frame format

This clause specifies the format of the tags added to and removed from user data frames by the tag encoding and decoding functions that support the EISS (6.8, 6.9, 6.10, 6.11) and the Backbone Service Instance Multiplex Entity (6.18). It:

a) Reviews the purpose of tagging, and the functionality provided.
b) Specifies generic rules for the representation of tag fields and their encoding in the octets of an MSDU.
c) Specifies a general tag format, comprising a Tag Protocol Identifier (TPID), Tag Control Information (TCI), with additional information as signaled in the TCI.
d) Specifies the format of the TPID for each IEEE 802 media access control method.
e) Describes the types of tags that can be used, including the following:
    1) A C-TAG used at ports on a C-VLAN component
    2) An S-TAG used at ports on an S-VLAN component
    3) An I-TAG used at PIPs on an I-component and CBPs on a B-component
f) Documents the allocation of EtherType values to identify the types of tag specified in this standard.
g) Specifies the format of the TCI and additional information for each tag type.

Further analysis of the frame formats and the format translations that can occur when frames are tagged or untagged when relayed between different media access control methods can be found in Annex G.

9.1 Purpose of tagging

Tagging a frame with a VLAN tag:

a) Allows a VID to be conveyed, facilitating consistent VLAN classification of the frame throughout the network and enabling segregation of frames assigned to different VIDs.
b) Allows priority (IEEE Std 802.1AC, 6.8) to be conveyed with the frame when using IEEE 802 LAN media access control methods that provide no inherent capability to signal priority.

9.2 Representation and encoding of tag fields

In this subclause, octets are numbered starting from 1 and increasing in the order in which they are encoded in the sequence of octets that constitute an MSDU.

Where bits in consecutive octets are used to encode a binary number in a single field, the lower octet number encodes the more significant bits of the field, and the LSB of the lower octet number and the most significant bit (MSB) of the next octet both form part of the field.

Where the value of a field comprising a sequence of octets is represented as a sequence of two-digit hexadecimal values separated by hyphens (e.g., A1-5B-03), the leftmost hexadecimal value (A1 in this example) appears in the lowest numbered octet of the field and the rightmost hexadecimal value (03 in this example) appears in the highest numbered octet of the field.

The bits in an octet are numbered from 1 to 8, where 1 is the LSB.

When the terms set and reset are used in the text to indicate the values of single-bit fields, set is encoded as a binary 1 and reset as a binary 0 (zero).

When the encoding of a field or a number of fields is represented using a diagram,

a) Octets are shown with the lowest numbered octet nearest the top of the page, the octet numbering increasing from the top to bottom; or
b) Octets are shown with the lowest numbered octet nearest the left of the page, the octet numbering increasing from left to right;
c) Within an octet, bits are shown with bit 8 to the left and bit 1 to the right.

9.3 Tag format

Each tag comprises the following sequential information elements:

a) A Tag Protocol Identifier (TPID) (9.4)
b) Tag Control Information (TCI) that is dependent on the tag type (9.5, 9.6)
c) Additional information, if and as required by the tag type and TCI

The tag encoding function supports each EISS (6.8) instance by using an instance of the ISS to transmit and receive frames and encodes the above information in the first and subsequent octets of the MSDU that will accompany an ISS M_UNITDATA.request, immediately prior to encoding the sequence of octets that constitute the corresponding EISS M_UNITDATA.request's MSDU. On reception the tag decoding function is selected by the TPID and decodes the TCI and additional information octets (if present) prior to issuing an EISS M_UNITDATA.indication with an MSDU that comprises the subsequent octets.

9.4 TPID formats

The TPID includes an EtherType value that is used to identify the frame as a tagged frame and to select the correct tag decoding functions. Such an EtherType is known as the Tag EtherType. The TPID is EtherType encoded, i.e., is two octets in length and contains only the assigned EtherType value.

9.5 Tag Protocol identification

The following types of tags are specified:

a) A C-TAG, for general use by C-VLAN Bridges (5.9) and C-VLAN components of Provider Edge Bridges (5.10.1).
b) An S-TAG, reserved for use by S-VLAN Bridges (5.10), the S-VLAN component of Provider Edge Bridges (5.10.1) and BEBs (5.12), and C-VLAN Bridges signaling priority to a PBN or a PBBN (6.13).
c) An I-TAG, reserved for use by BEBs (5.7, 5.8, 5.12).

NOTE—The S-TAG is identical to the B-TAG (see 25.2).

A distinct EtherType has been allocated (Table 9-1) for use in the TPID field (9.4) of each tag type so they can be distinguished from each other, and from other protocols.

Table 9-1—IEEE 802.1Q™ EtherType allocations

Tag Type	Name	Value
Customer VLAN Tag	IEEE 802.1Q Tag Protocol EtherType (802.1QTagType)	81-00
Service VLAN Tag or Backbone VLAN Tag	IEEE 802.1Q Service Tag EtherType (802.1QSTagType)	88-A8
Backbone Service Instance Tag	IEEE 802.1Q Backbone Service Instance Tag EtherType (802.1QITagType)	88-E7

9.6 VLAN Tag Control Information (TCI)

The VLAN TCI field (Figure 9-1) is two octets in length and encodes the vlan_identifier, drop_eligible, and priority parameters of the corresponding EISS M_UNITDATA.request as unsigned binary numbers.

Figure 9-1—VLAN TCI format

The VID is encoded in a 12-bit field. A VLAN Bridge may not support the full range of VID values but shall support the use of all VID values in the range 0 through a maximum N, less than or equal to 4094 and specified for that implementation. Table 9-2 identifies VID values that have specific meanings or uses.

Table 9-2—Reserved VID values

VID value (hexadecimal)	Meaning/Use
0	The null VID. Indicates that the tag header contains only priority information; no VID is present in the frame. This VID value shall not be configured as a PVID or a member of a VID Set, or configured in any FDB entry, or used in any Management operation.
1	The default PVID value used for classifying frames on ingress through a Bridge Port. The PVID value of a Port can be changed by management.
2	The default SR_PVID value used for SRP [35.2.1.4 item i)] Stream related traffic. The SR_PVID value of a Port can be changed by management.
FFF	Reserved for implementation use. This VID value shall not be configured as a PVID or a member of a VID Set, or transmitted in a tag header. This VID value may be used to indicate a wildcard match for the VID in management operations or FDB entries.

NOTE 1—There is a distinction between the range of VIDs that an implementation can support and the maximum number of active VIDs supported at any one time. An implementation supports only 16 active VIDs, for example, may use VIDs chosen from anywhere in the identifier space, or from a limited range. The latter can result in difficulties where different Bridges in the same network support different maximums. It is recommended that new implementations of this standard support the full range of VIDs, even if the number of active VIDs is limited.

The priority and drop_eligible parameters are conveyed in the 3-bit PCP field and the DEI field as specified in 6.9.3.

NOTE 2—Previous versions of this standard used bit 5 of octet 1 of the TCI in C-TAGs as a Canonical Format Indicator (CFI). Bridges conformant to this version of the standard will not interoperate with Bridges that set the CFI as a result of inserting C-TAGs in frames received from an IEEE 802.5™ Token Ring LAN. Bridges conformant to this version of the standard will interoperate with Bridges that forward bit 5 of octet 1 as a CFI but do not have 802.5 Token Ring interfaces.

9.7 Backbone Service Instance Tag Control Information (I-TAG TCI)

The I-TAG TCI field (Figure 9-2) is 16 octets in length and encodes the priority, drop_eligible, destination_address, and source_address parameters of the corresponding service request primitive as unsigned binary numbers. I-TAGs are encoded and decoded at PIPs and CBPs of BEBs as specified in 6.10, 6.11, and 6.18.

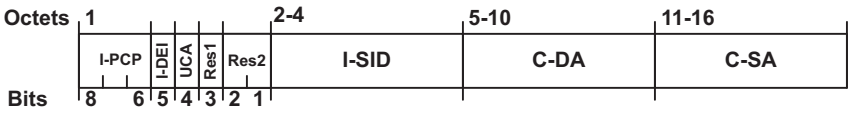


Figure 9-2—I-TAG TCI format

The I-TAG TCI contains the following fields:

a) *I-PCP (Priority Code Point)*—This 3-bit field encodes the priority and drop_eligible parameters of the service request primitive associated with this frame using the same encoding as specified for VLAN tags in 6.9.3. The PBBN operates on the priority associated with the B-TAG.

b) *I-DEI (Drop Eligible Indicator)*—This 1-bit field carries the drop_eligible parameter of the service request primitive associated with this frame. The PBBN operates on the drop eligibility associated with the B-TAG.

c) *UCA (Use Customer Addresses)*—A single-bit flag that, when containing a value of one, signals a Backbone Service Instance Multiplex Entity (6.18) to use the addresses contained in the C-DA and C-SA fields.

d) *Res1 (Reserved 1)*—This 1-bit field is reserved for future standardization. The Res1 field contains a value of zero when the tag is encoded, and is ignored when the tag is decoded.

e) *Res2 (Reserved 2)*—This 2-bit field is reserved for future standardization. The Res2 field contains a value of zero when the tag is encoded. The frame will be discarded if this field contains a nonzero value when the tag is decoded.

f) *I-SID (Backbone Service Instance Identifier)*—This 24-bit field carries the identifier of the backbone service instance.

g) *C-DA (Encapsulated Customer Destination MAC address)*—Contains the address in the destination_address parameter of the service request primitive associated with this frame. The address is represented using the Hexadecimal Representation as specified in IEEE Std 802 with the octet containing the I/G bit in the lowest numbered octet of the field.

h) *C-SA (Encapsulated Customer Source MAC address)*—Contains the address in the source_address parameter of the service request primitive associated with this frame. The address is represented using the Hexadecimal Representation as specified in IEEE Std 802 with the octet containing the I/G bit in the lowest numbered octet of the field.

The I-SID is encoded in a 24-bit field. Table 9-3 identifies I-SID values that have specific meanings or uses.

Table 9-3—Reserved I-SID values

I-SID value (hexadecimal)	Meaning/Use
0	Reserved for implementation use. This I-SID value shall not be configured as an identifier for a backbone service instance or transmitted in an I-TAG header. This I-SID value may be used in management and control operations, e.g., to indicate a deleted or null I-SID in ISIS-SPB TLVs (see Clause 28).
1	Default value—Unassigned ISID on a VIP.
2 through FE	Reserved for future standardization.
FF	SPBM default I-SID.
FFFFFF	Reserved for implementation use. This I-SID value shall not be configured as an identifier for a backbone service instance or transmitted in an I-TAG header. This I-SID value may be used to indicate a wildcard match for the I-SID in management operations.

NOTE—There is a distinction between the range of I-SIDs that an implementation can support, and the maximum number of active backbone service instances supported at any one time. An implementation that supports only 2^{16} active backbone service instances, for example, may use I-SIDs chosen from anywhere in the identifier space. Implementations of this standard support the full range of I-SIDs, even if the number of active backbone service instances is limited.

10. Multiple Registration Protocol (MRP) and Multiple MAC Registration Protocol (MMRP)

The Multiple Registration Protocol allows participants in an MRP application to register attributes with other participants in a Bridged Network. The definition of attribute types, their values, and the semantics associated with values when registered, are specific to each MRP application.

This clause:

a) Provides an overview of the use of MRP within a bridged network (10.1).
b) Describes the architecture of MRP participants for end stations and Bridge Ports (10.2).
c) Specifies registration propagation between the per-Port Participants in a Bridge (10.3).
d) Details requirements to be met by the MRP design (10.4).
e) Details requirements for interoperability between MRP participants (10.5).
f) Provides an overview of protocol operation (10.6).
g) Provides a detailed specification of the protocol (10.7).
h) Describes the structure of PDUs exchanged between MRP participants (10.8).

Subclauses 10.9 through 10.12 define an MRP application, the Multiple MAC Registration Protocol (MMRP), that registers attributes of two types—MAC addresses and Group service requirements. Values of these attributes control MAC address filtering by MMRP participants.

Clause 11 defines a second MRP application, the Multiple VLAN Registration Protocol (MVRP), that registers VLAN membership information.

Clause 35 defines a third MRP application, the Multiple Stream Registration Protocol (MSRP), that registers data Stream characteristics and reserves Bridge resources as appropriate to provide QoS guarantees.

Clause 39 defines a fourth MRP application, the Multiple I-SID Registration Protocol (MIRP), that serves as an alternative to MVRP for per-VLAN flushing of learned MAC address information in I-components.

10.1 MRP overview

MRP allows a participant in a given MRP application to make or withdraw *declarations* of *attributes*, and for those declarations (or withdrawals) to result in the *registration* (or removal of registrations) of those attributes with the other MRP Participants for that application.

A declaration by an MRP Participant for an end station or Bridge Port is recorded by an Applicant state machine for the declared attribute and Port. Changes in the Applicant state machine's variables trigger the transmission of MRPDUs to communicate the declaration (or withdrawal).

A registration is recorded by a Registrar state machine for the attribute at each participating end station and Bridge Port that receives the MRPDU. Removal of a given attribute registration occurs only if all the other participants connected to the same LAN withdraw the declaration.

Attributes registered on Bridge Ports that are part of the applicable *active topology* (8.4, 10.3.1) are declared on all the other Bridge Ports that are also part of that active topology. Hence, a given declaration is propagated to all application participants, and registered in each Bridge on those Ports that are "nearest" to the source or sources of the declaration within the active topology.

NOTE—Unless otherwise stated, the following description assumes operation within the Base Spanning Tree Context (see 10.3.1). While registration can occur on any Bridge Port, regardless of Port State (8.4), propagation follows the spanning tree active topology. All the Bridge Ports shown in Figure 10-1, Figure 10-2, and Figure 10-3 are in the Forwarding Port State.

Figure 10-1 illustrates the result of a single end station making a declaration, and shows the Bridge Ports that also make declarations to propagate the attribute. The attribute is propagated to all LANs in the Bridged Network, but the directional nature of the propagation results in registration only on Bridge Ports that receive a declaration of that attribute from the attached LAN.

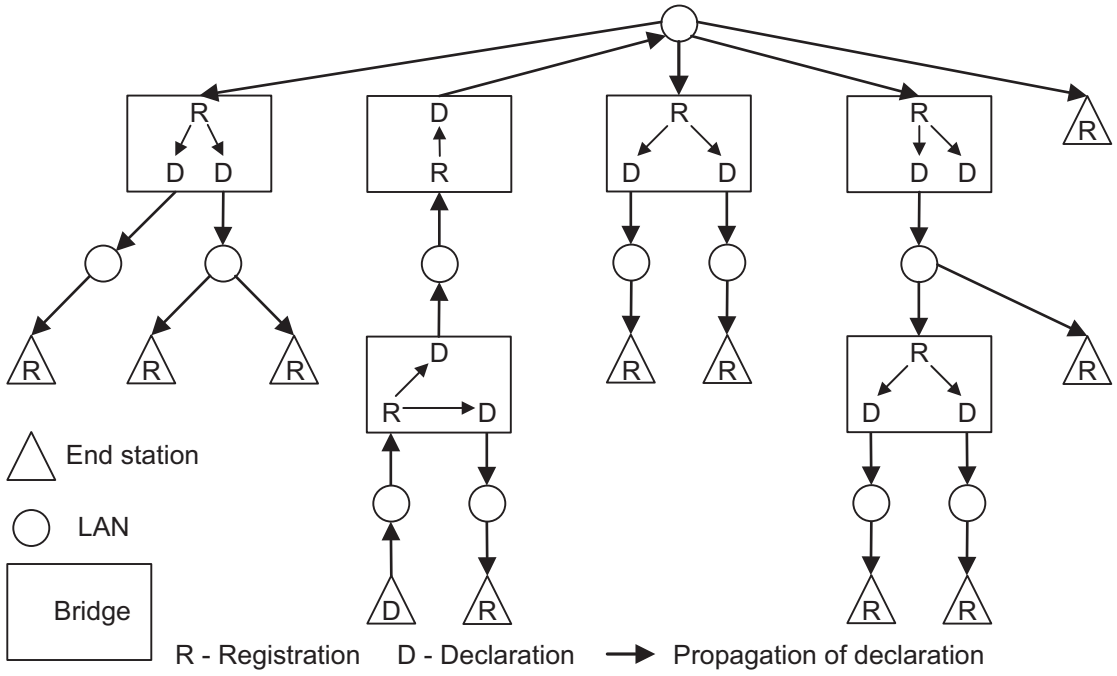


Figure 10-1—Example—Attribute value propagation from one station

Figure 10-2 illustrates the result of different end stations declaring the same attribute on different LANs. All end stations register the attribute, and some Bridges register it on more than one Port.

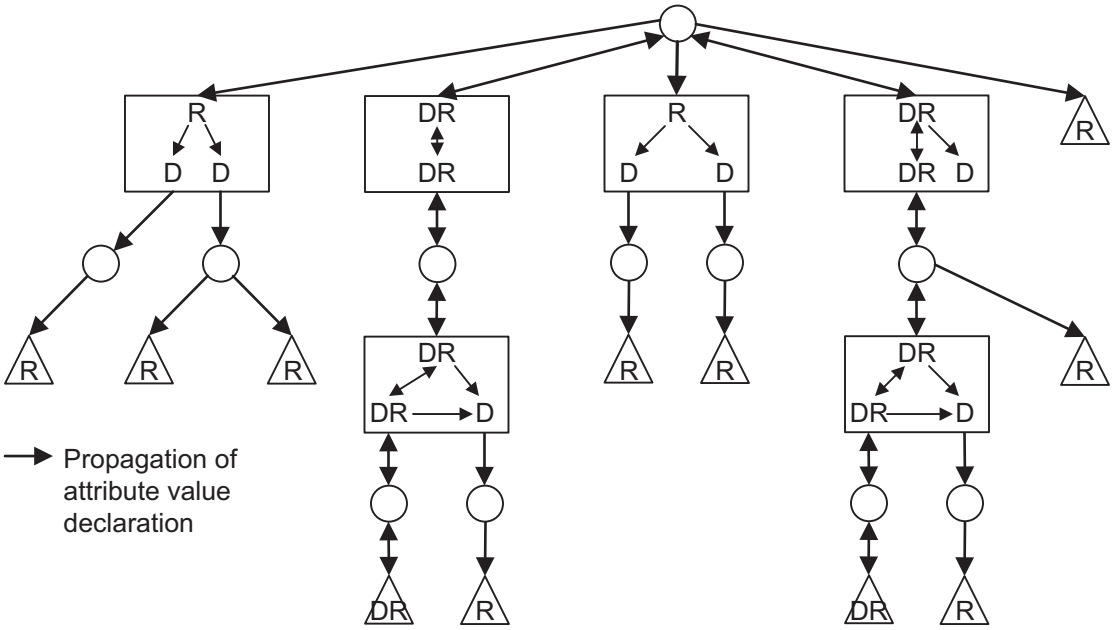


Figure 10-2—Example—Attribute value propagation from two stations

The set of Bridge Ports and end stations that both declare and register a given attribute defines the subset of the active topology that connects all the participants interested in that attribute. A registration can be regarded as a pointer to participants that have declared that attribute, as illustrated in Figure 10-3 (using the same set of declarations and registrations that were illustrated in Figure 10-2).

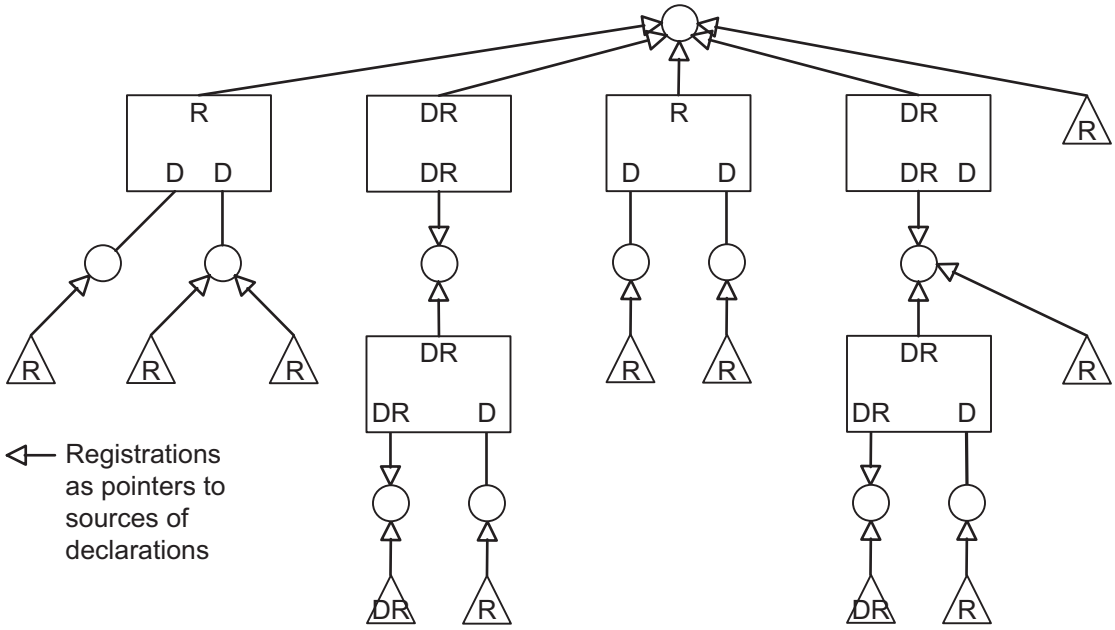


Figure 10-3—Example—Registrations as pointers to the sources of declarations

Situations where it is desirable to form “reachability trees” are generally good candidates for the use of MRP. For example, if the attribute in Figure 10-3 is a group MAC address that is used as a destination address for a video data stream, and it is deemed desirable for that video data to be sent only to the subset of the active topology that contains end stations that have declared that attribute, then an end station that is the source of that video stream could use the presence or absence of a registration as an indication of whether to send the data on the LAN to which it is attached. Any Bridge receiving the data could determine on which Ports the data should be forwarded.

VLAN Bridges that do not support MRP are transparent to MRP exchanges, and forward received MRPDUs on all Ports in the active topology. Similarly, VLAN Bridges that do not implement a given MRP application are transparent to MRP exchanges destined for that application, and forward any such received MRPDUs on all Ports that are participating in the active topology for the VLAN concerned.

MRP operates only on Ports that are MAC_Operational (IEEE Std 802.1AC). If the Port is operating as a network access port (IEEE Std 802.1X), MRP uses the controlled port (8.13.9). On any Port whose MAC_Operational parameter is FALSE, any MRP entity shall not transmit MRPDUs, and shall discard, without processing, any received MRPDUs.

MRP provides a means to mark initial attribute declarations and propagated attribute declarations as “new,” signaling to the recipient of the declaration that the attribute value is being newly declared, or is being redeclared following a change in the underlying topology. The rules applied to the marking and propagation of newly declared values in this way are common to all MRP Applications; however, the action taken on receipt of an attribute declaration marked as “new” is specific to each MRP Application. For example, MMRP (10.9) makes no use of the “new” marking, whereas MVRP (Clause 11) uses the “new” marking to permit FDB entries to be flushed on a per-VID basis following a topology change.

10.2 MRP architecture

An MRP Participant consists of an application component and an MRP Attribute Declaration (MAD) component. The application component is responsible for the semantics associated with attribute values and their registration, including the use of explicitly signaled new declarations, and uses the following two primitives to request MAD to make or withdraw attribute declarations:

MAD_Join.request (attribute_type, attribute_value, new)

MAD_Leave.request (attribute_type, attribute_value)

where *attribute_type* specifies the type of the attribute declaration, and *attribute_value* specifies the instance of that type, and the Boolean *new* parameter indicates an explicit new declaration.

Within a Bridge, a per application MRP Attribute Propagation (MAP) component (10.3) propagates information between the per-Port Participants, using the same request and indication primitives. If the value of tcDetected (13.25) for the Port and MAP Context (10.3.1) associated with the MRP Participant is nonzero, then the value of the *new* parameter in the propagated MAD_Join.request is set TRUE.

The MAD component executes MRP (10.6, 10.7), generating MRP messages for transmission and processing messages received from other Participants, and uses the following two primitives to notify its application component of a change in Attribute registration:

MAD_Join.indication (attribute_type, attribute_value, new)

MAD_Leave.indication (attribute_type, attribute_value)

One such Participant, per MRP application, exists for each point of attachment to a LAN where Attributes for that application are to be declared or registered, i.e., one Participant per application in an end station, and one per application per Port in a Bridge. The encoding of Attribute values in MRPDUs and their subsequent decoding is application specific, within the general structure specified in 10.8, and each MRPDU conveys messages generated by the MAD component for a single application.

Figure 10-4 illustrates the components of MRP Participants in a two-Port Bridge and an end station.

For each MRP application, the following are defined:

a) A set of Attribute types used by the application.
b) The Attribute values permitted for each Attribute type.
c) The semantics associated with each Attribute type and value.
d) The use made of MAP Contexts by the application.
e) The group MAC address and EtherType for protocol exchanges between application Participants.
f) The structure and encoding of the Attribute types and values in MRPDUs.
g) The requirements for MRP state machine support in end stations and Bridges.
h) The circumstances, if any, in which the application makes use of the “new” declaration capability.

NOTE 1—Not all applications of MRP will make use of the “new” declaration capability.

i) If the application makes use of the “new” declaration capability, the semantics that new registrations carry in that application.
j) The number of attribute values out of the possible range of values for which the application is expected to be capable of maintaining current state information.

NOTE 2—In some applications, such as MVRP, the failure of one Bridge in a network to maintain state for all possible attribute values would have major consequences for the integrity of the network. For such applications, the application definition will mandate the ability to track the state of all possible attribute values.

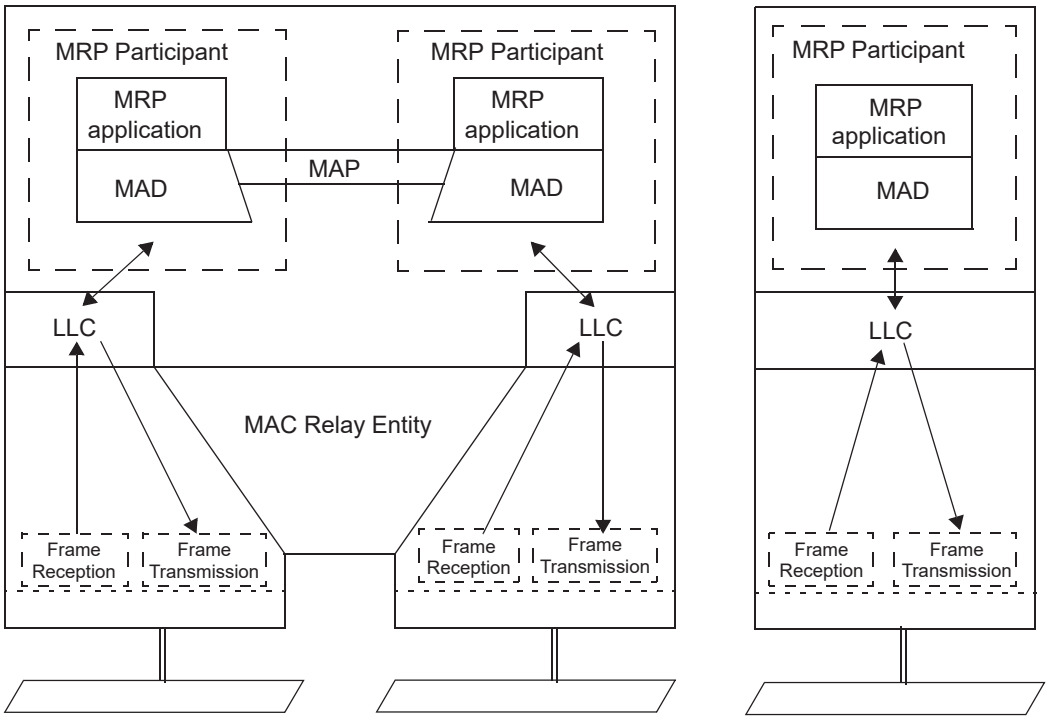


Figure 10-4—MRP architecture

10.3 MRP Attribute Propagation (MAP)

The MAP function enables propagation of attributes registered on Bridge Ports across the network to other participants. Each MRP application specifies the operation of the MAP function. This subclause specifies the operation of the MAP function for the MMRP application, the MVRP application (11.2.1), and the MSRP application (35.2). In addition, 35.2.4 specifies additional MSRP attribute processing rules that modify the MAP function defined below.

For a given MRP application and MAP Context (10.3.1), and for the set of Ports that have a Port State (8.4) of Forwarding for that MAP Context, and for the set of attributes associated with that MAP Context:

a) Any MAD_Join.indication, or any MAD_Join.request issued by the MRP application, received by MAP from a given Port in the set is propagated as a MAD_Join.request to the instance(s) of MAD associated with each other Port in the set. If the value of tcDetected (13.25) for the given Port and MAP Context is nonzero, then the value of the *new* parameter in the propagated MAD_Join.request is set TRUE, regardless of the value of this parameter in the indication or request that is being propagated.
b) Any MAD_Leave.indication, or any MAD_Leave.request issued by the MRP application, received by MAP from a given Port in the set is propagated as a MAD_Leave.request to the instance(s) of MAD associated with each other Port in the set (Port P, say) if and only if no registration now exists for that Attribute on any other Port in the set excluding P.

These rules propagate attribute registrations through any given Port if any other Port has seen a registration for that attribute, and propagate deregistrations if all other Ports are now deregistered.

As the set of Ports with a Port State of Forwarding for a given MAP Context can change dynamically, for example as a result of spanning tree reconfiguration, MAP operates as follows after such a change:

c) If a Port is added to the set, and that Port has registered an attribute (i.e., a MAD_Join.indication or MAD_Join.request has occurred more recently than any MAD_Leave.indication or MAD_Leave.request for the attribute), then MAD_Join.requests are propagated to the MAD instances for each of the other Ports in the set.
d) If a Port is added to the set, but that Port has not declared an attribute that other Ports in the set have registered, then MAD_Join.requests are propagated by those other Ports to the MAD instance for that Port.
e) If a Port is removed from the set, and that Port has registered an attribute and no other Port has, then MAD_Leave.requests are propagated to the MAD instances for each of the other Ports in the set.

NOTE—If a Port is removed from the set, and that Port has declared one or more attributes, then this Port transmits a Leave message (see 10.6) for every attribute that it has declared.

f) If a Port is removed from the set, and that Port has registered an attribute that another Port has also registered, then a MAD_Leave.request is propagated to the MAD instance for that other Port.

10.3.1 MAP Context

For a given Port of an MRP-aware Bridge and MRP application supported by that Bridge, an instance of an MRP Participant can exist for each *MRP Attribute Propagation Context (MAP Context)* understood by the Bridge. A MAP Context identifies the set of Bridge Ports that form the applicable *active topology* (8.4).

Examples of MAP Contexts are as follows:

a) The active topology formed by the operation of RSTP (Clause 13). This MAP Context provides the same connectivity as the spanning tree in each Bridge and is known as the *Base Spanning Tree Context*.
b) The active topology formed by the subset of Bridge Ports, and the underlying spanning tree, that support a given VID. This MAP Context is known as a *VLAN Context.*

NOTE—This standard uses the Base Spanning Tree Context and VLAN Contexts to define the operation of MMRP and MVRP; however, other MAP Contexts may be used for other applications, or for extending MMRP functionality.

MRP exchanges can occur on all of the Ports of a Bridge; however propagation across a Bridged Network of attribute registrations for a given application uses only those Bridge Ports that are part of the active topology identified by the MAP Context. Each MRP application specification identifies the contexts it can operate within and assigns MAP Context identifiers for use in conjunction with the operation of MRP and its administrative controls (10.7.2, 10.7.3).

A MAP Context identifier of 0 always identifies the *Base Spanning Tree Context*. The MRP application specifies how the MAP Context of each MRPDU is identified if any other context is used.

10.3.1.1 MAD and Port role changes

A spanning tree provides a loop-free active topology connecting all the Bridges and all the LANs in a network. Hence, any Bridge Port that forwards frames connects two otherwise disconnected parts of the topology. Each Alternate Port on a Bridge A (say) connects to a LAN that has a Port of another Bridge with a better priority vector than A can supply; hence, each of A's Alternate Ports is a potential connection to part of the network that is not connected to any of A’s Designated Ports, all LANs and Bridges in any such part having an equal or worse priority vector than A. Therefore, an Alternate Port on A potentially connects to the part of the network connected to by A's Root Port. Since any part of the network is fully connected, in the absence of registration controls, A's Alternate Port will have registered the same attributes as its Root Port.

For implementations running over RSTP or MSTP, this gives rise to the risk of information loops when Port roles change; because of the store and forward nature of attribute propagation and the potentially rapid transitions of Port roles (compared to the relatively slow transitions that occurred with STP), these can arise even when there are no data loops.

To prevent such information loops from occurring, the information held by MAD's Registrars for a Port (i.e., information registered on a Port as a result of protocol activity on the LAN to which that Port is connected) is discarded whenever the Port transitions from an Alternate port or Root Port role to become a Designated Port. No such discard is needed for changes in the other direction, i.e., changes from Designated Port to Root Port or Alternate Port.

10.4 Requirements to be met by MRP

MRP establishes, maintains, withdraws, and disseminates attribute declarations and registrations among the MRP Participants attached to a Bridged Network. The protocol meets the following requirements for Applicant and Registrar behavior, error recovery, performance, scalability, compatibility with non-MRP-aware devices, and the load imposed on Bridges, end stations, and the network:

a) Participants can issue declarations for MRP application attributes (10.2, 10.3, 10.7.3, and 10.7.7).
b) Participants can withdraw declarations for attributes (10.2, 10.3, 10.7.3, and 10.7.7).
c) Each Bridge propagates declarations to MRP Participants (10.3).
d) MRP Participants can track the current state of declaration and registration of attributes on each Port of the participant device (10.7.7 and 10.7.8).
e) MRP Participants can remove state information relating to attributes that are no longer active within part or all of the network, e.g., as a result of the failure of a participant (10.7.8 and 10.7.9).
f) The latency involved in issuing, propagating, or revoking attribute declarations, is small (i.e., comparable to the frame propagation delay) and increases linearly as a function of the diameter of the network (10.7.7, 10.7.8, and 10.7.9).
g) MRP is resilient in the face of the failure of MRP Participants.
h) MRP is resilient in the face of single packet loss.
i) MRP will operate correctly in networks where:
    1) All Bridges support both Basic and Extended Filtering Services; or where
    2) Some Bridges support only Basic Filtering Services and some both Basic and Extended Filtering Services (10.5, 10.7.7, 10.7.8, and 10.7.9).
j) The communications bandwidth consumed on any particular LAN by Applicants and Registrars in exchanging MRPDUs will be a small percentage of the total available bandwidth, and independent of the total traffic supported by the network. The bandwidth consumed will be a function of the number of attributes registered.

10.5 Requirements for interoperability between MRP Participants

To ensure the interoperability of MRP, the following are required:

a) All MRP applications use a group MAC address as the destination address of MRPDUs, selected in accordance with the stated requirements of the MRP application concerned for the type of Bridge component in which the application is implemented. The addresses used may be taken from the set of addresses specified in Table 10-1, or taken from the set of reserved addresses specified in Table 8-1, Table 8-2, and Table 8-3, or other group MAC addresses, chosen according to the particular properties required by the application concerned.

    NOTE 1—The addresses in Table 8-1, Table 8-2, Table 8-3, and Table 10-1 differ from other group MAC addresses in terms of the scope of transmission within a network, as a consequence of the forwarding/filtering decisions that are taken relative to them by different types of Bridge component.

b) Table 10-1 specifies a set of group MAC addresses, some that have been assigned for use by existing applications defined in this standard, and others reserved for future standardization. Addresses in this set have the property that:
    1) Where a given address in the set is used by a Bridge component to support an MRP application, frames destined for that address shall not be forwarded by that Bridge component; i.e., a Static

Filtering Entry for that address is maintained for that group MAC address in order to prevent the forwarding of frames destined for that address.

2) Where a given address in the set is not used by a Bridge component to support any MRP application, frames destined for that address received on any Port that is part of a given active topology shall be forwarded by that Bridge component on all other Ports that are part of that active topology.

Table 10-1—MRP application addresses

Assignment[a]	Value
Customer and Provider Bridge MMRP address	01-80-C2-00-00-20
Customer Bridge MVRP address	01-80-C2-00-00-21
Reserved	01-80-C2-00-00-22
Reserved	01-80-C2-00-00-23
Reserved	01-80-C2-00-00-24
Reserved	01-80-C2-00-00-25
Reserved	01-80-C2-00-00-26
Reserved	01-80-C2-00-00-27
Reserved	01-80-C2-00-00-28
Reserved	01-80-C2-00-00-29
Reserved	01-80-C2-00-00-2A
Reserved	01-80-C2-00-00-2B
Reserved	01-80-C2-00-00-2C
Reserved	01-80-C2-00-00-2D
All Provider Bridge Intermediate Systems	01-80-C2-00-00-2E
All Customer Bridge Intermediate Systems	01-80-C2-00-00-2F

[a] MIRP is an MRP application, but is not assigned an address from this table (39.2.1.5, 39.2.1.6).

c) The transmission and reception of MRPDUs between MRP Participants, formatted as defined for the application using the generic PDU format defined in 10.8, shall use LLC procedures. Each MRP application uses a unique EtherType value in order to identify the application protocol. Table 10-2 specifies the EtherType values assigned to existing applications.

Table 10-2—MRP EtherType values

Assignment	Value
MMRP EtherType	88-F6
MVRP EtherType	88-F5
MSRP EtherType	22-EA
MIRP EtherType	89-29

NOTE 2—For the purposes of this standard, the expression “use LLC procedures” includes making use of the service provided by link layer protocol entities that support protocol discrimination by means of an EtherType value.

d) MRPDUs, i.e., frames with the destination MAC addresses selected as specified in item a) and the EtherType values specified in item c), that are destined for applications supported by a Bridge component, and that are not well formed (i.e., are not structured and encoded as defined in 10.8 and with attribute types and values encoded as defined by the MRP application), shall be discarded on receipt.

10.6 Protocol operation

This subclause provides an informal introduction. The definitive specification of MRP is contained in 10.7 and 10.8.

MRP is a simple, fully distributed, many-to-many protocol, that supports efficient, reliable, and rapid declaration and registration of attributes by multiple participants on shared and virtual shared media. MRP also incorporates optimizations to speed attribute declarations and withdrawals on point-to-point media. Correctness of MRP operation is independent of the relative values of protocol timers, and the protocol design is based primarily on the exchange of idempotent protocol state rather than commands.

A full MRP Participant maintains Registrar and Applicant state machines for each Attribute of interest, and a LeaveAll state machine and PeriodicTransmission state machine for the participant as a whole.

The job of the Registrar is to record declarations of the attribute made by other Participants on the LAN. It does not send any protocol messages, as the Applicant looks after the interests of all would-be Participants.

The job of the Applicant is twofold:

a) To ensure that this Participant's declaration is correctly registered by other Participants' Registrars.
b) To prompt other Participants to reregister after one withdraws a declaration.

NOTE 1—Applicant-Only implementations are concerned only with item a).

The basic design of MRP is oriented to LAN environments, where there is generally a low probability of frame loss, and ensures that timely registration of attributes is unaffected unless at least two out of a set of immediately related frames are lost. The LeaveAll state machine periodically ensures that Participants reregister attributes, thus guarding against an extended failure to register or deregister. In potentially lossy environments such as service instances supported by PBNs, where frame losses are temporally correlated, the PeriodicTransmission machine ensures successful registration without immediately contributing to congestive loss.

If one Applicant has both declared and registered an Attribute, other Applicants do not need to reiterate the declaration. MRP messages convey both Applicant and Registrar state to allow suppression of such repeated declarations. The Applicant state machine distinguishes between Active Participants (that have sent a message or messages to make a declaration), Passive Participants (that require registration, but have not had to declare the attribute so far to register it, and will not have to explicitly deregister), and Observers (that do not require registration at present, but track the attribute's registration in case they do and become Passive Participants). The following four distinct messages communicate the transmitting participant's state for an Attribute:

— Empty—Not declared, and not registered.
— In—Not declared, but registered.
— JoinEmpty—Declared, but not registered.
— JoinIn—Declared and registered.

One message communicates a withdrawal of a prior declaration, so that Registrars do not have to track individual Applicants:

— Leave—Previously registered, but now withdrawn.

A further message conveys a declaration from a new Participant, or a Participant newly added to the active topology reached through a Bridge Port. This information is propagated by the MAP component, and so includes additional registrations elsewhere in the bridged network:

— New—Newly declared, and possibly not previously registered.

The LeaveAll state machine uses the following single message that applies to all Attributes.

— LeaveAll—All registrations will shortly be deregistered; Participants need to reregister.

The Registrar for each Attribute actually implements the following three states for the Attribute:

— IN—Registered.
— LV—Previously registered, but now being timed out.
— MT—Not registered.

A single timer, the leavetimer, is associated with each Registrar and operates in the LV state. In that state, MRP messages for the Attribute report it as unregistered (using Empty or Join Empty) but the MAD Leave indication is delayed until the leavetimer expires and the state transitions to MT.

NOTE 2—The accuracy required for the leavetimer is sufficiently coarse to permit the use of a single operating system timer per Participant with 2 bits of state for each Registrar.

The Applicant for each Attribute implements states that record whether it wishes to make a new declaration, to maintain or withdraw an existing declaration, or has no declaration to make. It also records whether it has actively made a declaration, or has been passive, taking advantage of or simply observing the declarations of others. It counts the New, JoinIn, and JoinEmpty messages it has sent, and JoinIn messages sent by others, to ensure that at least two such messages have been sent since it last received a LeaveAll or Leave message, and at least one since it last received a JoinEmpty or Empty message. This ensures that each of the other Participant's Registrars for the Attribute either have received (assuming no packet loss) two Join or New messages or have reported the Attribute as registered. The Applicant state machine (Table 10-3) uses the following states:

— VO—Very anxious Observer. The applicant is not declaring the attribute, and has not received a JoinIn message since the state machine was initialized, or since last receiving a Leave or LeaveAll.
— VP—Very anxious Passive. The applicant is declaring the attribute, but has neither sent a Join nor received a JoinIn since the state machine was initialized, or since last receiving a LeaveAll or Leave.
— VN—Very anxious New. The applicant is declaring the attribute, but has not sent a message since receiving a MAD Join request for a new declaration.
— AN—Anxious New. The applicant is declaring the attribute, and has sent a single New message since receiving the MAD Join request for the new declaration.
— AA—Anxious Active. The applicant is declaring the attribute, and has sent a Join message, since the last Leave or LeaveAll, but either has not received another JoinIn or In, or has received a subsequent message specifying an Empty registrar state.
— QA—Quiet Active. The applicant is declaring the attribute and has sent at least one of the required Join or New messages since the last Leave or LeaveAll, has seen or sent the other, and has received no subsequent messages specifying an Empty registrar state.
— LA—Leaving Active. The applicant has sent a Join or New message since last receipt of a Leave or LeaveAll, but has subsequently received a MAD Leave request and has not yet sent a Leave message.
— AO—Anxious Observer. The applicant is not declaring the attribute, but has received a JoinIn since last receiving a Leave or LeaveAll.
— QO—Quiet Observer. The applicant is not declaring the attribute, but has received two JoinIns since last receiving a Leave or LeaveAll, and at least one since last receiving a message specifying an Empty registrar state.
— AP—Anxious Passive. The applicant is declaring the attribute, and has not sent a Join or a New since last receiving a Leave or a LeaveAll but has received messages as for the Anxious Observer state.

— QP—Quiet Passive. The applicant is declaring the attribute, and has not sent a Join or a New since last receiving a Leave or a LeaveAll but has received messages as for the Quiet Observer state.
— LO—Leaving Observer. The applicant is not declaring the attribute, and has received a Leave or LeaveAll message.

If an Applicant receives a Leave or LeaveAll message it will send a JoinEmpty or Empty message, and that message will prompt any other Applicants that are declaring the attribute to send a JoinIn. An Applicant that sends a LeaveAll message will also ensure that an Empty message is sent to prompt other Applicants to repeat their declaration. Thus, if any Participant's Registrar deregisters an Attribute, at least two messages will be lost before another Participant's Applicant fails to make a required redeclaration.

To facilitate and encourage the transmission of timely protocol information and the encoding of messages for multiple Attributes within the same MRPDU, rather than the use and subsequent queuing of multiple PDUs prior to transmission, PDU transmission is specified in terms of requests for a transmission opportunity, and the Applicant and LeaveAll state machines specify the necessary addition of messages to an MRPDU when that opportunity occurs. Whenever a state machine transitions to a state that requires transmission of a message, a transmit opportunity is requested if one is not already pending. The message actually transmitted (if any) is that appropriate to the state of the machine when the opportunity is presented.

NOTE 3—Specifying transmit opportunity requests and their subsequent use is also intended to aid correct implementation in systems where a transmission is not possible immediately, e.g., shortly after whole or part of the system is initialized when other claims on system resources take precedence or interfaces are not yet available.

To support the efficient encoding of many messages in a single MRPDU, the number of message types has been kept to the minimum consistent with protocol goals and requirements, and the state machines specify both whether it is necessary to send a message and a message type that can always be sent—thus removing the need for a further "no message" encoding. The MRPDU structure and compact encoding (10.8) allows all potential attributes for certain MRP applications, e.g., MVRP (Clause 11), to be encoded in a single IEEE 802.3 frame and this further promotes protocol efficiency through ready detection of missing registrations. Protocol efficiency and correct registration are further supported by encoding a LeaveAll message (if required) at the beginning of the MRPDU, and by using an Applicant state machine that minimizes state changes for those Attributes whose redeclaration can be encoded in the same PDU—if the LeaveAll is received by another Participant so also will be the redeclaration, and sequential processing of the encoded messages by the recipient will ensure that the registration is uninterrupted. Applicant states for Attributes that cannot be redeclared in the same PDU allow for receipt of the LeaveAll but loss of the redeclaration.

LeaveAll messages are transmitted to ensure that any failure to withdraw a declaration does not result in an unwanted permanent registration—perhaps the system or process responsible for the registration has been removed from the LAN or has ceased to operate. Attributes registered by the Participant transmitting the LeaveAll as well as those receiving it are therefore timed out. The LeaveAll state machine (10.7.9) for the Participant operates a single timer, the leaveAllTimer, that causes a transmit opportunity to be requested when it expires, and transmission of a LeaveAll at the next opportunity. Reception of a LeaveAll message from another Participant causes the timer to be restarted without generating a message, thus suppressing multiple LeaveAll messages from Participants connected to the same LAN.

NOTE 4—In the face of changing inputs, arbitrary loss, delay, reordering, and unsignaled interruption in participation, no protocol will meet its objectives. What can be said is that the objectives will be met after a known period of operation within specified limits, and what failures are most likely otherwise. MRP favors ensuring that registrations are made, at the expense of tolerating prolonged registrations. Thus, the LeaveAll mechanism, when it has an effect, most often implements "garbage collection." At the same time it will also ensure that failed registrations are (re-)established. These objectives cannot be ensured if the LeaveAllTime is set to zero; therefore, it is recommended to set the LeaveAllTime to a nonzero value as soon as is practicable.

When MRP Participants are connected by a shared or virtual shared medium, protocol performance is improved and the effect on other protocols using the LAN minimized if the Participants transmit at different times, avoiding a multicast storm and allowing some to optimize their transmissions based on messages

received. A request for a transmit opportunity starts a randomized join timer, with a maximum value chosen to ensure successful reregistration(s) within a Leave time period (10.7.4), and the transmit opportunity is offered when the timer expires. If more messages are to be sent than can fit in a single PDU, a further transmit opportunity is requested.

When two MRP Participants are connected by a point-to-point medium or service instance delaying MRPDU transmission provides no benefit. In bridged networks it is desirable to transmit without delay, minimizing the denial of service that might occur while registration changes propagate after reconfiguration, and maximizing the benefit from using protocols such as RSTP and MSTP. When operPointToPointMAC (IEEE Std 802.1AC) is TRUE, transmit opportunities are scheduled immediately on request, subject to rate limiting (10.7.4).

Use of point-to-point service connecting at most two Participants allows further protocol optimization, e.g., receipt of an In message does acknowledge registration. However, not all LAN media support reliable determination of point-to-point status, particularly if nonstandard bridge-like devices are present. When operating in point-to-point mode, MRP avoids behavior that could cause failure, potentially continuous rapid exchanges of messages, or flapping registrations if there are more than two Participants. This standard permits simple point-to-point subset implementations of MRP, but these will successfully operate on shared media—albeit at reduced efficiency.

NOTE 5—IEEE Std 802.1AE (MAC Security) can ensure that there are at most two communicating Participants.

In certain contexts, often encountered in PBNs or PBBNs, it is necessary to control the VLAN entries in the FDB using Static VLAN Registration Entries, and retain only the ability to signal the need to flush learned MAC Address Entries via MRP. A New-Only Participant supports this need by implementing only a part of the Applicant and Registrar state machines, but not implementing the LeaveAll state machine, and by transmitting and receiving only New messages. It is also possible to simplify an MRP Participant that only wishes to make declarations; for example, for an end station that uses MMRP (10.9) to declare a need to receive group addressed frames, but is not a source of such frames, and therefore does not need to support source pruning by registering declarations from other Participants. Such an Applicant-Only Participant does not implement the Registrar or LeaveAll state machines, never sends LeaveAll, Empty, or JoinEmpty messages (which would elicit unnecessary Joins from its peer Participants), and does not implement the administrative controls defined in 10.7.2 and 10.7.3. The following five types of MRP implementation conform to this standard:

— Full Participant
— Full Participant, point-to-point subset
— New-Only Participant
— Applicant-Only Participant
— Applicant-Only point-to-point subset, also referred to as the Simple-Applicant Participant

While Simple-Applicant and Full Participant point-to-point subset implementations can operate on shared media, their initial Join and Leave messages are not suppressed. Significant additional, and unnecessary, traffic can result from attaching several such implementations to the same shared medium. Devices that do not perform registration should use an Applicant-Only Participant rather than a Simple-Applicant Participant.

NOTE 6—At the time of the development of this standard the LAN MACs most commonly used were point-to-point but the use of virtual shared media was increasing.

10.7 Protocol specification

The operation of MRP as executed by the MRP Attribute Declaration (MAD, 10.2) component of an MRP Participant is represented by the following state machines:

a) A per-Attribute Applicant state machine (10.7.7)
b) A per-Attribute Registrar state machine (10.7.8)
c) A LeaveAll state machine for the Participant as a whole (10.7.9)
d) A PeriodicTransmission state machine for the Participant as a whole (10.7.10)

These state machines are specified as compact state tables, and make use of the following:

e) Notational conventions and abbreviations for protocol events, actions, and timer operations (10.7.1)
f) Registrar Administrative Controls (10.7.2)
g) Applicant Administrative Controls (10.7.3)
h) Protocol timers (10.7.4)
i) Protocol event definitions (10.7.5)
j) Protocol action definitions (10.7.6)

A Full Participant implements the complete Applicant state machine (Table 10-3) and the Registrar state machine (Table 10-4) for each Attribute declared, registered, or tracked, together with a single instance of the LeaveAll state machine (Table 10-5) and the PeriodicTransmission state machine (Table 10-6).

The point-to-point subset of the Full Participant implements the same state machines, but omits certain Applicant state machine states and actions as specified by Table 10-3.

A New-Only Participant implements the Applicant state machine, with the omission of certain states and actions, as specified in Table 10-3, and the Registrar state machine (Table 10-4), for each Attribute declared, registered, or tracked, but does not implement the LeaveAll state machine (Table 10-5) or the PeriodicTransmission state machine (Table 10-6). Applications that permit both Full Participants and New-Only Participants define managed objects (12.9) to make the selection on a per-Port basis.

An Applicant-Only Participant implements the Applicant state machine, with the omission of certain states and actions as specified by Table 10-3, for each Attribute declared, registered, or tracked, together with a single instance of the PeriodicTransmission state machine (Table 10-6).

The point-to-point subset of the Applicant-Only Participant (the Simple-Applicant Participant) implements the same state machines, but omits certain Applicant state machine states and actions as specified by Table 10-3.

NOTE—Conceptually, per-Attribute state is maintained for all possible values of all Attribute types that are defined for a given application; however, in real implementations of MRP, it is likely that the range of possible Attribute values in some applications will preclude this, and the implementation will limit the state to those Attribute values in which the Participant has an immediate interest, either as a Member or as a likely future Member.

Timer values, their relationships, and default values are described in 10.7.11 and Table 10-7, protocol management statistics accumulated by each MAD component in 10.7.12, and interoperability considerations for potentially misordering networks in 10.7.13.

The encoding of MRP messages in MRPUs is specified in 10.8, which also specifies the parsing and checks applied to received PDUs.

10.7.1 Notational conventions and abbreviations

The following conventions are used in the abbreviations used in this subclause:

rXXX	receive PDU XXX
sXXX	send PDU XXX
txXXX	transmit opportunity
XXX!	state machine event
!XXX	"Not XXX"; i.e., logical NOT applied to the condition XXX

The following abbreviations are used in the state machine descriptions. For their meaning, see 10.7.5 and 10.7.6.

Protocol events:

Begin!	Initialize state machine (10.7.5.1)
New!	A new declaration (10.7.5.4)
Join!	Declaration without signaling new registration (10.7.5.5)
Lv!	Withdraw a declaration (10.7.5.6)
tx!	Transmission opportunity without a LeaveAll (10.7.5.7)
txLA!	Transmission opportunity with a LeaveAll (10.7.5.8)
txLAF!	Transmission opportunity with a LeaveAll, and with no room (Full) (10.7.5.9)
rNew!	receive New message (10.7.5.14)
rJoinIn!	receive JoinIn message (10.7.5.15)
rIn!	receive In message (10.7.5.18)
rJoinMt!	receive JoinEmpty message (10.7.5.16)
rMt!	receive Empty message (10.7.5.19)
rLv!	receive Leave message (10.7.5.17)
rLA!	receive a LeaveAll message (10.7.5.20)
Flush!	Port role changes from Root Port or Alternate Port to Designated Port (10.7.5.2)
Re-Declare!	Port role changes from Designated to Root Port or Alternate Port (10.7.5.3)
periodic!	A periodic transmission event occurs (10.7.5.10)
leavetimer!	leavetimer has expired (10.7.5.21)
leavealltimer!	leavealltimer has expired (10.7.5.22)
periodictimer!	periodictimer has expired (10.7.5.23)

Protocol actions:

New	send a New indication to MAP and the MRP application (10.7.6.12)
Join	send a Join indication to MAP and the MRP application (10.7.6.13)
Lv	send a Lv indication to MAP and the MRP application (10.7.6.14)
sN	send a New message (10.7.6.2)
sJ	send a JoinIn or JoinMT message (10.7.6.3)
sL	send a Lv message (10.7.6.4)
s	send an In or an Empty message (10.7.6.5)
[s]	send an In or an Empty message, if required for optimization of the encoding (10.7.6.5)
[sL]	send a Lv message, if required for optimization of the encoding (10.7.6.4)
[sJ]	send a Join message, if required for optimization of the encoding (10.7.6.3)
sLA	send a Leave All message (10.7.6.6)
periodic	Periodic transmission event (10.7.6.7).
leavetimer	Leave period timer (10.7.4.2)
leavealltimer	Leave All period timer (10.7.4.3)
periodictimer	Periodic Transmission timer (10.7.4.4)
-x-	Inapplicable event/state combination. No action or state transition occurs in this case.

Timers are used in the state machine descriptions in order to cause actions to be taken after defined time periods have elapsed. The following terminology is used in the state machine descriptions to define timer states and the actions that can be performed upon them:

a) A timer is said to be *running* if the most recent action to be performed upon it was a *start.*
b) A running timer is said to have *expired* when the time period associated with the timer has elapsed since the most recent start action took place.
c) A timer is said to be *stopped* if it has expired or if the most recent action to be performed upon it was a *stop* action.
d) A *start* action sets a stopped timer to the running state, and associates a time period with the timer. This time period supersedes any periods that might have been associated with the timer by previous start events.
e) A *stop* action sets a timer to the stopped state.

The following abbreviations are used for the state names in the state tables and state diagrams:

Registrar states (see 10.6):

IN In
LV Leaving
MT Empty

Applicant and Simple-Applicant states (see 10.6):

VO Very anxious Observer
VP Very anxious Passive
VN Very anxious New
AN Anxious New
AA Anxious Active
QA Quiet Active
LA Leaving Active
AO Anxious Observer
QO Quiet Observer
AP Anxious Passive
QP Quiet Passive
LO Leaving Observer

10.7.2 Registrar Administrative Controls

Associated with each instance of the Registrar state machines are *Registrar Administrative Control* parameters. These parameters allow administrative control to be exercised over the registration state of each Attribute value, and hence, via the propagation mechanism provided by MAP, allow control to be exercised over the propagation of declarations.

a) *Normal Registration*. The Registrar responds to incoming MRP messages as specified by Table 10-4.
b) *Registration Fixed (New ignored)*. The Registrar ignores all MRP messages, and remains IN (registered).
c) *Registration Fixed (New propagated)*. The Registrar ignores all MRP messages except New, and remains IN (registered).
d) *Registration Forbidden*. The Registrar ignores all MRP messages, and remains MT (unregistered).

The default value of this parameter is *Normal Registration*.

If the value of this parameter is *Registration Fixed* (New ignored) or Registration Fixed (New propagated), In and JoinIn messages are sent. If the value of this parameter is *Registration Forbidden,* Empty or JoinEmpty messages are sent. If the value of this parameter is *Registration Fixed (New propagated),* only New messages are accepted.

NOTE—The Registrar Administrative Controls are realized by means of the contents of the Port Map parameters of static entries in the FDB for all MRP applications In the case of MMRP, the static entries concerned are Static Filtering Entries (8.8.1); in the case of MVRP and MIRP, the static entries concerned are Static VLAN Registration Entries (8.8.2). The contents of the Port Map parameters in static entries can be modified by means of the management operations defined in Clause 12. In the absence of such control information for a given attribute, the default value "Normal Registration" is assumed.

10.7.3 Applicant Administrative Controls

An overall control parameter for each Applicant state machine, the *Applicant Administrative Control,* determines whether the Applicant state machine participates in MRP exchanges.

a) *Normal Participant.* The state machine participates normally in MRP exchanges.
b) *New-Only Participant*. The state machine sends only New MRP messages.
c) *Non-Participant.* The state machine does not send any MRP messages.

The default value of this parameter is Normal Participant.

NOTE 1—The Applicant Administrative Control parameters can be modified for any MRP application by means of the management operations defined in Clause 12. In the absence of such information for a given attribute, the default value "Normal Participant" is assumed.

NOTE 2—The Applicant Administrative Control parameters can be set per attribute type (see 12.9.2).

10.7.4 Protocol timers

10.7.4.1 jointimer

The Join Period Timer, jointimer, controls the interval between transmit opportunities that are applied to the Applicant state machine. An instance of this timer is required on a per-Port, per-MRP Participant basis. The value of JoinTime used to initialize this timer is determined in accordance with 10.7.11.

10.7.4.2 leavetimer

The Leave Period Timer, leavetimer, controls the period of time that the Registrar state machine will wait in the LV state before transiting to the MT state. An instance of the timer is required for each state machine that is in the LV state. The Leave Period Timer is set to the value LeaveTime when it is started; LeaveTime is defined in Table 10-7.

10.7.4.3 leavealltimer

The Leave All Period Timer, leavealltimer, controls the frequency with which the LeaveAll state machine generates LeaveAll PDUs. The timer is required on a per-Port, per-MRP Participant basis. If LeaveAllTime is zero, the Leave All Period Timer is not started; otherwise, the Leave All Period Timer is set to a random value, T, in the range LeaveAllTime < T < 1.5 × LeaveAllTime when it is started. LeaveAllTime is defined in Table 10-7.

10.7.4.4 periodictimer

The Periodic Transmission timer, periodictimer, controls the frequency with which the PeriodicTransmission state machine generates periodic! events. The timer is required on a per-Port basis. The Periodic Transmission timer is set to one second when it is started.

10.7.5 Protocol event definitions

Unless stated otherwise in these event definitions, MRPDU reception in a Bridge can occur through all Ports of a Bridge, and events generated as a result of such reception affect only those state machines that are associated with the Port through which the PDU was received.

10.7.5.1 Begin!

The state machine is initialized or reinitialized.

10.7.5.2 Flush!

A Flush! event signals to the Registrar state machine that there is a need to rapidly deregister information on the Port associated with the state machine as a result of a topology change that has occurred in the network topology that supports the propagation of MRP information. If the network topology is maintained by means of the spanning tree protocol state machines, then, for the set of Registrar state machines associated with a given Port and spanning tree instance, this event is generated when the Port Role changes from either Root Port or Alternate Port to Designated Port.

When a Flush! event occurs for a given Port and spanning tree instance, a leavealltimer! event (10.7.5.22) is also signaled to the LeaveAll state machine for that Port and spanning tree instance.

10.7.5.3 Re-declare!

A Re-declare! event signals to the Applicant and Registrar state machines that there is a need to rapidly redeclare registered information on the Port associated with the state machines as a result of a topology change that has occurred in the network topology that supports the propagation of MRP information. If the network topology is maintained by means of the spanning tree protocol state machines, then, for the set of Applicant and Registrar state machines associated with a given Port and spanning tree instance, this event is generated when the Port Role changes from Designated Port to either Root Port or Alternate Port.

10.7.5.4 New!

A new declaration is made. The event is deemed to have occurred if the MAD Service User issues a MAD_Join.request service primitive for the Attribute instance associated with that state machine, indicating a new declaration.

10.7.5.5 Join!

A declaration is made. The event is deemed to have occurred if the MAD Service User issues a MAD_Join.request service primitive for the Attribute instance associated with that state machine.

10.7.5.6 Lv!

A declaration is withdrawn. The event is deemed to have occurred if the MAD Service User issues a MAD_Leave.request service primitive for the Attribute instance associated with that state machine.

10.7.5.7 tx!

A transmission opportunity occurs, without a LeaveAll being signaled by the LeaveAll state machine.

NOTE—The tx! event is modified by the behavior of the LeaveAll state machine. If the LeaveAll state machine has signaled LeaveAll, then tx! is modified to txLA! (see 10.7.5.8).

10.7.5.8 txLA!

A transmission opportunity occurs, with a LeaveAll being signaled by the LeaveAll state machine.

10.7.5.9 txLAF!

A transmission opportunity occurs, with a LeaveAll being signaled by the LeaveAll state machine, and with no room available in the PDU.

10.7.5.10 periodic!

This event indicates to the Applicant state machine that the timer used to stimulate periodic transmission has expired.

10.7.5.11 periodicEnabled!

This event indicates to the Periodic Transmission state machine that it has been enabled by management action (12.9.3).

10.7.5.12 periodicDisabled!

This event indicates to the Periodic Transmission state machine that it has been disabled by management action (12.9.3).

10.7.5.13 Message reception events

For an instance of the Applicant state machine or the Registrar state machine, a message reception event is deemed to have occurred if an MRPDU (10.8) is received, and the following conditions are true:

a) The PDU was addressed to an MRP application (the MRP application address, Table 10-1, or MIRP address, 39.2.1.6) and had an EtherType (Table 10-2) in accordance with that of the MRP application associated with the state machine.
b) The PDU contains a Message (10.8.1) in which the Attribute Type is the type associated with the state machine.
c) The Message contains a VectorAttribute (10.8.1.2) where the range defined by the FirstValue and NumberOfValues includes the attribute value associated with the state machine.

The specific type of message reception event is determined by the event value (10.8.2.5) associated with the state machine. The possible message reception event types are specified in 10.7.5.14 through 10.7.5.20.

10.7.5.14 rNew!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the New message.

10.7.5.15 rJoinIn!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the JoinIn message.

10.7.5.16 rJoinMt!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the JoinMt message.

10.7.5.17 rLv!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the Lv message.

10.7.5.18 rIn!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the In message.

10.7.5.19 rMt!

For an instance of the Applicant or Registrar state machine, a message reception event (10.7.5.13) occurs, and the event value (10.8.2.5) associated with the state machine specifies the Mt message.

10.7.5.20 rLA!

For an instance of the Applicant state machine, the Registrar state machine, or the LeaveAll state machine, the rLA! event is deemed to have occurred if either:

a) The LeaveAll state machine associated with that instance of the Applicant or Registrar state machine performs the sLA action (10.7.6.6); or
b) An MRPDU (10.8) is received, and the following conditions are true:
    1) The PDU's destination MAC address and EtherType are in accordance with the definition of the MRP application associated with the state machine.
    2) The PDU contains a Message (10.8.1) in which the Attribute Type is the type associated with the state machine.
    3) The Message contains a LeaveAllEvent (10.8.2.6) that carries the value LeaveAll.

NOTE—The LeaveAll state machine operates on a per-application (not per-Attribute Type) basis, but the LeaveAll message operates on a per-Attribute Type basis. Hence, when the LeaveAll state machine issues a LeaveAll, it must generate a LeaveAll Attribute for each Attribute Type supported by the application concerned.

10.7.5.21 leavetimer!

For an instance of the Registrar state machine, the leavetimer! event is deemed to have occurred when the leavetimer associated with that state machine expires.

10.7.5.22 leavealltimer!

For an instance of the LeaveAll state machine, the leavealltimer! event is deemed to have occurred either when the leavealltimer associated with that state machine expires or when a Flush! event (10.7.5.2) occurs for the Port and spanning tree instance associated with that state machine.

10.7.5.23 periodictimer!

For an instance of the PeriodicTransmission state machine, the periodictimer! event is deemed to have occurred when the periodictimer associated with that state machine expires.

10.7.6 Protocol Action definitions

10.7.6.1 MRPDU transmission actions

Unless stated otherwise in these action definitions, MRPDU transmission as a result of the operation of a state machine in a Bridge occurs only through the Port associated with that state machine. MRPDUs shall be transmitted using the destination MAC address and EtherType value defined by the MRP application associated with the state machine.

When the action specifies the transmission of attribute state information, an MRPDU, formatted as defined in 10.8.1, is transmitted so that:

a) The PDU contains a Message (10.8.1.2) that carries an Attribute Type (10.8.2.2) that corresponds to the type of attribute associated with the state machine concerned.
b) The Message contains a VectorAttribute (10.8.2.10) in which the FirstValue (10.8.2.7) and NumberOfValues (10.8.2.8) defines a range of attribute values that includes the attribute value associated with the state machine.
c) The Vector (10.8.2.10) encodes an AttributeEvent value in the vector position corresponding to the attribute value for this state machine. The choice of AttributeEvent value is determined by the specific transmission action, as defined below.

NOTE—As explained in 10.8.2.10.1 each attribute in a vector is associated with its own individual state machine. A naive implementation of MRP can therefore be quite inefficient.

In the case of LeaveAll transmission actions, the LeaveAll event value specified by the transmission action is encoded in the NumberOfValues field of the VectorAttribute.

10.7.6.2 sN

The AttributeEvent value New is encoded in the Vector as specified in 10.7.6.1.

10.7.6.3 sJ, [sJ]

If the Registrar state is IN, then the AttributeEvent value JoinIn is encoded in the Vector as specified in 10.7.6.1.

If the Registrar state is MT or LV, then the AttributeEvent value JoinMt is encoded in the Vector as specified in 10.7.6.1.

NOTE—The [sJ] variant indicates that the action is only necessary in cases where transmitting the value, rather than terminating a vector and starting a new one, makes for more optimal encoding; i.e., transmitting the value is not necessary for correct protocol operation.

10.7.6.4 sL

The AttributeEvent value Lv is encoded in the Vector as specified in 10.7.6.1.

10.7.6.5 s, [s]

If the Registrar state is IN, then the AttributeEvent value In is encoded in the Vector as specified in 10.7.6.1.

If the Registrar state is MT or LV, then the AttributeEvent value Mt is encoded in the Vector as specified in 10.7.6.1.

NOTE—In the [s] variant, this value is transmitted only if its inclusion makes for more optimal encoding; i.e., transmitting the value is not necessary for correct protocol operation.

10.7.6.6 sLA

The LeaveAll event value specified by the transmission action is encoded in the NumberOfValues field of the VectorAttribute as specified in 10.7.6.1.

The sLA action also gives rise to a rLA! event (10.7.5.20) against all instances of the Applicant state machine, or the Registrar state machine, associated with the MRP participant.

10.7.6.7 periodic

Causes a periodic! event (10.7.5.10) against all Applicant state machines associated with the participant.

10.7.6.8 Start leavetimer

Causes leavetimer to be started, in accordance with the definition of the timer in 10.7.4.2.

10.7.6.9 Stop leavetimer

Causes leavetimer to be stopped.

10.7.6.10 Start leavealltimer

When LeaveAllTime is nonzero, this causes leavealltimer to be started, in accordance with the definition of the timer in 10.7.4.3.

10.7.6.11 Start periodictimer

Causes periodictimer to be started, in accordance with the definition of the timer in 10.7.4.4.

10.7.6.12 New

This action causes a MAD_Join.indication primitive to be issued to the MAD Service User, indicating the Attribute instance corresponding to the state machine concerned, with the *new* parameter set TRUE.

10.7.6.13 Join

This action causes a MAD_Join.indication primitive to be issued to the MAD Service User, indicating the Attribute instance corresponding to the state machine concerned, with the *new* parameter set FALSE.

10.7.6.14 Lv

This action causes a MAD_Leave.indication primitive to be issued to the MAD Service User, indicating the Attribute instance corresponding to the state machine concerned.

10.7.7 Applicant state machine

A full MRP Participant maintains a single instance of the Applicant state machine (Table 10-3) for each Attribute value for which the Participant needs to maintain state information.

10.7.8 Registrar state machine

A full MRP Participant maintains a single instance of this state machine for each Attribute value that is currently registered, or that the Registrar state machine is in the process of deregistering.

NOTE—As with the Applicant, state information is conceptually maintained for all possible values of all Attribute types that are defined for a given application; however, in real implementations of MRP, it is likely that the range of possible Attribute values in some applications will preclude this, and the implementation will limit the state to those Attribute values in which the Participant has an immediate interest. In the case of simple devices that have no interest in what other Participants have registered, it may be appropriate for that device to ignore Registrar operation altogether.

The detailed operation of this state machine is described in Table 10-4.

10.7.9 LeaveAll state machine

A single LeaveAll state machine exists for each full MRP Participant. Leave All messages generated by this state machine also generate LeaveAll events against all the Applicant and Registrar state machines associated with that Participant and Port; hence, LeaveAll generation is treated by those state machines in the same way as reception of a LeaveAll message from an external source.

If the LeaveAllTime is changed from a value of zero to a nonzero value, a Begin! event shall be signaled to the LeaveAll state machine to cause it to reinitialize.

The detailed operation of this state machine is described in Table 10-5.

Table 10-3—Applicant state table

		STATE											
		VO[11,12]	**VP**[6]	**VN**[6, 12]	**AN**[6, 12]	**AA**[6]	**QA**[12]	**LA**[6]	**AO**[3,11]	**QO**[3,11]	**AP**[3,6]	**QP**[3]	**LO**[6]
EVENT	**Begin!**[12]	—	VO	VO	VO	VO	VO	VO	VO	VO	VO	VO	VO
	New![12]	VN	VN	—	—	VN	VN	VN	VN	VN	VN	VN	VN
	Join!	VP	—	—	—	—	—	AA	AP	QP	—	—	VP
	Lv!	—	VO	LA	LA	LA	LA	—	—	—	AO	QO	—
	rNew!	—	—	—	—	—	—	—	—	—	—	—	—
	rJoinIn!	AO[4]	AP[4]	—	—	QA	—	—	QO	—	QP	—	—
	rIn!	—	—	—	—	QA[5]	—	—	—	—	—	—	—
	rJoinMt! || rMt!	—	—	—	—	—	AA	—	—	AO	—	AP	VO
	rLv! || rLA! || Re-declare!	LO[1]	—	—	VN	VP[9]	VP[9]	—[10]	LO[1]	LO[1]	VP	VP	—
	periodic!	—	—	—	—	—	AA	—	—	—	—	AP	—
	tx![7, 12]	[s] —	sJ AA	sN AN	sN QA[8]	sJ QA	[sJ] —	sL VO	[s] —	[s] —	sJ QA	[s] —	s VO
	txLA![2]	[s] LO	s AA	sN AN	sN QA	sJ QA	sJ —	[s] LO	[s] LO	[s] LO	sJ QA	sJ QA	[s] —
	txLAF![2]	LO	VP	VN	VN	VP	VP	LO	LO	LO	VP	VP	—

Notes to the table:

[1] Applicant-Only participants exclude the LO state, and transition to VO.

[2] These events do not occur for Applicant-Only participants.

[3] Point-to-point subset participants exclude the AO, QO, AP, and QP states.

[4] Ignored (no transition) if point-to-point subset or if operPointToPointMAC is TRUE.

[5] Ignored (no transition) if operPointToPointMAC is FALSE. See MRP Design Notes below.

[6] Request opportunity to transmit on entry to VN, AN, AA, LA, VP, AP, and LO states.

[7] If the MRPDU is full and cannot convey a required message there is no change of state and an additional transmit opportunity is requested if that has not been done already.

[8] QA if the Registrar is IN, and AA otherwise. See MRP Design Notes below.

MRP design notes:

[5] On shared media the receipt of In does not confirm registration by all Participants, and the In could have been sent by an Applicant-Only participant.

[8] Since New messages do not convey registrar state, a Leave could have been received without an Empty or JoinEmpty prompt being sent, the transition to AA guards against loss of that Leave by another Applicant.

[9] The design accepts a small possibility of a continued registration (after rLv! if a Lv! occurs before a further Join is sent) in return for not accumulating many Active participants when Join!s and Lv!s are frequent. rLv! processing is deliberately not optimized for point-to-point.

[10] If a Leave has been received, the Registrar for the transmitting participant is very probably IN, as this Applicant has not yet sent a Leave, so the pending Leave is required. The small savings from avoiding transmission of Leaves pending on receipt of LeaveAlls does not merit distinguishing the rLv! and rLA! cases.

[11] The VO, AO, and QO states represent states where the attribute is neither being declared by the Participant nor being registered by any other station on the LAN. In implementations where dynamic creation and discarding of state machines is desirable, the state machine can be discarded when in any of these states, pending a future requirement to declare or register that attribute value.

12 A New-Only Participant recognizes only the Begin!, New!, and tx! events, and ignores all others, so can only reach the VO, VN, AN, and QA states.

Table 10-4—Registrar state table

		STATE		
		IN	**LV**	**MT**
EVENT	**Begin!**	MT	MT	MT
	rNew!	New IN	New Stop leavetimer IN	New IN
	rJoinIn! || rJoinMt!	IN	Stop leavetimer IN	Join IN
	rLv! || rLA! || txLA! || Re-declare!	Start leavetimer LV	-x-	-x-
	Flush!	Lv MT	Lv MT	MT
	leavetimer!	-x-	Lv MT	MT[a]

[a]If operPointToPointMAC is TRUE, proceed directly to the Lv/MT transition as defined in the LV State for the leavetimer! Event. This avoids the delay resulting from the leavetimer. If operPointToPointMAC is FALSE, the state machine is executed as shown.

Table 10-5—LeaveAll state table

		STATE	
		Active[a]	**Passive**
EVENT	**Begin!**	Start leavealltimer Passive	Start leavealltimer Passive
	tx!	sLA Passive	-x-
	rLA!	Start leavealltimer Passive	Start leavealltimer Passive
	leavealltimer!	Start leavealltimer Active	Start leavealltimer Active

[a] Request opportunity to transmit on entry to the Active state

10.7.10 PeriodicTransmission state machine

A single PeriodicTransmission state machine exists for each Port. Periodic Transmission events are generated on a regular basis, against all Applicant state machines that are associated with that Port.

The detailed operation of this state machine is described in Table 10-6.

Table 10-6—PeriodicTransmission state table

		STATE	
		Active	**Passive**
EVENT	**Begin!**	Start periodictimer Active	Start periodictimer Active
	periodicEnabled!	-x-	Start periodictimer Active
	periodicDisabled!	Passive	-x-
	periodictimer!	Start periodictimer periodic Active	-x-

10.7.11 Timer values

MRP *correctness* is not critically dependent on the values of protocol timers. However, the protocol operates more efficiently, and with less likelihood of unwanted deregistrations, if the following relationships are maintained between timer values used by peer Participants:

a) LeaveTime should be at least twice the maximum JoinTime, plus six times the timer resolution, to allow reregistration after a Leave or LeaveAll even if a message is lost.
b) To minimize the volume of rejoining traffic generated following a LeaveAll, the value chosen for LeaveAllTime should be large relative to LeaveTime.

The default timer values (Table 10-7) maintain these relationships. They may be modified on a per-Port basis by means of the management functionality defined in Clause 12.

Table 10-7—MRP timer parameter default values

Parameter	Value (centiseconds)
JoinTime	20
LeaveTime	60–100
LeaveAllTime	1000

NOTE—The default values for the MRP timers are independent of media access method or data rate. This is a deliberate choice, made in the interests of maximizing the “plug and play” characteristics of the protocol.

Implementation of the timers for MRP shall be based on a timer resolution of 1 centisecond or less.

If operPointToPointMAC (IEEE Std 802.1AC) is TRUE, a request for a transmit opportunity should result in such an opportunity as soon as is practicable, given other system constraints, and shall occur within the value specified for JoinTime subject to not more than three such transmission opportunities occurring in any period of 1.5 × JoinTime.

If operPointToPointMAC is FALSE, and there is no pending request, a transmit opportunity shall occur at a time value randomized between 0 and JoinTime seconds. These provisions shall apply even if a point-to-point subset Applicant has been implemented.

10.7.12 Operational reporting and statistics

10.7.12.1 Failure to register

Each MRP Participant maintains a count of the number of times that it has received a registration request, but has failed to register the attribute concerned due to lack of space in the FDB to record the registration. The value of this count may be examined by management (see 12.9.2.1.3).

NOTE—Further action to be taken on such events is a matter for implementation choice.

10.7.12.2 Peer tracking

An implementation may support the ability to record against each Registrar state machine the MAC address of the originator of the MRPDU that caused the most recent state change for that state machine (see 12.9.3.1.3).

10.7.13 Interoperability considerations

Correct operation of MRP for a given MRP application requires that protocol exchanges among a given set of communicating MRP Participants maintain sequentiality; i.e., that Participant A cannot receive MRPDU B (generated as a consequence of Participant B receiving MRPDU A) before Participant A has received MRPDU A. In circumstances where the Participants concerned are all attached to the same LAN, such sequentiality is ensured. However, if a set of MRP Participants communicates via an intervening Bridge that does not implement that MRP application (or does not implement MRP at all), the sequentiality constraints expressed in 8.6.6, 8.6.7, and 8.6.8 are insufficient to guarantee the correct operation of MRP. In order for the correct sequencing of PDUs to be maintained through such a Bridge, the following constraint must be met:

> If MRPDU A is received on Port X, and is due to be forwarded on Ports Y and Z, and subsequent to being forwarded on Y, MRPDU B is received on Port Y for forwarding on Port Z, then forwarding of B cannot precede A on Port Z.

NOTE—This expresses a stronger sequencing constraint for multicast frames than is stated in 8.6, but a weaker constraint than was required for conformance to IEEE Std 802.1D, 1993 Edition [B10].

The consequence of failure to meet this constraint is that the users of a given MRP application may experience an increased incidence of loss of registration. Therefore, it is inadvisable to construct LAN configurations involving forwarding of MRPDUs through intervening Bridges if those Bridges do not meet the constraint expressed previously.

10.7.14 External control

The MRP External Control feature (12.32.4) specifies a managed object that the network manager uses to:

a) Disable MRP attribute propagation (MAP) for the MRP Participant of a Bridge Port.
b) Read MRP attribute registrations that the MRP Participant receives.
c) Write MRP attribute values for the MRP Participant to declare.

There is one MRP External Control managed object for each MRP Participant (per Port per MRP application per MAP Context, as specified in 10.2 and 10.3.1).

Under default operation, the MRP External Control feature (externalControl attribute FALSE) is ignored by the operation of MRP and has no effect on MRP Attribute Propagation (MAP) specified in 10.3.

When the MRP External Control feature is enabled by network management (externalControl attribute TRUE), the operation of MAP in the Bridge performs as specified in 12.32.4, but all other aspects of MRP operation are performed as specified in Clause 10.

10.8 Structure and encoding of Multiple Registration Protocol Data Units (MRPDUs)

This subclause describes the generic structure and encoding of the MRPDUs exchanged between all MRP Participants. The structure and encoding of elements that are specific to the operation of the MRP applications are defined by the applications themselves.

Each MRPDU identifies the MRP application by which it was generated, and to which it is being transmitted. Bridges that receive MRPDUs identified as belonging to an MRP application that they do not support shall forward such PDUs on all other Ports with a Port State (8.4) of Forwarding.

NOTE 1—If MRP is used to support an application that can operate in any MAP Context other than 0 (the Base Spanning Tree Context), the application specification describes how that context is identified in protocol exchanges.

Each MRPDU carries one or more MRP messages, each of which identify one or more MRP events (e.g., Join, Leave, LeaveAll) and the attribute class(es) and value(s) to which each event applies. A given MRP Participant shall process MRPDUs in the order in which they are received, and shall process the MRP Messages in a PDU in the order in which they were put into the Data Link Service Data Unit (DLSDU).

NOTE 2—Any messages generated as a consequence of state machine responses to an sLA action and its associated LeaveAll events will be put into the DLSDU after the LeaveAll message(s), or into a later DLSDU.

10.8.1 Structure

10.8.1.1 Transmission and representation of octets

All MRPDUs consist of an integral number of octets, numbered starting from 1 and increasing in the order that they are put into a DLSDU. The bits in each octet are numbered from 1 to 8, where 1 is the low-order bit.

When consecutive octets are used to represent a binary number, the lower octet number has the most significant value.

When the encoding of (an element of) an MRPDU is represented using a diagram in this clause, the following representations are used:

a) Octet 1 is shown toward the top of the page, higher numbered octets being toward the bottom.
b) Where more than one octet appears on a given line, octets are shown with the lowest numbered octet to the left, higher numbered octets being to the right.
c) Within an octet, bits are shown with bit 8 to the left and bit 1 to the right.

10.8.1.2 Structure definition

MRP makes use of an EtherType value as the means of identifying the MRP application that has transmitted, and that will receive, a given MRPDU. Table 10-2 lists the set of MRP applications that are defined, and the EtherType values that correspond to them.

A protocol version field is included in the structure of the MRPDU, in order to provide the ability to identify enhancements to MRP applications.

MRPDUs exchanged according to the protocol specified in this clause shall have the following structure:

a) The first octet contains the *ProtocolVersion*.
b) Following the Protocol Version are one or more *Messages*. The last element in the PDU is an *EndMark*.
c) Each Message consists of an *AttributeTyp*e, an *AttributeLength*, and an *AttributeList,* in that order.
d) An Attribute List consists of one or more *VectorAttribute*s. The last element in the AttributeList is an EndMark.
e) A VectorAttribute consists of a *VectorHeader*, a *FirstValue*, and a *Vector,* in that order. The VectorHeader is able to encode both a *LeaveAllEven*t and the number of attribute events encoded in the vector.
f) If the end of an MRPDU is encountered before an EndMark is reached, then processing of the PDU is terminated as if an EndMark had been reached.

The following Backus-Naur Form (BNF) productions give the formal description of the MRPDU structure:

MRPDU ::= ProtocolVersion, Message {, Message}, EndMark
ProtocolVersion BYTE ::= *Defined by the specific MRP application*
Message ::= AttributeType, AttributeLength[, AttributeListLength], AttributeList
AttributeType BYTE ::= *Nonzero integer defined by the specific MRP application*
AttributeLength BYTE ::= *Nonzero integer defined by the specific MRP application*
AttributeListLength SHORT ::= *Nonzero integer defined by the specific MRP application*
AttributeList ::= VectorAttribute {, VectorAttribute}, EndMark
VectorAttribute ::= VectorHeader, FirstValue {, Vector}
VectorHeader SHORT ::= (LeaveAllEvent * 8192) + NumberOfValues
FirstValue ::= Defined by the specific MRP application
Vector ::= ThreePackedEvents {, ThreePackedEvents}
[, FourPackedEvents {, FourPackedEvents}]
ThreePackedEvents BYTE ::= (((((AttributeEvent) *6) + AttributeEvent) *6) + AttributeEvent)
AttributeEvent BYTE ::= New | JoinIn | In | JoinMt | Mt | Lv
FourPackedEvents BYTE ::= ((FourPackedType *64) + (FourPackedType *16)
+ (FourPackedType *4) + FourPackedType)
FourPackedType BYTE ::= *Integer defined by the specific MRP application*
LeaveAllEvent BYTE ::= NullLeaveAllEvent | LeaveAll
NumberOfValues SHORT ::= Number of events encoded in the vector
EndMark SHORT ::= 0x0000 | End of PDU
NullLeaveAllEvent ::= 0
LeaveAll ::= 1
New ::= 0
JoinIn ::= 1
In ::= 2
JoinMt ::= 3
Mt ::= 4
Lv ::= 5

The parameters carried in MRPDUs, as identified in this structure definition, shall be encoded as specified in 10.8.2.

Figure 10-5 illustrates the structure of the MRPDU and its components.

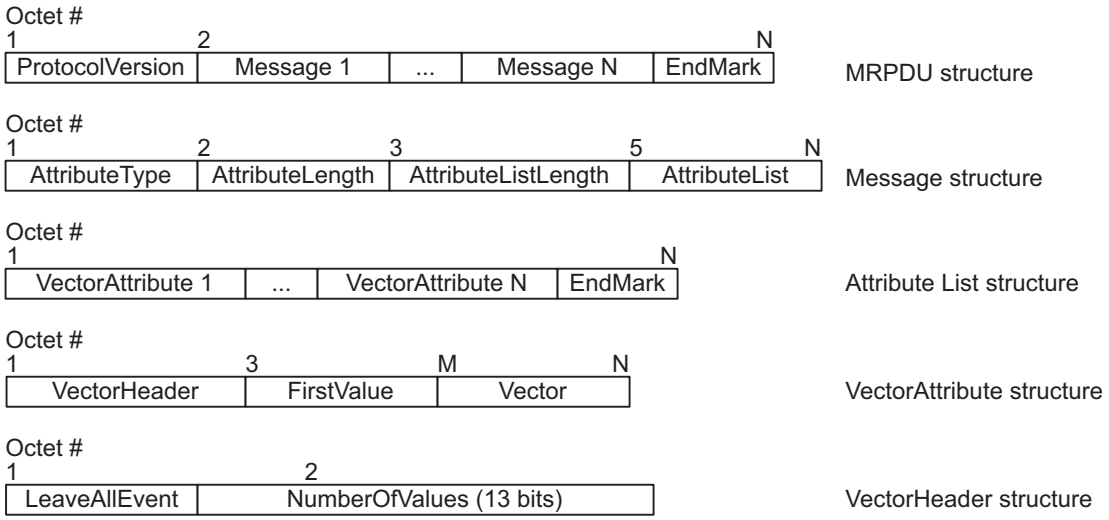


Figure 10-5—Format of the major components of an MRPDU

10.8.2 Encoding of MRPDU parameters

10.8.2.1 Encoding of ProtocolVersion

A ProtocolVersion shall be encoded in a single octet, taken to represent an unsigned binary number. It takes a value that is determined by the application concerned.

NOTE—The handling of protocol version information is defined in 10.8.3.5.

10.8.2.2 Encoding of AttributeType

An AttributeType shall be encoded as a single octet, taken to represent an unsigned binary number. The AttributeType identifies the type of Attribute to which the message applies. The range of values that can be taken by the AttributeType, and the meanings of those values, are defined by the application concerned. The value 0 is reserved, and shall not be used as an AttributeType by any MRP application. MRP applications may otherwise allocate meanings to any set of values of AttributeType in the range 1 through 255.

The definition of AttributeType values in the application associates the following with each AttributeType value defined:

a) The size, in octets, of attribute values, and how they are encoded.
b) Any restrictions that are placed upon the range of attribute values that the vector is permitted to represent.

10.8.2.3 Encoding of AttributeLength

An AttributeLength shall be encoded as a single octet, taken to represent an unsigned binary number. The AttributeLength indicates the length, in octets, of the FirstValue field (10.8.2.7) for the Attribute to which the message applies.

10.8.2.4 Encoding of AttributeListLength

An AttributeListLength shall be encoded as two octets, taken to represent an unsigned binary number. The AttributeListLength indicates the length, in octets, of the AttributeList field for the Attribute to which the message applies. This field is not present in all MRPDUs. Specifically, Multiple MAC Registration Protocol Data Units (MMRPDUs) and Multiple VLAN Registration Protocol Data Units (MVRPDUs) do not use this field, whereas Multiple Stream Protocol Data Units (MSRPDUs) do use this field.

10.8.2.5 Encoding of AttributeEvent

An AttributeEvent shall be encoded as an unsigned decimal number in the range 0 through 5. The permitted values and meanings of the AttributeEvent are as follows:

0: New operator
1: JoinIn operator
2: In operator
3: JoinMt operator
4: Mt operator
5: Lv operator

Further values of AttributeEvent are reserved.

The AttributeEvent is interpreted on receipt as a MAD event to be applied to the state machine for the Attribute defined by the AttributeType and AttributeValue to which the AttributeEvent relates.

10.8.2.6 Encoding of LeaveAllEvent

A LeaveAllEvent shall be encoded as an unsigned binary number. The permitted values and meanings of LeaveAllEvent are as follows:

0: NullLeaveAllEvent operator
1: LeaveAll operator

Further values of LeaveAllEvent are reserved.

The LeaveAllEvent is interpreted on receipt as a MAD Leave All event to be applied to the state machines for all Attributes of the type defined by the AttributeType field.

The value NullLeaveAllEvent signifies that there is no Leave All event to process, and is included purely for encoding efficiency in the vector attribute structures. Receipt of this value does not cause any event to be applied to any state machine.

10.8.2.7 Encoding of FirstValue

A FirstValue is encoded in N octets, taken to be an unsigned binary number, in accordance with the specification for the AttributeType defined by the MRP application concerned. The length, in octets, of the FirstValue field is specified by the value contained in the AttributeLength field (10.8.2.3). When NumberOfValues is greater than one (1) FirstValue is incremented in a way that is defined by each MRP application. For example MMRP simply increments FirstValue by adding the number one (1) to it, whereas MSRP adds one (1) to multiple fields within the FirstValue for each increment. Throughout this specification FirstValue incremented by one is denoted as FirstValue + 1, incrementing by two is denoted as FirstValue + 2, etc.

10.8.2.8 Encoding of VectorHeader

The VectorHeader is used to encode both the value of the LeaveAllEvent (10.8.2.6) and the NumberOfValues, the number of AttributeEvent values encoded in a Vector (10.8.2.10). The VectorHeader is taken to be an unsigned binary number, encoded in two octets, as follows:

a) The value of the LeaveAllEvent is multiplied by 8192.
b) The resulting number is added to NumberOfValues.

The range of values that NumberOfValues can take is restricted, such that the following are true:

c) The size of the Vector that is defined by this number will fit in the available space in the PDU.
d) Incrementing FirstValue the number of times specified in NumberOfValues does not exceed the permitted numeric range of FirstValue as defined for the application concerned.
e) The number of AttributeEvent values does not exceed 8191.
f) If the number of AttributeEvent values is zero, FirstValue is ignored and the value is skipped. However, FirstValue is still present, and of the correct length, in octets, as specified by the AttributeLength field (10.8.2.3) for the Attribute to which the message applies.
g) If LeaveAllEvent is a NullLeaveAllEvent, the number of AttributeEvent values is nonzero.

10.8.2.9 Encoding of EndMark

An EndMark shall be encoded as two octets, taken to represent an unsigned binary number. It takes the numeric value 0.

Further values of EndMark are reserved and shall not be used.

NOTE—As defined by the MRPDU structure definition in 10.8.1, if the end of the MRPDU is encountered, this is taken to be an End Mark from the point of view of processing the PDU contents.

10.8.2.10 Encoding of Vector

10.8.2.10.1 Encoding of Vector ThreePackedEvents

The Vector is encoded as zero or more 8-bit values, each containing a numeric value, ThreePackedEvents, derived from three packed numeric values, each of which represents an AttributeEvent, in the range 0 through 5.

As can be seen from the BNF definition of ThreePackedEvents, each 8-bit value is derived by successively adding an event value and multiplying the result by 6. In order to facilitate the subsequent description, the event values are numbered from *first* to *third*, as follows:

ThreePackedEvents BYTE ::=
(((((*first*AttributeEvent) × 6) + *second*AttributeEvent) × 6) + *third*AttributeEvent)

The NumberOfValues field in the VectorHeader of the VectorAttribute determines the number of 8-bit ThreePackedEvents values, *E*, that will be present in the vector; hence E is determined by dividing NumberOfValues by 3 and rounding any noninteger answer up to the nearest larger integer.

The FirstValue field of the VectorAttribute determines which of the originator's state machines the *first* AttributeEvent value in the first ThreePackedEvents value relates to. The *second* AttributeEvent value in the first ThreePackedEvents value corresponds to the state machine identified by (FirstValue + 1), and the *third* AttributeEvent value in the first ThreePackedEvents value corresponds to the state machine identified by (FirstValue + 2), and so on, through subsequent packed values.

Where the NumberOfValues field carries a value that is not a multiple of 3, there will be either one or two AttributeEvent values packed in the final ThreePackedEvents that are ignored; these values are encoded as the numeric value 0 on transmission and are ignored on receipt.

NOTE—If NumberOfValues is zero, there will be no ThreePackedEvents encoded in the vector.

10.8.2.10.2 Encoding of Vector FourPackedEvents

The Vector is encoded as zero or more 8-bit values, each containing a numeric value, FourPackedEvents, derived from four packed numeric values, each of which represent a FourPackedType, in the range 0 through 3. The FourPackedTypes are defined by each MRP application that uses FourPackedEvents. Note that not all MRP applications use FourPackedEvents.

As can be seen from the BNF definition of FourPackedEvents, each 8-bit value is derived by successively adding a FourPackedType value and multiplying the result by 4. In order to facilitate the subsequent description, the event values are numbered from first to fourth, as follows:

FourPackedEvents BYTE ::= ((firstFourPackedType × 64) + (secondFourPackedType × 16) + (thirdFourPackedType × 4) + (fourthFourPackedType))

The NumberOfValues field in the VectorHeader of the VectorAttribute determines the number of 8-bit FourPackedEvents values, E, that will be present in the vector; hence E is determined by dividing NumberOfValues by 4 and rounding any noninteger answer up to the nearest larger integer.

The FirstValue field of the VectorAttribute determines which of the originator's state machines the first FourPackedType value in the first FourPackedEvents value relates to. The second FourPackedType value in the first FourPackedEvents value corresponds to the state machine identified by (FirstValue + 1). The third FourPackedType value in the first FourPackedEvents value corresponds to the state machine identified by (FirstValue + 2), and the fourth FourPackedType value in the first FourPackedEvents value corresponds to the state machine identified by (FirstValue + 3), and so on, through subsequent packed values.

Where the NumberOfValues field carries a value that is not a multiple of 4, there will be one, two, or three FourPackedType values packed in the final FourPackedEvent that are ignored; these values are encoded as the numeric value 0 on transmission and are ignored on receipt.

NOTE—If NumberOfValues is zero, there will be no FourPackedEvents encoded in the vector.

10.8.3 Packing and parsing MRPDUs

The use of the End Mark (10.8.2.9) to signal the end of an AttributeList and the end of an MRPDU, and the fact that the (physical) end of the PDU is interpreted as an End Mark, simplifies the requirements both for packing information into MRPDUs and for correctly interpreting that information on receipt.

10.8.3.1 Packing

Successive Messages are packed into the MRPDU, and within each Message, successive VectorAttributes are packed into each Message, until the end of the PDU is encountered or there are no more VectorAttributes to pack at that time. The following cases can occur:

a) The PDU has sufficient room for all the VectorAttributes that require to be transmitted at that time to be packed. In this case, the PDU is transmitted, and subsequent PDUs are transmitted when there are further VectorAttributes to transmit.
b) The PDU has enough room for the first N VectorAttributes that require to be transmitted at that time to be packed. In this case, the PDU is transmitted, and the next N VectorAttributes are encoded in a subsequent PDU.

10.8.3.2 Handling of received MRPDUs

Received MRPDUs, i.e., PDUs that are constructed in accordance with the MRPDU format defined in 10.8, that carry a destination MAC address and MRP EtherType value as specified for use by a defined MRP application, are processed as follows:

a) In Bridges and end stations that support the operation of the MRP application concerned, all such PDUs shall be submitted to the MRP Participant associated with the reception Port for further processing.
b) In Bridges that do not support the operation of the MRP application concerned, all such PDUs shall be submitted to the Forwarding Process.

10.8.3.3 Discarding badly formed MRPDUs

An MRP Participant that receives an MRPDU shall discard that PDU if the PDU is not formatted according to the MRPDU format defined in 10.8.

10.8.3.4 Parsing

Successive Messages, and within each Message, successive VectorAttributes, are unpacked from the PDU. If this process terminates because the end of the PDU is reached, then the end of the PDU is taken to signal termination both of the current AttributeList and the overall PDU. The following two cases can occur:

a) The last VectorAttribute to be unpacked was complete. In this case, the VectorAttribute is processed normally, and processing of the PDU terminates.
b) The last VectorAttribute to be unpacked was incomplete. In this case, the entire PDU is discarded, and processing of the PDU terminates.

10.8.3.5 Handling of protocol versions

In order to ensure compatibility with previous protocol versions, while allowing the protocol to be extended, the following requirements shall be met by the implementation:

a) MRPDUs that carry a protocol version lower than the protocol version implemented shall be interpreted according to the definition corresponding to the protocol version carried in the PDU.
b) MRPDUs that carry a protocol version equal to or higher than the protocol version implemented shall be interpreted according to the definition corresponding to the protocol version implemented.
c) Where the MRPDU carries a higher protocol version than the version implemented, then:
    1) If a Message is encountered in which the AttributeType is not recognized, then that Message is discarded. This is achieved by discarding the successive VectorAttributes in the AttributeList until either an EndMark or the end of the PDU is reached. If an EndMark is reached, processing continues with the next Message.
    2) If a VectorAttribute is encountered in which the AttributeEvent is not recognized for the AttributeType concerned, then the VectorAttribute is discarded and processing continues with the next VectorAttribute, if the end of the PDU has not been reached.
    3) For the MSRP application (Clause 35), if a FirstValue is encountered in which a TLV is not recognized for the Type concerned, then the TLV is discarded and processing continues with the next TLV, if the end of the PDU has not been reached.

10.9 Multiple MAC Registration Protocol (MMRP)—Purpose

MMRP provides a mechanism that allows end stations and MAC Bridges to dynamically register (and subsequently, deregister) Group membership or individual MAC address information with the Bridges attached to the same LAN, and disseminates that information across all the Bridges that support Extended Filtering Services in the Bridged Network. The operation of MMRP relies upon the services provided by MRP.

The information registered, deregistered, and disseminated via MMRP can appear in any of the following forms:

a) *Group membership information*. This indicates the presence of MMRP participants that are members of a particular Group (or Groups), and carries the group MAC address(es) associated with the Group(s). The exchange of specific Group membership information can result in the creation or updating of MAC Address Registration Entries in the FDB to indicate the Port(s) and VID(s) of the VLAN(s) on which members of the Group(s) have been registered. The structure of these entries is described in 8.8.4.
b) *Group service requirement information*. This indicates that one or more MMRP participants require Forward All Groups or Forward Unregistered Groups to be the default Group filtering behavior (see 6.16.7 and 8.8.6).
c) *Individual MAC address information*.

Registration of Group membership information makes Bridges aware that frames destined for the group MAC address concerned should only be forwarded in the direction of the registered members of the Group. Therefore, forwarding of frames destined for the address associated with that Group occurs only on Ports on which such membership registration has been received.

Registration of Group service requirement information makes the Bridges aware that Ports that can forward frames in the direction from which the information has been received should modify their default Group forwarding behavior in accordance with the service requirement expressed.

NOTE 1—Modification of default Group forwarding behavior allows Bridge Ports to accommodate MMRP-unaware devices in the Bridged Network by forwarding frames destined for unregistered group MAC addresses.

The operation of MMRP can result in:

d) The propagation of Group membership information and Group service requirement information, and consequent creation, updating, or deletion of MAC Address Registration Entries in the FDBs of all Bridges in the network that support Extended Filtering Services.
e) Consequent changes to the Group filtering behavior of such Bridges.

In VLAN Bridges, MMRP operates only when the Bridge Filtering Mode is set to Extended Filtering Mode. Bridges that are unable to operate in Extended Filtering Mode, or have been set to operate in Basic Filtering Mode, are transparent with respect to MMRP exchanges, and forward any MRPDUs destined for the MMRP application through all Ports that are in Forwarding.

NOTE 2—An MMRP user is not prevented from registering an individual MAC address associated with a location different from its actual location. Such registration could result in denial of service to the station associated with that MAC address and, possibly, the interception of associated traffic by an unintended recipient. Such consequences of the misuse of individual MAC address registration can be prevented by using MMRP individual MAC address registration only in secure network environments (i.e., only in networks providing perimeter security).

10.10 MMRP Model of operation

MMRP defines an *MRP application* that provides the extended filtering services defined in 6.16.5 and 6.16.7. To this end, MMRP makes use of:

a) The declaration and propagation services offered by *MRP Attribute Declaration* (MAD; 10.2 and 10.3,) and *MRP Attribute Propagation* (MAP; 10.2 and 10.3) to declare and propagate Group membership, Group service requirement, and individual MAC address information within the Bridged Network.
b) The registration services offered by MAD (10.2 and 10.3) to allow Group membership, Group service requirement, and individual MAC address information to control the frame filtering behavior of participating devices.

Figure 10-6 illustrates the architecture of MMRP in the case of a two-Port Bridge and an end station, for a given VLAN Context. Where MMRP is used in multiple VLAN Contexts, an instance of the MMRP Participant exists for each VLAN context.

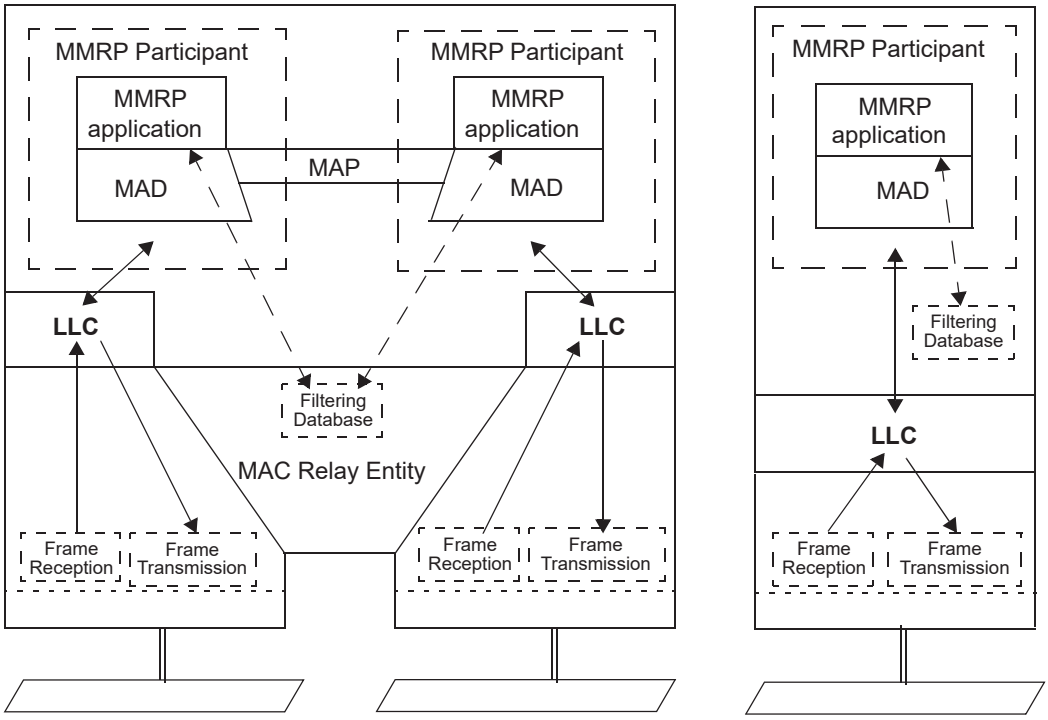


Figure 10-6—Operation of MMRP for a single VLAN Context

As shown in the diagram, the MMRP Participant consists of the following components:

c) The MMRP application, described in 10.12
d) MRP Attribute Propagation (MAP), described in 10.3
e) MRP Attribute Declaration (MAD), described in 10.2

10.10.1 Propagation of Group Membership information

The Forwarding Process uses the MAC Address Registration entries in the FDBs to ensure that frames are transmitted only through those Bridge Ports necessary to reach LANs to which Group members are attached. Figure 10-7 illustrates the MAC Address Registration Entries created by MMRP for a single Group.

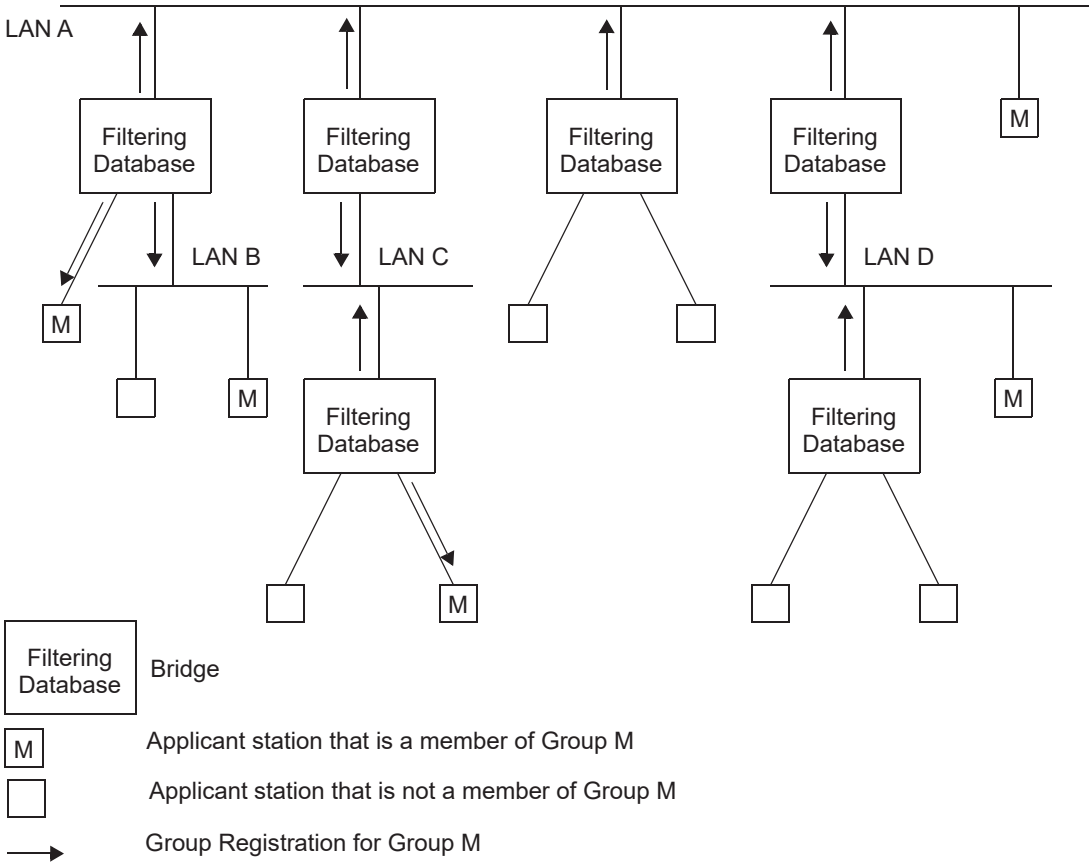


Figure 10-7—Example Directed Graph

By receiving frames from all Ports and forwarding only through Ports for which MMRP has created MAC Address Registration Entries, Bridges facilitate Group distribution mechanisms based on the concept of an Open Host Group. Any MMRP Participants (10.2) that wish to receive frames transmitted to a particular Group or Groups request membership of the Group(s) concerned. Any MAC Service user that wishes to send frames to a particular Group can do so from any point of attachment to the Bridged Network. These frames can be received on all LANs to which registered MMRP Participants are attached, but the filtering applied by Bridges ensures that frames are not transmitted on LANs that are not part of the active topology between the sources of the frames and the registered Group members. MMRP and the MAC Address Registration Entries thus restrict the frames to pruned subsets of the overall loop-free active topology.

NOTE—The term “Open Host Group” comes from the terminology introduced in the definition of the Internet Group Membership Protocol (IGMP) defined by the IETF.

MAC Service users that are sources of MAC frames destined for the Group do not have to register as members of the Group themselves unless they also wish to receive frames transmitted to the Group address by other sources.

10.10.2 Propagation of Group service requirement information

MMRP propagates Group service requirement information in the same manner as for Group registration information. If any Port in a given Bridge has a registered Group service requirement of All Groups or All Unregistered Groups (expressed in terms of the control information in Static Filtering Entries and/or MAC Address Registration Entries with a MAC address specification of All Groups or All Unregistered Groups), this fact is propagated on all other Ports of the Bridge, resulting in the registration of that information on Ports of adjacent Bridges. As a consequence of that registration, the default Group filtering behavior of those Ports can change in order to maintain compatibility with the service requirements expressed by the registered information, as defined in 8.8.6. This ensures that connectivity can be maintained in LANs where the service requirements of different regions of the Bridged Network differ.

NOTE—In a Bridged Network where the default Group filtering behavior is not the same for all "edge" Ports, service requirement propagation will tend to result in all "backbone" Ports switching to the highest precedence Group filtering behavior in use in the network. The precedence rules are defined in 8.8.6.

10.10.3 Source pruning

As described in 10.10.1, the operation of MMRP defines a subtree of the spanning tree as a result of the creation of MAC Address Registration Entries in the FDBs of the Bridges. End stations are also able to make use of the Group Membership information registered via MMRP to allow them to keep track of the set of Groups for which active members currently exist and the service requirements of upstream devices. This allows end stations that are sources of frames destined for a Group to suppress the transmission of such frames, if their registered Group membership and Group service requirement information indicates that there are no valid recipients of those frames reachable via the LANs to which they are attached.

NOTE—In effect, for the purposes of frame transmission, the end station can be viewed as if it operates as a single Port Bridge, with its own default Group filtering behavior and FDB entries updated via MMRP that tell it whether multicast frames that it has generated should be forwarded onto the attached LAN. In order to achieve this, it is necessary for the end station to implement both the Registrar and the Applicant functionality of MRP, as described in 10.6, 10.7.7, and 10.7.8. The Applicant-Only and Simple-Applicant Participants described in 10.6 do not contain the Registrar functionality that would be required for source pruning.

This end system behavior is known as *source pruning.* Source pruning allows MAC Service users that are sources of MAC frames destined for a number of Groups, such as server stations or routers, to avoid unnecessary flooding of traffic on their local LANs in circumstances where there are no current Group members in the network that wish to receive such traffic.

10.10.4 Use of Group service requirement registration by end stations

The ability to propagate Group service requirement information is described in this standard primarily as a means of propagating the requirements of the Bridges themselves. However, this mechanism can also be used by end stations that have requirements involving some aspect of promiscuous reception, such as Routers or network monitors. A MMRP-aware end station wishing to receive all multicast traffic can declare membership of All Groups on the LAN to which it is attached; similarly, an end station that wishes to receive unregistered multicast traffic can do so by declaring membership of All Unregistered Groups.

10.11 Default Group filtering behavior and MMRP propagation

The propagation of MMRP registrations within a VLAN Context has implications with respect to the choice of default Group filtering behavior within a Bridged Network. As MMRP frames are transmitted only on outbound Ports that are in the Member set (8.8.10) for the VID concerned, propagation of Group registrations by a given Bridge occurs only toward regions of the Bridged Network where that VID has been (statically or dynamically) registered. This is illustrated in Figure 10-8; dotted lines in the diagram show those regions of the Bridged Network where propagation of registrations for Group M for VID V does not occur. Consequently, the FDBs of the lower two Bridges will not contain any Dynamic MAC Address Registration Entry for Group M for VID V.

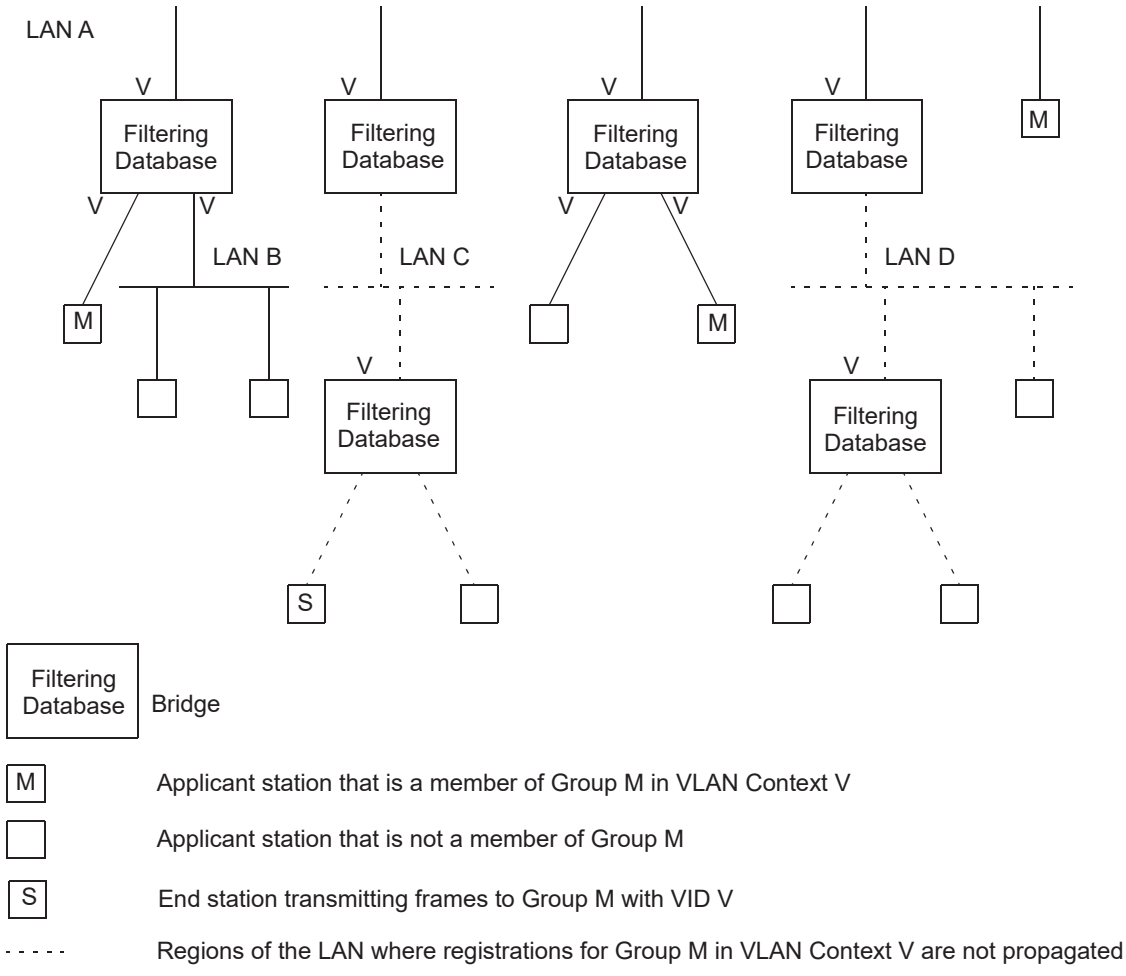


Figure 10-8—Example of MMRP propagation in a VLAN Context

The action of these two Bridges on receipt of frames, on either of their lower Ports, destined for Group M and VID V, will depend upon the Default Group Filtering Behavior adopted by their upper Ports, which are the Ports that are in the Member set for VID V. If the Default Group Filtering Behavior is either Forward All Groups or Forward Unregistered Groups, then these Bridges will forward the frames. If the Default Group Filtering Behavior is Filter Unregistered Groups, then these Bridges will filter the frames. In the scenario shown, the choice of Default Group Filtering Behavior is therefore crucial with respect to whether end station S, or any other station that is "outside" the VLAN, is able to send frames to members of the Group. The choice between Filter Unregistered Groups and the other default behaviors therefore has the effect of defining VLANs that are closed to external unregistered traffic (Filter Unregistered Groups) or open to external unregistered traffic (either of the other default behaviors).

10.12 Definition of the MMRP application

10.12.1 Definition of MRP elements

10.12.1.1 Use of MAP Contexts by MMRP

MMRP operates within a MAP Context, or set of MAP Contexts, that is determined by the type of Bridge component supporting the MMRP application. In a MAC Bridge component MMRP operates in the Base Spanning Tree Context. In a C-VLAN component or S-VLAN component MMRP operates in the set of C-VLAN Contexts or S-VLAN Contexts, respectively, that corresponds to the VIDs that are supported by the Virtual Bridged Network.

The MAP Context Identifier used to identify a VLAN Context shall be equal to the VID used to identify the corresponding VLAN.

The set of Ports of a Bridge defined to be part of the active topology for a given VLAN Context shall be equal to the set of Ports of a Bridge for which the following are true:

a) The Port is a member of the *Member set* (8.8.10) for that VID.
b) The Port is one of the Ports of the Bridge that are part of the active topology for the spanning tree that supports that VID.

NOTE—The above definition applies equally to SST and MST environments. It ensures that MMRP operates in either environment, without the MMRP implementations needing to be aware of whether the VLAN Contexts that apply are all supported by the same spanning tree, as in the SST environment, or are potentially distributed across two or more spanning trees, as in the MST environment.

VLAN Contexts can be hierarchical. For example, in a PBN that forwards C-VLAN-tagged frames between CBNs, there can be multiple C-VLAN Contexts within each S-VLAN context. Likewise, there can be multiple C-VLAN Contexts and/or S-VLAN Contexts within the Base Spanning Tree Context. While it is theoretically possible for an MMRP application to support hierarchical MAP Contexts by maintaining an MMRP Participant for each possible (or at least anticipated) combination of C-VLAN, S-VLAN and Base Spanning Tree MAP Contexts, an MMRP application is not required to support hierarchical MAP Contexts. The identification of MMRPDUs belonging to a hierarchical MAP Context, and the treatment of such MMRPDUs, is discussed in 10.12.1.2.

10.12.1.2 Context identification in MMRP

In a MAC Bridge component, received MMRPDUs that are untagged are identified with the Base Spanning Tree Context and are directed to the MRP Participant for the Base Spanning Tree. Received MMRPDUs that are VLAN-tagged identify hierarchical MAP Contexts. If the MMRP application does not support hierarchical MAP Contexts (i.e., maintain an MRP Participant for each possible S-VLAN and/or C-VLAN Context within the Base Spanning Tree Context), then the received MMRPDUs are not directed to any MRP Participant and are transmitted, including the original VLAN tag(s), on each port in the Base Spanning Tree Context except the reception port.

Implementations of MMRP in VLAN Bridges apply the same ingress rules (8.6.2) to received MMRPDUs that are defined for the reception Port. Therefore,

a) MMRP frames with no VLAN classification (i.e., untagged or priority-tagged MMRPDUs) are discarded if the Acceptable Frame Types parameter (6.9) for the Port is set to *Admit Only VLAN-tagged frames*. Otherwise, they are classified either according to the PVID for the Port, or as determined by protocol-based VLAN classification (6.12) if that capability is implemented.
b) VLAN-tagged MMRP frames are classified according to the VID carried in the tag header, optionally translated using the VID translation table (6.9).

c) If Ingress Filtering (8.6.2) is enabled, and if the Port is not in the Member set (8.8.10) for the MMRP frame's VLAN classification, then the frame is discarded.

The VLAN classification thus associated with a received MMRP frame establishes the C-VLAN Context or S-VLAN Context for the received PDU, depending on whether the reception port is on a C-VLAN component or S-VLAN component, and identifies the MRP Participant instance to which the PDU is directed. MMRPDUs received at an S-VLAN component and containing a C-TAG, either alone or within an S-TAG, identify hierarchical MAP Contexts. If the MMRP application does not support hierarchical MAP Contexts (i.e., maintain an MRP Participant for each possible C-VLAN Context within each S-VLAN Context), then the received MMRPDUs are not directed to any MRP Participant and are transmitted, including the original C-TAG, on each port in the S-VLAN Context except the reception port.

MMRPDUs transmitted by MMRP Participants are VLAN classified according to the VLAN Context associated with that Participant. MMRP Participants in VLAN Bridges apply the same egress rules that are defined for the transmission Port (8.6.4). Therefore,

d) MMRPDUs are transmitted through a given Port only if the Member Set for the VID concerned indicates that the VID is registered on that Port.
e) MMRPDUs are transmitted through a given Port as VLAN-tagged frames or as untagged frames in accordance with the state of the Untagged Set (8.8.10) for that Port and for the VID concerned.

   Where VLAN-tagged frames are transmitted, the VID field of the tag header carries the VLAN Context Identifier value, optionally translated using the VID translation table (6.9).

10.12.1.3 MMRP application address

The group MAC address used as the destination address for MRPDUs destined for MMRP Participants shall be the group MAC address identified in Table 10-1 as "Customer and Provider Bridge MMRP address."

10.12.1.4 MMRP application EtherType

The EtherType used for MRPDUs destined for MMRP Participants shall be the MMRP EtherType identified in Table 10-2.

10.12.1.5 MMRP ProtocolVersion

The ProtocolVersion for the version of MMRP defined in this standard takes the hexadecimal value 0x00.

10.12.1.6 MMRP AttributeType definitions

MMRP defines two AttributeTypes (10.8.2.2) that are carried in MRP exchanges, as follows:

a) The Service Requirement Vector Attribute Type
b) The MAC Vector Attribute Type

Attributes identified by the Service Requirement Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify values of Group service requirements. The value of AttributeType used to identify the Service Requirement Vector Attribute Type in MRPDUs (10.8.2.2) shall be 1.

Attributes identified by the MAC Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify a sequence of values of MAC addresses. The value of AttributeType used to identify the MAC Vector Attribute Type in MRPDUs (10.8.2.2) shall be 2.

10.12.1.7 MMRP FirstValue definitions

The FirstValue field (10.8.2.7) in instances of the MAC Vector Attribute Type shall be encoded in MRPDUs as six octets, each taken to represent an unsigned binary number. The octets are derived from the Hexadecimal Representation of a MAC Address (defined in IEEE Std 802) as follows:

a) Each two-digit hexadecimal numeral in the Hexadecimal Representation is taken to represent an unsigned hexadecimal value, in the normal way, i.e., the rightmost digit of each numeral represents the least significant digit of the value, the leftmost digit is the most significant.
b) The first octet of the attribute value encoding is derived from the left-most hexadecimal value in the Hexadecimal Representation of the MAC address. The LSB of the octet (bit 1) is assigned the LSB of the hexadecimal value, the second significant bit is assigned the value of the second significant bit of the hexadecimal value, and so on.
c) The second through sixth octets of the encoding are similarly assigned the value of the second through sixth hexadecimal values in the Hexadecimal Representation of the MAC address.

FirstValue + 1 is defined as adding 1 to FirstValue. There are no restrictions on the range of values that can be represented in this data type.

The FirstValue field in instances of the Service Requirement Attribute Type shall be encoded in MRPDUs (10.8.2.7) as a single octet, taken to represent an unsigned binary number. Only two values of this type are defined:

d) All Groups shall be encoded as the value 0.
e) All Unregistered Groups shall be encoded as the value 1.

The remaining possible values (2 through 255) are reserved.

10.12.1.8 MMRP AttributeLength definitions

The AttributeLength field (10.8.2.3) in instances of the MAC Vector Attribute Type shall be encoded in MRPDUs (10.8) as an unsigned binary number, equal to the value 0x06.

The AttributeLength field (10.8.2.3) in instances of the Service Requirement Vector Attribute Type shall be encoded in MRPDUs (10.8) as an unsigned binary number, equal to the value 0x01.

10.12.1.9 MMRP AttributeListLength definitions

The AttributeListLength field (10.8.2.4) is not present in the MMRPDUs.

10.12.1.10 MMRP Vector definitions

The ThreePackedEvent vectors are encoded as defined in 10.8.2.10.1.

The FourPackedEvent vectors (10.8.2.10.2) are not present in the MMRPDUs.

10.12.2 Provision and support of Extended Filtering Services

10.12.2.1 Initiating MMRP registration and deregistration

The MMRP application element of an MRP Participant provides the dynamic registration and deregistration services defined in 6.16.7.1, as follows:

On receipt of a REGISTER_MAC_ADDRESS service primitive, the MMRP Participant issues a MAD_Join.request. The attribute_type parameter of the request carries the value of the MAC Vector Attribute Type (10.12.1.6) and the attribute_value parameter carries the value of the MAC_ADDRESS parameter of the service primitive.

On receipt of a DEREGISTER_MAC_ADDRESS service primitive, the MMRP Participant issues a MAD_Leave.request. The attribute_type parameter of the request carries the value of the MAC Vector Attribute Type (10.12.1.6) and the attribute_value parameter carries the value of the MAC_ADDRESS parameter of the service primitive.

On receipt of a REGISTER_SERVICE_REQUIREMENT service primitive, the MMRP Participant issues a MAD_Join.request. The attribute_type parameter of the request carries the value of the Service Requirement Vector Attribute Type (10.12.1.6) and the attribute_value parameter carries the value of the REQUIREMENT_SPECIFICATION parameter of the service primitive.

On receipt of a DEREGISTER_SERVICE_REQUIREMENT service primitive, the MMRP Participant issues a MAD_Leave.request. The attribute_type parameter of the request carries the value of the Service Requirement Vector Attribute Type (10.12.1.6) and the attribute_value parameter carries the value of the REQUIREMENT_SPECIFICATION parameter of the service primitive.

NOTE—If the EISS is supported, the Extended Filtering service primitives issued by the MAC Service user should include a VID parameter in addition to the MAC_ADDRESS or REQUIREMENT_SPECIFICATION parameters, in order to identify the MMRP Participant associated with the primitive.

10.12.2.2 Registration and deregistration events

The MMRP application element of an MRP Participant responds to registration and deregistration events signaled by MAD as follows:

On receipt of a MAD_Join.indication, the MMRP application element specifies the Port associated with the MMRP Participant as Forwarding in the Port Map field of the MAC Address Registration Entry (8.8.4) for the MAC address specification carried in the attribute_value parameter and the VID associated with the MAP Context. If such a MAC Address Registration Entry does not exist in the FDB, a new MAC Address Registration Entry is created.

Creation of new MAC Address Registration Entries may be restricted by the Restricted_MAC_Address_Registration control (10.12.2.3). If this control is TRUE, creation of a new dynamic entry is permitted only if there is a Static Filtering Entry for the MAC address with a Registrar Administrative Control value of Normal Registration.

NOTE—Group Membership and Group service requirement information can be recorded in the FDB by means of MAC Address Registration Entries (see 8.8.4). In the case of Group Membership Information, the MAC address specification in the MAC Address Registration Entry is a group MAC address. In the case of Group service requirement information, the MAC address specification is either “All Group Addresses” or “All Unregistered Group Addresses.”

On receipt of a MAD_Leave.indication, the MMRP application element specifies the Port associated with the MMRP Participant as Filtering in the Port Map field of the MAC Address Registration Entry (8.8.4) for the MAC address specification carried in the attribute_value parameter and the VID associated with the MAP Context. If such an FDB entry does not exist in the FDB, then the indication is ignored. If setting that Port to Filtering results in there being no Ports in the Port Map specified as Forwarding (i.e., all MMRP members are deregistered), then that MAC Address Registration Entry is removed from the FDB.

10.12.2.3 Administrative controls

The provision of static control over the registration state of the state machines associated with the MMRP application is achieved by means of the Registrar Administrative Control parameters associated with the operation of MRP (10.7.2). These parameters are represented in the FDB by the information held in Static Filtering Entries (8.8.1). If no Static Filtering Entry exists for a given MAC address specification, the value of the Registrar Administrative Control parameter for the corresponding attribute value is Normal Registration for all Ports of the Bridge.

The initial state of the Permanent Database (i.e., the state of the Permanent Database in a Bridge that has not been otherwise configured by management action) includes a Static Filtering Entry with a MAC address specification of All Groups, in which the Port Map indicates Registration Fixed (New ignored). This Static Filtering Entry will have the effect of determining the default Group filtering behavior of all Ports of the Bridge to be Forward All Groups. This Permanent Database entry may be deleted or updated by management action.

NOTE—This specification of an initial Static Filtering Entry means that operation using Forward Unregistered Groups or Filter Unregistered Groups requires a conscious action on the part of the network manager or administrator.

Where management capability is implemented, the Registrar Administrative Control parameters can be applied and modified by means of the management functionality defined in 12.7.

The provision of static control over the ability of Applicant state machines to participate in protocol exchanges is achieved by means of the Applicant Administrative Control parameters associated with the operation of MRP (10.7.3). Where management capability is implemented, the Applicant Administrative Control parameters can be applied and modified by means of the management functionality defined in Clause 12.

Further administrative control over dynamic MAC address registration may be achieved, if supported, by means of a per-Port Restricted_MAC_Address_Registration control parameter. If the value of this control is TRUE for a given Port, the creation or modification of Dynamic MAC Address Registration Entries as a result of MMRP exchanges on that Port shall be restricted only to those MAC addresses for which Static Filtering Entries exist in which the Registrar Administrative Control value is Normal Registration. If the value of the Restricted_MAC_Address_Registration control is FALSE, dynamic MAC address registration is not so restricted. Where management capability is implemented, the value of the Restricted_MAC_Address_Registration control can be manipulated by means of the management functionality defined in Clause 12. If management of this parameter is not supported, the value of this parameter shall be FALSE for all Ports.

10.12.3 Use of “new” declaration capability

MMRP does not make use of the “new” declaration capability.

10.12.4 Attribute value support requirements

Implementations of MMRP shall maintain state information for all attribute values that support the Group service requirement registration (10.12.1.7).

Implementations of MMRP shall be capable of supporting any attribute value in the range of possible values that can be registered using Group membership and individual MAC address registration (10.12.1.7); however, the maximum number of attribute values for which the implementation is able to maintain current state information is an implementation decision. The number of values that the implementation can support shall be stated in the PICS.

10.12.5 Registrar Administrative Controls

MMRP supports the Registration Fixed (New ignored) value, but not the Registration Fixed (New propagated) value, of the Registrar Administrative Controls (10.7.2).

11. VLAN topology management

The egress rules (8.6.4) defined for the Forwarding Process in VLAN Bridges rely on the existence of configuration information for each VID that defines the set of Ports of the Bridge through which one or more members are reachable. This set of Ports is known as the Member Set (8.8.10), and its membership is determined by the presence or absence of configuration information in the FDB, in the form of Static and Dynamic VLAN Registration Entries (8.8.2, 8.8.5).

Reliable operation of the VLAN infrastructure requires VLAN membership information held in the FDB to be maintained in a consistent manner across all VLAN Bridges in the Virtual Bridged Network, in order to ensure that frames destined for end station(s) on a given VLAN can be correctly delivered, regardless of where in the Bridged Network the frame is generated. Maintenance of this information by end stations that are sources of VLAN-tagged frames can allow such stations to suppress transmission of such frames if no members exist for the VLAN concerned.

This standard defines the following mechanisms that allow VLAN membership information to be configured:

a) Dynamic configuration and distribution of VLAN membership information by means of the MVRP, as described in 11.2.
b) Static configuration of VLAN membership information via Management mechanisms, as described in Clause 12, which allow configuration of Static VLAN Registration Entries.

These mechanisms provide for the configuration of VLAN membership information as a result of the following:

c) Dynamic registration actions taken by end stations or Bridges in the Bridged Network.
d) Administrative actions.

11.1 Static and dynamic VLAN configuration

The combined functionality provided by the ability to configure Static VLAN Registration Entries in the FDB, coupled with the use of the Restricted_VLAN_Registration control (11.2.3.2.3) and the ability of MVRP to dynamically create and update Dynamic VLAN Registration Entries, offers the following possibilities with respect to how VIDs are configured on a given Port:

a) *Static configuration only*. The management facilities described in Clause 12 are used to establish precisely which VIDs have this Port in their Member set, and the MVRP management controls are used to disable the operation of MVRP on that Port. Hence, any use of MVRP by devices reachable via that Port is ignored, and the Member set for all VIDs can therefore only be determined by means of static entries in the FDB.
b) *Static configuration with topology changes.* The management facilities described in Clause 12 are used to establish precisely which VLANs have this Port in their Member set, and the MVRP or MIRP management controls are used to permit the signaling, via MVRP or MIRP, of network topology changes that require flushing learned address information from the FDB. MVRPDUs and MIRPDUs received from devices reachable via that Port are ignored for the purposes of creating or deleting Dynamic VLAN Registration Entries in the FDB on that Port, and the Member set for all VLANs can therefore only be determined by means of static entries in the FDB.
c) *Dynamic configuration only*. The operation of MVRP is relied upon to establish Dynamic VLAN Registration Entries that will dynamically reflect which VIDs are registered on the Port, their contents changing as the configuration of the network changes. The MVRP management controls are set to enable the operation of MVRP on that Port.

d) *Combined static and dynamic configuration*. The static configuration mechanisms are used in order to configure some VLAN membership information; for other VIDs, MVRP is relied upon to establish the configuration. The MVRP management controls are set to enable the operation of MVRP on that Port.

All of the previous approaches are supported by the mechanisms defined in this standard, and each approach is applicable in different circumstances. For example:

e) Use of static configuration may be appropriate on Ports where the configuration of the attached devices is fixed, or where the network administrator wishes to establish an administrative boundary outside of which any MVRP registration information is to be ignored. For example, it might be desirable for all Ports serving end user devices to be statically configured in order to ensure that particular end users have access only to VLANs identified by particular VIDs.
f) Use of static configuration with topology changes can be appropriate where the configuration of VLANs and ports is static in some part of the network, but dynamic in another part, so that changes in the topology of the dynamic part can necessitate the flushing of learned MAC address information in Bridges in the static part. For example, in a PBBN, a topology change in a customer network with dual attachments to the provider can require a provider's I-component to signal a MAC address flush across the backbone, even though the VLANs on the VIPs involved are statically configured.
g) Use of dynamic configuration may be appropriate on Ports where the VLAN configuration is inherently dynamic; where users of particular VIDs can connect to the network via different Ports on an ad hoc basis, or where it is desirable to allow dynamic reconfiguration in the face of spanning tree topology changes. In particular, if the "core" of the Virtual Bridged Network contains redundant paths that are pruned by the operation of the spanning tree protocol, then it is desirable for Bridge Ports that form the core network to be dynamically configured.
h) Use of both static and dynamic configuration can be appropriate on Ports where it is desirable to place restrictions on the configuration of some VIDs, while maintaining the flexibility of dynamic registration for others. For example, on Ports serving mobile end user devices, this would maintain the benefits of dynamic VLAN registration from the point of view of traffic reduction, while still allowing administrative control over some VIDs via that Port.

11.2 Multiple VLAN Registration Protocol (MVRP)

MVRP defines an *MRP application* that provides the VLAN registration service defined in 11.2.2. MVRP makes use of MRP Attribute Declaration (MAD) and MRP Attribute Propagation (MAP), which provide the common state machine descriptions and the common attribute propagation mechanisms defined for use in MRP-based applications. The MRP architecture, MAD, and MAP are defined in Clause 10.

MVRP provides a mechanism for dynamic maintenance of the contents of Dynamic VLAN Registration Entries for each VID, and for propagating the information they contain to other Bridges. This information allows MVRP-aware devices to dynamically establish and update their knowledge of the set of VIDs associated with VLANs that currently have active members, and through which Ports those members can be reached.

11.2.1 MVRP overview

The operation of MVRP is closely similar to the operation of MMRP (10.9), which is used for registering Group membership and individual MAC address information. The primary differences are as follows:

a) The attribute values carried by the protocol are 12-bit VID values, rather than Group service requirement information and MAC Addresses.
b) The act of registering/deregistering a VID affects the contents of Dynamic Registration Entries (8.8.5), rather than the contents of MAC Address Registration Entries (8.8.4).

c) In an SST environment, there is a single MVRP Participant per port, as opposed to one MMRP Participant per VID per port, and the MVRP Participants all operate in a single MAP Context.
d) In an MST environment, there is again a single MVRP Participant per port, but each MVRP Participant operates in multiple MAP Contexts.

MVRP allows both end stations and Bridges in a Bridged Network to issue and revoke declarations relating to membership of VLANs. The effect of issuing such a declaration is that each MVRP Participant that receives the declaration will create or update a Dynamic VLAN Registration Entry in the FDB to indicate that VID is registered on the reception Port. Subsequently, if all Participants on a LAN that had an interest in a given VID revoke their declarations, the Port attached to that LAN is set to Unregistered in the Dynamic VLAN Registration Entry for that VID by each MVRP Participant attached to that LAN.

Figure 11-1 illustrates the architecture of MVRP in the case of a two-Port Bridge and an end station.

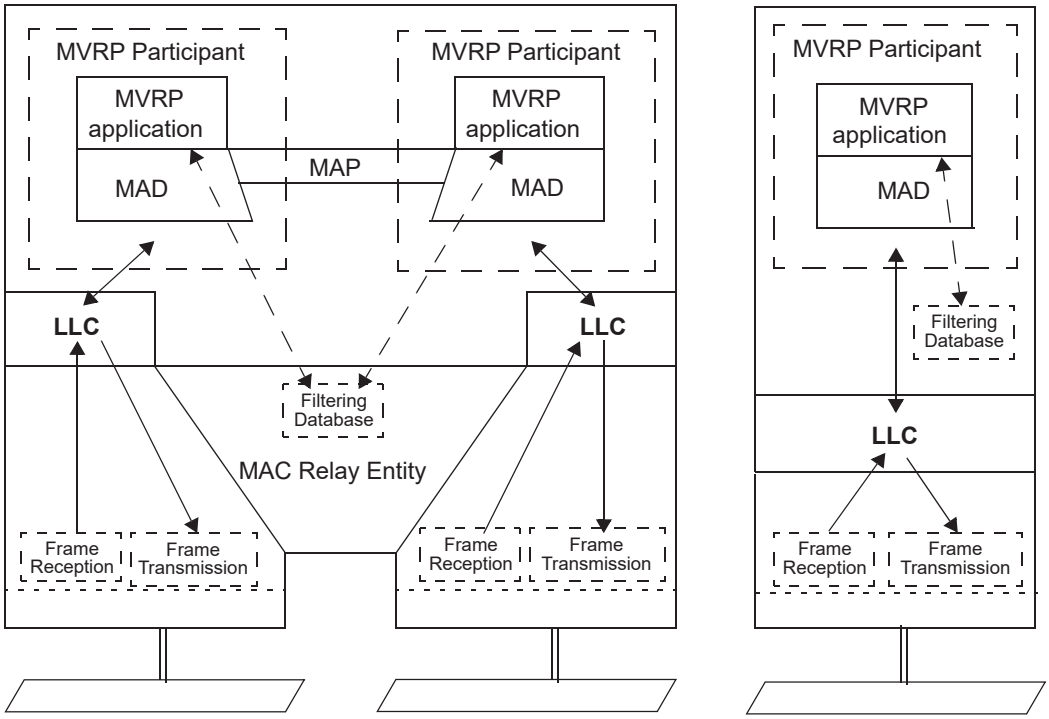


Figure 11-1—Operation of MVRP

As shown in the diagram, the MVRP Participant consists of the following components:

e) The MVRP application, described in 11.2.3
f) MRP Attribute Propagation (MAP), described in 10.3
g) MRP Attribute Declaration (MAD), described in 10.2

11.2.1.1 Behavior of end stations

VLAN-aware end stations participate in MVRP activity, as appropriate for the set of VIDs of VLANs of which they are currently members. MVRP provides a way for such an end station to ensure that the VIDs of VLAN(s) of which it is a member are registered for each Port on any LAN to which the end station is attached. MVRP also provides for that VID information to be propagated across the spanning tree to other VLAN-aware devices, as described in 11.2.1.2.

Incoming VLAN membership information (from all other devices on the same LAN) allows such end stations to "source prune" (i.e., discard at source; see 10.10.3) any traffic destined for VLANs that currently have no other members in the Bridged Network, thus avoiding the generation of unnecessary traffic on their local LANs. This is illustrated in Figure 11-1 by an FDB shown as being present in the end station.

NOTE—Non-VLAN-aware end stations have no need to register VLAN membership via MVRP; indeed, this would be impossible for them to achieve if truly VLAN-unaware, as they would have no knowledge of the set of VLANs in which they participate. Their VLAN registration requirements are taken care of by means of the configuration of PVIDs (and possibly other VLAN classification mechanisms) and the propagation of registered VIDs by the Bridges.

11.2.1.2 Behavior of Bridges

VLAN Bridges register and propagate VLAN memberships on all Bridge Ports that are part of the active topology of the underlying spanning tree(s). Incoming VID registration and deregistration information is used to update the Dynamic VLAN Registration Entries associated with each VID. Any changes in the state of registration of a given VID on a given Port are propagated on Ports that are part of the active topology of the underlying spanning tree, in order to ensure that other MVRP-aware devices in the Bridged Network update their FDBs appropriately. In Bridges that support multiple spanning tree instances, the MST Configuration Table (12.12, 13.8) is used to determine which spanning tree instance is to be used to propagate registration information for each supported VID.

The FDBs in all MVRP-aware devices are thus automatically configured such that the Port Map in the Dynamic VLAN Registration Entry for a given VID indicates that a given Port is registered if one or more members of the corresponding VLAN are reachable through the Port.

NOTE—The information that determines whether frames destined for each VID are transmitted VLAN-tagged or untagged is carried in Static VLAN Registration Entries (8.8.2); if no such entry exists for a VID, then it is assumed that frames for that VID are transmitted VLAN-tagged on all Ports. Therefore, if the configuration information held in the FDB for a given VID consists only of information configured by the operation of MVRP (i.e., only a Dynamic VLAN Registration Entry), then all traffic for that VID will be VLAN-tagged on transmission.

11.2.1.3 Use of the PVID and VID Set

The initial state of the Permanent Database contains a Static VLAN Registration Entry for the Default PVID, in which the Port Map indicates Registration Fixed (New ignored) on all Ports. This ensures that in the default state, where the value of every PVID of each Port is the Default PVID and where the VID Set of each Port is empty, membership of the Default PVID is propagated across the Bridged Network to all other MVRP-aware devices. Subsequent management action may change both the Permanent Database and the FDB in order to modify or remove this initial setting, and may change the PVID and/or VID Set value(s) on any Port of the Bridge.

NOTE—In the absence of any modification of these initial settings, this ensures that connectivity is established across the Bridged Network for the VLAN corresponding to the Default PVID.

11.2.2 VLAN registration service definition

The VLAN registration service allows MAC Service users to indicate to the MAC Service provider the set of VLANs in which they wish to participate; i.e., that the MAC Service user wishes to receive traffic destined for members of that set of VLANs. The service primitives allow the service user to:

a) Register membership of a VLAN.
b) Deregister membership of a VLAN.

Provision of these services is achieved by means of MVRP and its associated procedures, as described in 11.2.3.

ES_REGISTER_VLAN_MEMBER (VID)

Indicates to the MAC Service provider that the MAC Service user wishes to receive frames destined for the VLAN identified by the VID parameter.

ES_DEREGISTER_VLAN_MEMBER (VID)

Indicates to the MAC Service provider that the MAC Service user no longer wishes to receive frames destined for the VLAN identified by the VID parameter.

The use of these services can result in the propagation of VID information across the spanning tree, affecting the contents of Dynamic VLAN Registration Entries (8.8.5) in Bridges and end stations in the Bridged Network, and thereby affecting the frame forwarding behavior of those Bridges and end stations.

11.2.3 Definition of the MVRP application

11.2.3.1 Definition of MRP elements

11.2.3.1.1 MAP Context for MVRP in SST environments

In an SST environment, MVRP operates in the Base Spanning Tree Context (10.3.1); i.e., MVRP operates only on the CIST. Consequently, all MVRPDUs sent and received by MVRP Participants in SST Bridges are transmitted as untagged frames.

11.2.3.1.2 MAP Contexts for MVRP in MST environments

In an MST environment, MVRP operates in multiple spanning tree contexts, one for each of the spanning trees. Each spanning tree context consists of the ports that are in the forwarding state for the corresponding spanning tree. The MVRP Participants associated with a given spanning tree operate in the MAP context identified by that spanning tree instance. MST Bridges can identify the MAP Contexts using the mappings of VID values to MSTID values (see 8.9.1). All MVRPDUs sent and received by MVRP Participants in MST Bridges are transmitted as untagged frames.

11.2.3.1.3 MVRP application address

The group MAC address used as the destination address for MRPDUs destined for MVRP Participants shall be either:

a) The group MAC address identified in Table 10-1 as “Customer Bridge MVRP address” if the MVRP Participant is implemented in a C-VLAN component; or
b) The group MAC address identified in Table 8-1 as “Provider Bridge MVRP Address” if the MVRP Participant is implemented in an S-VLAN component.

11.2.3.1.4 MVRP application EtherType

The EtherType used for MRPDUs destined for MVRP Participants shall be the MVRP EtherType identified in Table 10-2.

11.2.3.1.5 MVRP ProtocolVersion

The ProtocolVersion for the version of MVRP defined in this standard takes the hexadecimal value 0x00.

11.2.3.1.6 MVRP AttributeType definitions

MVRP defines a single Attribute Type (10.8.2.2) that is carried in MRP exchanges, as follows:

Attributes identified by the VID Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify a sequence of values of VIDs. The value of AttributeType used to identify the VID Vector Attribute Type in MRPDUs (10.8.2.2) shall be 1.

11.2.3.1.7 MVRP FirstValue definitions

The FirstValue field in instances of the VID Vector Attribute Type shall be encoded in MRPDUs (10.4) as two octets, taken to represent an unsigned binary number, and equal to the value of the VID that is to be encoded.

The range of permitted values that can be encoded in the FirstValue fields in MVRP is restricted to the range 0 through 4094.The value 0 represents the VID of the untagged frame on which the MRPDU is transmitted or received, and 1 through 4094 identify specific VIDs. If enabled by management [item e) in 12.9.2.2.2], and if there is only one VID whose untagged set includes the Port of an MVRP Participant, the Participant shall transmit the value 0 in place of that VID. All MVRP Participants shall translate the value 0 in a received message to the PVID of the receiving Port.

NOTE—Previous revisions of this Standard did not provide for transmission or reception of 0 as an MVRP Attribute value. No automatic means for determining whether the other MVRP Participants on a LAN are capable of receiving the value 0 are provided. Therefore, extreme care is in order when configuring an MVRP Participant to transmit Attribute value 0, as compliant implementations of previous revisions of this standard could drop such MRPDUs as badly formed.

11.2.3.1.8 MVRP AttributeLength definitions

The AttributeLength field (10.12.1.8) in instances of the VID Vector Attribute Type shall be encoded in MRPDUs (10.8) as an unsigned binary number, equal to the value 0x02.

11.2.3.1.9 MVRP AttributeListLength definitions

The AttributeListLength field (10.8.2.4) is not present in the MVRPDUs.

11.2.3.1.10 MVRP Vector definitions

The ThreePackedEvent vectors are encoded as defined in 10.8.2.10.1.

The FourPackedEvent vectors (10.8.2.10.2) are not present in the MVRPDUs.

11.2.3.2 Provision and support of the VLAN registration service

11.2.3.2.1 Initiating VLAN membership declaration

The MVRP application element of a MVRP Participant provides the dynamic registration and deregistration services defined in 11.2.2, as follows:

On receipt of an ES_REGISTER_VLAN_MEMBER service primitive, the MVRP Participant issues a MAD_Join.request service primitive (10.2, 10.3). The attribute_type parameter of the request carries the value of the VID Vector Attribute Type (11.2.3.1.6) and the attribute_value parameter carries the value of the VID parameter carried in the ES_REGISTER_VLAN_MEMBER primitive.

On receipt of an ES_DEREGISTER_VLAN_MEMBER service primitive, the MVRP Participant issues a MAD_Leave.request service primitive (10.2, 10.3). The attribute_type parameter of the request carries the value of the VID Vector Attribute Type (11.2.3.1.6) and the attribute_value parameter carries the value of the VID parameter carried in the ES_DEREGISTER_VLAN_MEMBER primitive.

11.2.3.2.2 VLAN membership registration

The MVRP application element of a MVRP Participant responds to registration and deregistration events signaled by MAD as follows:

On receipt of a MAD_Join.indication whose attribute_type is equal to the value of the VID Vector Attribute Type (11.2.3.1.6), the MVRP application element indicates the reception Port as Registered in the Port Map of the Dynamic VLAN Registration Entry for the VID indicated by the attribute_value parameter. If no such entry exists, there is sufficient room in the FDB, and the VID is within the range of values supported by the implementation (see 9.6), then an entry is created. If not, then the indication is not propagated and the registration fails.

The creation of new Dynamic VLAN Registration Entries can be restricted by use of the Restricted_VLAN_Registration control (11.2.3.2.3). If the value of this control is TRUE, then creation of a new dynamic entry is permitted only if there is a Static VLAN Registration Entry for the VID concerned, in which the Registrar Administrative Control value is Normal Registration.

On receipt of a MAD_Leave.indication whose attribute_type is equal to the value of the VID Vector Attribute Type (11.2.3.1.6), the MVRP application element indicates the reception Port as not Registered in the Port Map of the Dynamic VLAN Registration Entry for the VID indicated by the attribute_value parameter. If no such entry exists, the indication is ignored.

11.2.3.2.3 Administrative controls

The provision of static control over the declaration or registration state of the state machines associated with the MVRP application is achieved by means of the Registrar Administrative Control parameters provided by MRP (10.7.2). These parameters are represented as Static VLAN Registration Entries in the FDB (8.8.2). Where management capability is implemented, these parameters can be manipulated by means of the management functionality defined in 12.7.

The provision of static control over the ability of Applicant and Registrar state machines to participate in protocol exchanges is achieved by means of the Applicant Administrative Control parameters and Registrar Administrative Control parameters associated with the operation of MRP (10.7.2, 10.7.3). Where management capability is implemented, the Applicant and Registrar Administrative Control parameters can be applied and modified by means of the management functionality defined in 12.9. A separate managed variable [item c) in 12.9.2.1.3] controls whether the Applicant state machine transmits 0 or the VID as the Attribute for a VLAN on a Port in that VLAN’s untagged set.

Further administrative control over dynamic VLAN registration can be achieved, if supported, by means of a per-Port Restricted_VLAN_Registration control parameter. If the value of this control is TRUE for a given Port, the creation or modification of Dynamic VLAN Registration Entries as a result of MVRP exchanges on that Port shall be restricted only to those VIDs for which Static VLAN Registration Entries exist in which the Registrar Administrative Control value is Normal Registration. If the value of the Restricted_VLAN_Registration control is FALSE, dynamic VLAN registration is not so restricted. The recommended default value of this parameter is FALSE. Where management capability is implemented, the value of the Restricted_VLAN_Registration control can be manipulated by means of the management functionality defined in 12.10. If management of this parameter is not supported, the value of this parameter shall be FALSE for all Ports.

11.2.4 VID translation table

If a VID Translation Table (6.9) is in use for a Bridge Port, the VID values received in MVRP Attributes are translated on reception of MVRPDUs prior to MVRP processing as specified in this subclause (11.2), and translated after processing for encoding MVRP Attributes in transmitted MVRPDUs. The interpretation of the MVRP Attribute value 0 is not affected by the VID Translation Table in either direction.

NOTE—In the case that the Port on which an MVRPDU is transmitted is in the untagged set of the VID matching the PVID of the Port receiving the MVRPDU, the use of the value 0 in the FirstValue field effectively performs a VID translation.

11.2.5 Use of “new” declaration capability

MVRP makes use of the “new” declaration capability in order to allow FDB entries to be removed or rapidly aged out on a per-VID basis following a topology change in the network connectivity supporting the VID concerned. The rules for propagation of “new” declarations as defined in Clause 10 ensure that all MADs that originate from, or are propagated through, a Bridge Port that has recently transitioned to Forwarding are marked as “new” declarations.

When any MVRP declaration marked as “new” is received on a given Port, either as a result of receiving an MVRPDU from the attached LAN (MAD_Join.indication), or as a result of receiving a request from MAP or the MVRP Application (MAD_Join.request), any Dynamic Filtering Entries in the FDB for that Port and for the VID corresponding to the attribute value in the MAD_Join primitive are removed.

11.2.6 New-Only Participant and Registrar Administrative Controls

A Bridge may support an MVRP New-Only Participant (10.6). This can be useful in an I-component that has statically configured S-VLAN registrations, but must still accommodate signaling the flushing of learned MAC address information. The choice of whether a given Port’s MVRP Participant operates as a Full Participant or a New-Only Participant is controlled by a managed object (12.9.2). This managed object is separate from the one controlling whether a given Port uses Registration Fixed (New ignored) or Registration Fixed (New propagated) Static VLAN Registration Entries [item d) in 12.7.7.3.3].

NOTE 1—Configuring an MVRP Participant as a New-Only Participant makes the assumption that all of the MVRP Participants on the LAN are configured completely via Static VLAN Registration Entries, and that no Dynamic VLAN Registration Entries are needed. If this assumption is violated, then the Bridged Network can fail to provide connectivity for the VLANs that need Dynamic VLAN Registration Entries. Therefore, extreme care is in order when configuring a New-Only MVRP Participant.

If a MAD_Join.indication is received by the MVRP MAD with the *new* parameter set, e.g., because a “new” MVRP declaration is received on a Port configured for New propagated [item d) in 12.7.7.3.3] as a result of receiving an MVRPDU from the attached LAN, and that MAD_Join.indication does not correspond to a Static VLAN Registration Entry of Registration Fixed (New propagated) in the FDB, that MAD_Join.indication shall be discarded without being propagated.

NOTE 2—If only one S-VLAN is configured per VIP, then using a MIRP Participant (Clause 39) can provide bandwidth and processing savings over using an MVRP New-Only Participant on a VIP. See 39.2.1.1 and 39.2.1.6.

11.2.7 Attribute value support requirements

Implementations of MVRP shall be capable of supporting all attribute values in the range of possible values that can be registered using MVRP, and shall be capable of maintaining current state information for all attributes in the range of possible values.

12. Bridge management

This clause defines the set of managed objects, and their functionality, that allow administrative configuration of VLANs.

This clause:

a) Introduces the functions of management to assist in the identification of the requirements placed on Bridges for the support of management facilities.
b) Establishes the correspondence between the Processes used to model the operation of the Bridge (8.3) and the managed objects of the Bridge.
c) Specifies the management operations supported by each managed object.

12.1 Management functions

Management functions relate to the users' needs for facilities that support the planning, organization, supervision, control, protection, and security of communications resources, and account for their use. These facilities may be categorized as supporting the functional areas of Configuration, Fault, Performance, Security, and Accounting Management. Each functional area is summarized in 12.1.1 through 12.1.5, together with the facilities commonly required for the management of communication resources, and the particular facilities provided in that functional area by Bridge Management.

It can be necessary, particularly in PBNs, for multiple organizations to manage a single Bridge, with each organization having different abilities to manage, or even detect the existence of, Bridge Ports, Bridges, or entire networks. Access to all of the managed objects in Clause 12 for reading, writing, or detection can be restricted. Access by certain organizations can be limited to only a small number of managed objects, particularly to those specified in 12.14.

12.1.1 Configuration Management

Configuration Management provides for the identification of communications resources, initialization, reset and close-down, the supply of operational parameters, and the establishment and discovery of the relationship between resources. The facilities provided by Bridge Management in this functional area are:

a) The identification of all Bridges that together make up the network and their respective locations and, as a consequence of that identification, the location of specific end stations to particular individual LANs.
b) The ability to remotely reset, i.e., reinitialize, specified Bridges.
c) The ability to control the priority with which a Bridge Port transmits frames.
d) The ability to force a specific configuration of a spanning tree.
e) The ability to control the propagation of frames with specific group MAC addresses to certain parts of the configured network.
f) The ability to identify the VIDs in use, and through which Ports of the Bridge and for which Protocols frames destined for a given VID may be received and/or forwarded.
g) The ability to create and delete the functional elements of CFM and to control their operation.
h) The ability to create and delete the functional elements of DDCFM and to control their operations.
i) The ability to create and delete the functional elements of congestion notification and to control their operation.
j) The ability to control the operation of MIRP.
k) The ability to control the operation of SPB.
l) The ability to configure the functional elements of EVB and to control their operation.

12.1.2 Fault Management

Fault Management provides for fault prevention, detection, diagnosis, and correction. The facilities provided by Bridge Management in this functional area are:

a) The ability to identify and correct Bridge malfunctions, including error logging and reporting.
b) Within the context of multiple management organizations, the ability to:
    1) Actively monitor the connectivity of a set of managed endpoints on individual VLANs, simultaneously over multiple physical extents.
    2) Actively monitor and ensure the segregation of data among different VLANs.
    3) Issue trains of point-to-point query-response messages to selected network components in a VLAN.
    4) Issue multicast query-relay-response messages to determine the path taken by frames addressed to specific individual MAC addresses through a VLAN.
    5) Determine whether a flow of specified data frames (e.g., frames associated with a service instance or selected data frames with certain destination address) can reach a particular destination.
    6) Determine whether a flow of data frames can be sent without error from a specific location within a network to a station or stations specified by the DA field of each frame.

12.1.3 Performance Management

Performance Management provides for evaluation of the behavior of communications resources and of the effectiveness of communication activities. The facilities provided by Bridge Management in this functional area are as follows:

a) The ability to gather statistics relating to performance and traffic analysis. Specific metrics include network utilization, frame forward, and frame discard counts for individual Ports within a Bridge.

12.1.4 Security Management

Security Management provides for the protection of resources. Bridge Management does not provide any specific facilities in this functional area.

12.1.5 Accounting Management

Accounting Management provides for the identification and distribution of costs and the setting of charges. Bridge Management does not provide any specific facilities in this functional area.

12.2 VLAN Bridge objects

Managed objects model the semantics of management operations. Operations on an object supply information concerning, or facilitate control over, the process or entity associated with that object.

The managed resources of a VLAN Bridge or Bridge component are those of the processes and entities in 8.3. Specifically,

a) The Bridge Management Entity (12.4 and 8.12)
b) The individual MAC Entities associated with each Bridge Port (12.5, 8.2, and 8.5)
c) The Forwarding Process of the MAC Relay Entity (12.6, 8.2, and 8.6)
d) The FDB of the MAC Relay Entity (12.7 and 8.8)
e) The Bridge Protocol Entity (12.8 and 8.10)
f) MRP participants (Clause 10)

g) MVRP participants (12.10, Clause 11)
h) MMRP participants (12.11, Clause 10)
i) The MST Configuration Table (12.12)
j) Additional objects to support Provider Bridge management (12.13)
k) The CFM Entities (12.14)
l) The DDCFM Entities (12.17)
m) The PBB-TE protection switching Entities (12.18)
n) The TPMR Entities (12.19)
o) The management entities for FQTSS (12.20)
p) The congestion notification entities (12.20.4)
q) The Shortest Path Bridging managed objects
r) The EVB entities (12.26)

The management of each of these resources is described in terms of managed objects and operations in 12.4 through 12.12.

NOTE—The values specified in this clause, as inputs and outputs of management operations, are abstract information elements. Questions of formats or encodings are a matter for particular protocols that convey or otherwise represent this information.

Some data elements that are represented by the managed objects specified in this clause are required to be persistent across reinitializations or rebooting of the system within which the objects are implemented. For example, it may be desirable for changes in configuration parameters to persist across such events. Where such a requirement exists, this is indicated in the specification by marking the object concerned with the keyword *"Persistent."*

12.3 Data types

This subclause specifies the semantics of operations independent of their encoding in management protocol. The data types of the parameters of operations are defined only as required for that specification.

The following data types are used:

a) Boolean.
b) Enumerated, for a collection of named values.
c) Unsigned, for all parameters specified as "the number of" some quantity, and for spanning tree priority values that are numerically compared. When comparing spanning tree priority values, the lower number represents the higher priority value.
d) MAC address.
e) Latin1 String, as defined by ANSI X3.159, for all text strings.
f) Time Interval, an Unsigned value representing a positive integral number of seconds, for all spanning tree protocol timeout parameters.
g) Counter, for all parameters specified as a "count" of some quantity. A counter increments and wraps with a modulus of 2 to the power of 64.
h) MRP Time Interval, an Unsigned value representing a positive integral number of centiseconds, for all MRP timeout parameters.
i) Port Number, an Unsigned value assigned to a Port as part of a Port Identifier. Valid Port Numbers are in the range 1 through 4095.
j) Port Priority, an Unsigned value used to represent the priority component of a Port Identifier. Valid Port Priorities are in the range 0 through 240, in steps of 16.

k) Bridge Priority, an Unsigned value used to represent the priority component of a Bridge Identifier. Valid Bridge Priorities are in the range 0 through 61440, in steps of 4096.

l) ComponentID, an unsigned value used to uniquely identify the management objects for a particular VLAN Bridge component (12.2, Clause 8, 5.4) within a system (such as a BEB) comprising multiple such components. ComponentIDs start at 1 and go through 4294967295. If the system has a single component it will have a ComponentID equal to 1.

m) ComponentType, an enumerated list used to classify a particular VLAN Bridge component within a system comprising multiple components.

n) Port Index, a handle, unique within a system, that identifies a port.

o) PIP Index, a Port Index for a PIP.

p) Percentage.

q) ECT-ALGORITHM. A 4-byte unsigned identifier. Used as a worldwide unique definition of an Equal Cost Tree (ECT) Algorithm, the first 3 bytes are expected to be taken from the OUI or CID space for the organization that has defined the algorithm. The last byte is allocated by that organization.

r) SPSourceID. A 20-bit Unsigned identifier. Used to represent a node uniquely within an SPT Domain (27.10).

s) Timer exp, an unsigned value from 0–31 representing a positive integer for the exponent of 2, which forms the multiplier of 10 μs, used for EVB protocol timeout parameters.

NOTE—For example, a value of 4 represents $2^4 \times 10$ μs, or 160 μs.

t) Boolean array, an array of Boolean values.

u) IP Address, an IPv4 address, IPv6 address, or null for no IP address.

12.4 Bridge Management Entity

The Bridge Management Entity is described in 8.12.

This managed resource comprises the following objects:

a) The Bridge Configuration (12.4.1)

b) The Port Configuration for each Port (12.4.2)

12.4.1 Bridge Configuration

The Bridge Configuration object models the operations that modify, or inquire about, the configuration of the Bridge's resources. There is a single Bridge Configuration object per Bridge.

The management operations that can be performed on the Bridge Configuration are as follows:

a) Discover Bridge (12.4.1.1)

b) Read Bridge (12.4.1.2)

c) Set Bridge Name (12.4.1.3)

d) Reset Bridge (12.4.1.4)

e) Read component table entry (12.4.1.5)

f) Update component table entry (12.4.1.5)

12.4.1.1 Discover Bridge

12.4.1.1.1 Purpose

To solicit configuration information regarding the Bridge(s) in the network.

12.4.1.1.2 Inputs

a) Inclusion Range, a set of ordered pairs of specific MAC addresses. Each pair specifies a range of MAC addresses. A Bridge shall respond if and only if:
   1) For one of the pairs, the numerical comparison of its Bridge Address with each MAC address of the pair shows it to be greater than or equal to the first, and
   2) Less than or equal to the second, and
   3) Its Bridge Address does not appear in the Exclusion List parameter below.

   The numerical comparison of one MAC address with another, for the purpose of this operation, is achieved by deriving a number from the MAC address according to the following procedure. The consecutive octets of the MAC address are taken to represent a binary number; the first octet that would be transmitted on a LAN medium when the MAC address is used in the source or destination fields of a MAC frame has the most significant value, the next octet the next most significant value. Within each octet, the first bit of each octet is the LSB.

b) Exclusion List, a list of specific MAC addresses.

12.4.1.1.3 Outputs

a) Bridge Address—the MAC address for the Bridge from which the Bridge Identifiers used by STP, RSTP, and MSTP are derived (8.13.8, 13.26).
b) Bridge Name—a text string of up to 32 characters, of locally determined significance.
c) Number of Ports—the number of Bridge Ports (MAC Entities).
d) Port Addresses—a list specifying the following for each Port:
   1) Port Number—the number of the Bridge Port (13.27).
   2) Port Address—the specific MAC address of the individual MAC Entity associated with the Port (8.13.2).
e) Uptime—count in seconds of the time elapsed since the Bridge was last reset or initialized.

   NOTE—Events that are considered to reset or initialize the Bridge include changing the MCID.

12.4.1.2 Read Bridge

12.4.1.2.1 Purpose

To obtain general information regarding the Bridge.

12.4.1.2.2 Inputs

None.

12.4.1.2.3 Outputs

a) Bridge Address—the MAC address for the Bridge from which the Bridge Identifiers used by RSTP and MSTP are derived (8.13.8, 13.26).
b) Bridge Name—a text string of up to 32 characters, of locally determined significance.
c) Number of Ports—the number of Bridge Ports (MAC Entities).
d) Port Addresses—a list specifying the following for each Port:
   1) Port Number (13.27).
   2) Port Address—the specific MAC address of the individual MAC Entity associated with the Port (8.13.2).
e) Uptime—count in seconds of the time elapsed since the Bridge was last reset or initialized.

12.4.1.3 Set Bridge Name

12.4.1.3.1 Purpose

To associate a text string, readable by the Read Bridge operation, with a Bridge.

12.4.1.3.2 Inputs

a) Bridge Name—a text string of up to 32 characters.

12.4.1.3.3 Outputs

None.

12.4.1.4 Reset Bridge

12.4.1.4.1 Purpose

To reset the specified Bridge. The FDB is cleared and initialized with the entries specified in the Permanent Database, and the Bridge Protocol Entity is initialized.

12.4.1.4.2 Inputs

None.

12.4.1.4.3 Outputs

None.

12.4.1.5 Bridge component configuration

There is a single Bridge component table per system. Each entry in the component table represents a component of the system (Table 12-1). The entries hold the parameters for each component including the component type and capabilities.

Table 12-1—Component table entry managed object

Name	Data type	Operations supported[a]	References
compComponentId	ComponentID	R	12.3 l)
compMACAddress	MAC address	R	8.13.8, 13.24
compNumberPorts	unsigned (1..4095)	R	12.4.1.1.3 c)
compComponentType	ComponentType	R	12.3 m)
compDeviceCapabilities	Boolean array (0..7)	R	12.10.1.1.3 b)
compTrafficClassesEnabled	Boolean	RW	—
compMmrpEnabledStatus	Boolean	RW	—

[a] R = Read-only access; RW = Read/Write access.

The operations that can be implemented on component table entries are as follows:

a) Read component table entry
b) Update component table entry

NOTE—The Bridge component table is implemented in Clause 17 as the BridgeBaseTable (see Table 17-3).

12.4.1.5.1 Component type enumeration

The compComponentType parameter can be assigned the following values:

a) iComponent—An I-component (5.7)
b) bComponent—A B-component (5.8)
c) cVlanComponent—A C-VLAN component (5.5)
d) sVlanComponent—An S-VLAN component (5.6)
e) dBridgeComponent—A MAC Bridge component (5.13)
f) edgeRelay—An EVB station ER (5.24.1)

12.4.1.5.2 Component device capabilities

The compDeviceCapabilities parameter contains an array of Boolean values for the following:

a) ExtendedFilteringServices
b) TrafficClasses
c) StaticEntryIndividualPort
d) IVLCapable
e) SVLCapable
f) HybridCapable
g) ConfigurablePvidTagging
h) LocalVlanCapable

12.4.2 Port configuration

The Port Configuration object models the operations that modify, or inquire about, the configuration of the Ports of a Bridge. Unless the system explicitly supports the ability to dynamically create and/or delete ports, there is a fixed set of Bridge Ports per Bridge (one for each MAC interface), and each is identified by a permanently allocated Port Number.

The allocated Port Numbers are not required to be consecutive. Also, some Port Numbers may be dummy entries, with no actual LAN Port (for example, to allow for expansion of the Bridge by addition of further MAC interfaces). Such dummy Ports shall support the Port Configuration management operations and other Port-related management operations in a manner consistent with the Port being permanently disabled.

The information provided by the Port Configuration consists of summary data indicating its name and type. Specific counter information pertaining to the number of frames forwarded, filtered, and in error is maintained by the Forwarding Process resource. The management operations supported by the Bridge Protocol Entity allow for controlling the states of each Port.

A port table entry can be implemented by a Bridge for each Port of each component (Table 12-2). It comprises the parameters for each Port including the port type, capabilities, and statistics.

The management operations that can be performed on the port table are as follows:

a) Read port table entry (12.4.2.1)
b) Update port table entry (12.4.2.1)

Table 12-2—Port table entry

Name	Data type	Operations supported[a]	References
portComponentId	ComponentID	R	12.4.1.5
portPortNumber	Port Number	R	13.25
portMACAddress	MAC address	R	12.4.1.1.3 a)
portDelayExceededDiscards	counter	R	—
portMtuExceededDiscards	counter	R	—
portCapabilities	unsigned	R	—
portTypeCapabilities	unsigned	R	—
portType	enumerated	R	12.4.2.1
portExternal	Boolean	R	—
portAdminPointToPoint	unsigned	RW	IEEE Std 802.1AC
portOperPointToPoint	Boolean	R	IEEE Std 802.1AC
portName	Latin1 String (SIZE(0..32))	RW	—
portMediaDependentOverhead	unsigned	R	12.4.2.2

[a] R = Read-only access; RW = Read/Write access.

12.4.2.1 Port type capabilities and enumeration

The portTypeCapabilities array has a bit for each port type the Port can take, while the portType is an enumeration. The portTypeCapabilities can take any combination of port types while the portType can take exactly one of the following values:

a) C-VLAN Bridge Port
b) Provider Network Port (PNP)
c) Customer Network Port (CNP)
d) Customer Edge Port (CEP)
e) Customer Backbone Port (CBP)
f) Virtual Instance Port (VIP)
g) D-Bridge Port
h) Remote Customer Access Port (RCAP) (12.13.3)
i) Station-facing Bridge Port (SBP) (12.26.2)
j) Uplink Access Port (UAP) (12.26.4)
k) Uplink relay port (URP) (12.26.5)

NOTE—A portType is not required for a downlink relay port (DRP) or an S-channel Access Port (CAP) as no special EVB objects are necessary. A DRP is type C-VLAN Bridge Port while a CAP is type CNP.

12.4.2.2 Media-dependent overhead

The portMediaDependentOverhead parameter provides the number of additional octets for media-dependent framing. The overhead includes:

a) All octets prior to the first octet of the Destination Address field and
b) The minimum number of octets after the last octet of the frame check sequence before a subsequent frame, including its media-dependent overhead, can be transmitted.

NOTE—An example of media-dependent overhead is 20 octets to account preamble, start of frame delimiter, and a minimal inter-frame gap (IFG) of 12 octets for IEEE 802.3 point-to-point media.

12.5 MAC entities

The Management Operations and Facilities provided by the MAC Entities are those specified in the Layer Management standards of the individual MACs. A MAC Entity is associated with each Bridge Port.

12.5.1 ISS Port Number table managed object (optional)

An instance of the ISS Port Number table can be implemented by a Bridge system to identify the ISS interfaces that can be assigned to Bridge Ports. The ISS table is required when the Bridge Port assigned to an ISS and the ISS itself are referenced using different Port Numbers. The ISS table is keyed on the ISS Port Number. Each ISS table entry identifies a mapping from the ISS Port Number to a Bridge Port's ComponentID and Port Number. An issToComponentID value of 0 indicates the ISS is not bound to a Bridge Port. The issToComponentID and issToPortNumber parameters are updated indirectly as a result of creating or updating other system-specific Port objects.

The operation that can be implemented on an ISS Port Number table is as follows:

a) Read ISS Port Number table entry (see Table 12-3)

Table 12-3—ISS Port Number table entry

Name	Data type	Operations supported[a]	References
issPortNumber	Port Number	R	12.3 i)
issMACAddress	MAC address	R	8.13.2
issToComponentID	ComponentID, 0	R	12.4.2
issToPortNumber	Port Number, 0	R	12.4.2

[a] R = Read-only access; RW = Read/Write access.

12.6 Forwarding process

The Forwarding Process contains information relating to the forwarding of frames. Counters are maintained that provide information on the number of frames forwarded, filtered, and dropped due to error. Configuration data, defining how frame priority is handled, is maintained by the Forwarding Process.

This managed resource comprises the following objects:

a) The Port Counters (12.6.1)
b) The Priority Handling objects for each Port (12.6.2)
c) The Traffic Class Table for each Port (12.6.3)

12.6.1 The Port Counters

The Port Counters object models the operations that can be performed on the Port counters of the Forwarding Process resource. There are multiple instances (one for each VID for each MAC Entity) of the Port Counters object per Bridge.

The management operation that can be performed on the Port Counters is Read Forwarding Port Counters (12.6.1.1).

12.6.1.1 Read forwarding port counters

12.6.1.1.1 Purpose

To read the forwarding counters associated with a specific Bridge Port.

12.6.1.1.2 Inputs

a) Port Number (13.27)
b) Optionally, VID (9.6)

If the VID parameter is supported, then the forwarding Port counters are maintained per VID per Port. If the parameter is not supported, then the forwarding Port counters are maintained per Port only.

12.6.1.1.3 Outputs

a) Frames Received—count of all valid frames received (including BPDUs, frames addressed to the Bridge as an end station, and frames that were submitted to the Forwarding Process, 8.5).
b) Optionally, Octets Received—count of the total number of octets in all valid frames received (including BPDUs, frames addressed to the Bridge as an end station, and frames that were submitted to the Forwarding Process).
c) Discard Inbound—count of valid frames received that were discarded by the Forwarding Process (8.6).
d) Forward Outbound—count of frames forwarded to the associated MAC Entity (8.5).
e) Discard Lack of Buffers—count of frames that were to be transmitted through the associated Port but were discarded due to lack of buffers (8.6.6).
f) Discard Transit Delay Exceeded—count of frames that were to be transmitted but were discarded due to the maximum Bridge transit delay being exceeded (buffering may have been available, 8.6.6).
g) Discard on Error—count of frames that were to be forwarded on the associated MAC but could not be transmitted (e.g., frame would be too large, 6.5.8).
h) If Ingress Filtering is supported (8.6.2), Discard on Ingress Filtering—count of frames that were discarded as a result of Ingress Filtering being enabled.
i) If flow filtering is supported (44.2), Discard TTL Expired—count of frames discarded because they were received with the TTL field expired.

12.6.2 Priority handling

The Priority Handling object models the operations that can be performed on, or inquire about, the Default Priority parameter, the Priority Regeneration Table parameter, the Outbound Access Priority Table parameter, the Priority Code Point parameters, and the Service Access Priority parameters for each Port. The operations that can be performed on this object are as follows:

a) Read Port Default Priority (12.6.2.1)
b) Set Port Default Priority (12.6.2.2)
c) Read Port Priority Regeneration Table (12.6.2.3)
d) Set Port Priority Regeneration Table (12.6.2.4)
e) Read Port Priority Code Point Selection (12.6.2.5)
f) Set Port Priority Code Point Selection (12.6.2.6)
g) Read Port Priority Code Point Decoding Table (12.6.2.7)
h) Optionally, Set Port Priority Code Point Decoding Table (12.6.2.8)
i) Read Port Priority Code Point Encoding Table (12.6.2.9)
j) Optionally, Set Port Priority Code Point Encoding Table (12.6.2.10)
k) Read Use_DEI parameter (12.6.2.11)
l) Optionally, Set Use_DEI parameter (12.6.2.12)
m) Read Require Drop Encoding parameter (12.6.2.13)
n) Optionally, Set Require Drop Encoding parameter (12.6.2.14)
o) Read Service Access Priority Selection (12.6.2.15)
p) Optionally, Set Service Access Priority Selection (12.6.2.16)
q) Read Service Access Priority Table (12.6.2.17)
r) Optionally, Set Service Access Priority Table (12.6.2.18)

12.6.2.1 Read Port Default Priority

12.6.2.1.1 Purpose

To read the current state of the Default Priority parameter (IEEE Std 802.1AC) for a specific Bridge Port.

12.6.2.1.2 Inputs

a) Port number.

12.6.2.1.3 Outputs

a) Default Priority value—Integer in range 0–7.

12.6.2.2 Set Port Default Priority

12.6.2.2.1 Purpose

To set the current state of the Default Priority parameter (IEEE Std 802.1AC) for a specific Bridge Port.

12.6.2.2.2 Inputs

a) Port number.
b) Default Priority value—Integer in range 0–7.

12.6.2.2.3 Outputs

None.

12.6.2.3 Read Port Priority Regeneration Table

12.6.2.3.1 Purpose

To read the current state of the Priority Regeneration Table parameter (6.9.4) for a specific Bridge Port.

12.6.2.3.2 Inputs

a) Port number.

12.6.2.3.3 Outputs

a) Regenerated Priority value for Received Priority 0—Integer in range 0–7.
b) Regenerated Priority value for Received Priority 1—Integer in range 0–7.
c) Regenerated Priority value for Received Priority 2—Integer in range 0–7.
d) Regenerated Priority value for Received Priority 3—Integer in range 0–7.
e) Regenerated Priority value for Received Priority 4—Integer in range 0–7.
f) Regenerated Priority value for Received Priority 5—Integer in range 0–7.
g) Regenerated Priority value for Received Priority 6—Integer in range 0–7.
h) Regenerated Priority value for Received Priority 7—Integer in range 0–7.

12.6.2.4 Set Port Priority Regeneration Table

12.6.2.4.1 Purpose

To set the current state of the Priority Regeneration Table parameter (6.9.4) for a specific Bridge Port.

12.6.2.4.2 Inputs

a) Port number.
b) Regenerated Priority value for Received Priority 0—Integer in range 0–7.
c) Regenerated Priority value for Received Priority 1—Integer in range 0–7.
d) Regenerated Priority value for Received Priority 2—Integer in range 0–7.
e) Regenerated Priority value for Received Priority 3—Integer in range 0–7.
f) Regenerated Priority value for Received Priority 4—Integer in range 0–7.
g) Regenerated Priority value for Received Priority 5—Integer in range 0–7.
h) Regenerated Priority value for Received Priority 6—Integer in range 0–7.
i) Regenerated Priority value for Received Priority 7—Integer in range 0–7.

12.6.2.4.3 Outputs

None.

12.6.2.5 Read Port Priority Code Point Selection

12.6.2.5.1 Purpose

To read which row of the Priority Code Point Encoding Table and Priority Code Point Decoding Table (6.9.3) is currently selected for use on this Port.

12.6.2.5.2 Inputs

a) Port Number: the number of the Bridge Port.

12.6.2.5.3 Outputs

a) Priority Code Point Selection. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.6.2.6 Set Port Priority Code Point Selection

12.6.2.6.1 Purpose

To set which row of the Priority Code Point Encoding Table and Priority Code Point Decoding Table (6.9.3) will be selected for use on this Port.

12.6.2.6.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Selection. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.6.2.6.3 Outputs

None.

12.6.2.7 Read Priority Code Point Decoding Table

12.6.2.7.1 Purpose

To read the current contents of a row in the Priority Code Point Decoding Table (6.9.3) for a Port.

12.6.2.7.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Row. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.6.2.7.3 Outputs

a) Priority value for Priority Code Point 0: Integer in range 0–7.
b) Drop_eligible value for Priority Code Point 0: Boolean.
c) Priority value for Priority Code Point 1: Integer in range 0–7.
d) Drop_eligible value for Priority Code Point 1: Boolean.
e) Priority value for Priority Code Point 2: Integer in range 0–7.
f) Drop_eligible value for Priority Code Point 2: Boolean.
g) Priority value for Priority Code Point 3: Integer in range 0–7.

h) Drop_eligible value for Priority Code Point 3: Boolean.
i) Priority value for Priority Code Point 4: Integer in range 0–7.
j) Drop_eligible value for Priority Code Point 4: Boolean.
k) Priority value for Priority Code Point 5: Integer in range 0–7.
l) Drop_eligible value for Priority Code Point 5: Boolean.
m) Priority value for Priority Code Point 6: Integer in range 0–7.
n) Drop_eligible value for Priority Code Point 6: Boolean.
o) Priority value for Priority Code Point 7: Integer in range 0–7.
p) Drop_eligible value for Priority Code Point 7: Boolean.

12.6.2.8 Set Priority Code Point Decoding Table

12.6.2.8.1 Purpose

To modify the contents of a row in the Priority Code Point Decoding Table (6.9.3) for a Port.

12.6.2.8.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D
c) Priority value for Priority Code Point 0: Integer in range 0–7.
d) Drop_eligible value for Priority Code Point 0: Boolean.
e) Priority value for Priority Code Point 1: Integer in range 0–7.
f) Drop_eligible value for Priority Code Point 1: Boolean.
g) Priority value for Priority Code Point 2: Integer in range 0–7.
h) Drop_eligible value for Priority Code Point 2: Boolean.
i) Priority value for Priority Code Point 3: Integer in range 0–7.
j) Drop_eligible value for Priority Code Point 3: Boolean.
k) Priority value for Priority Code Point 4: Integer in range 0–7.
l) Drop_eligible value for Priority Code Point 4: Boolean.
m) Priority value for Priority Code Point 5: Integer in range 0–7.
n) Drop_eligible value for Priority Code Point 5: Boolean.
o) Priority value for Priority Code Point 6: Integer in range 0–7.
p) Drop_eligible value for Priority Code Point 6: Boolean.
q) Priority value for Priority Code Point 7: Integer in range 0–7.
r) Drop_eligible value for Priority Code Point 7: Boolean.

12.6.2.8.3 Outputs

None.

12.6.2.9 Read Priority Code Point Encoding Table

12.6.2.9.1 Purpose

To read the current contents of a row in the Priority Code Point Encoding Table (6.9.3) for a Port.

12.6.2.9.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D

12.6.2.9.3 Outputs

a) Priority Code Point value for priority 0 with drop_eligible False: Integer in range 0–7.
b) Priority Code Point value for priority 0 with drop_eligible True: Integer in range 0–7.
c) Priority Code Point value for priority 1 with drop_eligible False: Integer in range 0–7.
d) Priority Code Point value for priority 1 with drop_eligible True: Integer in range 0–7.
e) Priority Code Point value for priority 2 with drop_eligible False: Integer in range 0–7.
f) Priority Code Point value for priority 2 with drop_eligible True: Integer in range 0–7.
g) Priority Code Point value for priority 3 with drop_eligible False: Integer in range 0–7.
h) Priority Code Point value for priority 3 with drop_eligible True: Integer in range 0–7.
i) Priority Code Point value for priority 4 with drop_eligible False: Integer in range 0–7.
j) Priority Code Point value for priority 4 with drop_eligible True: Integer in range 0–7.
k) Priority Code Point value for priority 5 with drop_eligible False: Integer in range 0–7.
l) Priority Code Point value for priority 5 with drop_eligible True: Integer in range 0–7.
m) Priority Code Point value for priority 6 with drop_eligible False: Integer in range 0–7.
n) Priority Code Point value for priority 6 with drop_eligible True: Integer in range 0–7.
o) Priority Code Point value for priority 7 with drop_eligible False: Integer in range 0–7.
p) Priority Code Point value for priority 7 with drop_eligible True: Integer in range 0–7.

12.6.2.10 Set Priority Code Point Encoding Table

12.6.2.10.1 Purpose

To modify the contents of a row in the Priority Code Point Encoding Table (6.9.3) for a Port.

12.6.2.10.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D
c) Priority Code Point value for priority 0 with drop_eligible False: Integer in range 0–7.
d) Priority Code Point value for priority 0 with drop_eligible True: Integer in range 0–7.
e) Priority Code Point value for priority 1 with drop_eligible False: Integer in range 0–7.
f) Priority Code Point value for priority 1 with drop_eligible True: Integer in range 0–7.
g) Priority Code Point value for priority 2 with drop_eligible False: Integer in range 0–7.
h) Priority Code Point value for priority 2 with drop_eligible True: Integer in range 0–7.
i) Priority Code Point value for priority 3 with drop_eligible False: Integer in range 0–7.

j) Priority Code Point value for priority 3 with drop_eligible True: Integer in range 0–7.
k) Priority Code Point value for priority 4 with drop_eligible False: Integer in range 0–7.
l) Priority Code Point value for priority 4 with drop_eligible True: Integer in range 0–7.
m) Priority Code Point value for priority 5 with drop_eligible False: Integer in range 0–7.
n) Priority Code Point value for priority 5 with drop_eligible True: Integer in range 0–7.
o) Priority Code Point value for priority 6 with drop_eligible False: Integer in range 0–7.
p) Priority Code Point value for priority 6 with drop_eligible True: Integer in range 0–7.
q) Priority Code Point value for priority 7 with drop_eligible False: Integer in range 0–7.
r) Priority Code Point value for priority 7 with drop_eligible True: Integer in range 0–7.

12.6.2.10.3 Outputs

None.

12.6.2.11 Read Use_DEI Parameter

12.6.2.11.1 Purpose

To read the current state of the Use_DEI parameter (6.9.3) for the Port.

12.6.2.11.2 Inputs

a) Port Number: the number of the Bridge Port.

12.6.2.11.3 Outputs

a) Use_DEI parameter: Boolean.

12.6.2.12 Set Use_DEI Parameter

12.6.2.12.1 Purpose

To set the current state of the Use_DEI parameter (6.9.3) for the Port.

12.6.2.12.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Use_DEI parameter: Boolean.

12.6.2.12.3 Outputs

None.

12.6.2.13 Read Require Drop Encoding Parameter

12.6.2.13.1 Purpose

To read the current state of the Require Drop Encoding parameter (8.6.6) for the Port.

12.6.2.13.2 Inputs

a) Port Number: the number of the Bridge Port.

12.6.2.13.3 Outputs

a) Require Drop Encoding parameter: Boolean.

12.6.2.14 Set Require Drop Encoding Parameter

12.6.2.14.1 Purpose

To set the current state of the Require Drop Encoding parameter (8.6.6) for the Port.

12.6.2.14.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Require Drop Encoding parameter: Boolean.

12.6.2.14.3 Outputs

None.

12.6.2.15 Read Service Access Priority Selection

12.6.2.15.1 Purpose

To read the current state of whether Service Access Priority Selection is enabled (6.13) for the Port.

12.6.2.15.2 Inputs

a) Port Number: the number of the Bridge Port.

12.6.2.15.3 Outputs

a) Enable Service Access Priority Selection: the permissible values are as follows:
    1) Enabled
    2) Disabled

12.6.2.16 Set Service Access Priority Selection

12.6.2.16.1 Purpose

To enable or disable Service Access Priority Selection (6.13) for the Port.

12.6.2.16.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Service Access Priority Selection: the permissible values are as follows:
    1) Enabled
    2) Disabled

12.6.2.16.3 Outputs

None.

12.6.2.17 Read Service Access Priority Table

12.6.2.17.1 Purpose

To read the current contents of the Service Access Priority Table (6.13.1) for the Port.

12.6.2.17.2 Inputs

a) Port Number: the number of the Bridge Port.

12.6.2.17.3 Outputs

a) Service Access Priority value for Received Priority 0: Integer in range 0–7.
b) Service Access Priority value for Received Priority 1: Integer in range 0–7.
c) Service Access Priority value for Received Priority 2: Integer in range 0–7.
d) Service Access Priority value for Received Priority 3: Integer in range 0–7.
e) Service Access Priority value for Received Priority 4: Integer in range 0–7.
f) Service Access Priority value for Received Priority 5: Integer in range 0–7.
g) Service Access Priority value for Received Priority 6: Integer in range 0–7.
h) Service Access Priority value for Received Priority 7: Integer in range 0–7.

12.6.2.18 Set Service Access Priority Table

12.6.2.18.1 Purpose

To modify the contents of the Service Access Priority Table (6.13.1) for the Port.

12.6.2.18.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Service Access Priority value for Received Priority 0: Integer in range 0–7.
c) Service Access Priority value for Received Priority 1: Integer in range 0–7.
d) Service Access Priority value for Received Priority 2: Integer in range 0–7.
e) Service Access Priority value for Received Priority 3: Integer in range 0–7.
f) Service Access Priority value for Received Priority 4: Integer in range 0–7.
g) Service Access Priority value for Received Priority 5: Integer in range 0–7.
h) Service Access Priority value for Received Priority 6: Integer in range 0–7.
i) Service Access Priority value for Received Priority 7: Integer in range 0–7.

12.6.2.18.3 Outputs

None.

12.6.3 Traffic Class Table

The Traffic Class Table object models the operations that can be performed on, or inquire about, the current contents of the Traffic Class Table (8.6.6) for a given Port. The operations that can be performed on this object are Read Port Traffic Class Table and Set Port Traffic Class Table.

12.6.3.1 Read Port Traffic Class Table

12.6.3.1.1 Purpose

To read the contents of the Traffic Class Table (8.6.6) for a given Port.

12.6.3.1.2 Inputs

a) Port Number.

12.6.3.1.3 Outputs

a) The number of traffic classes, in the range 1 through 8, supported on the Port.
b) For each value of traffic class supported on the Port, the value of the traffic class in the range 0 through 7, and the set of priority values assigned to that traffic class.

12.6.3.2 Set Port Traffic Class Table

12.6.3.2.1 Purpose

To set the contents of the Traffic Class Table (8.6.6) for a given Port.

12.6.3.2.2 Inputs

a) Port number.
b) For each value of traffic class supported on the Port, the value of the traffic class in the range 0 through 7, and the set of priority values assigned to that traffic class.

NOTE—If a traffic class value greater than the largest traffic class available on the Port is specified, then the value applied to the Traffic Class Table is the largest available traffic class.

12.6.3.2.3 Outputs

None.

12.7 Filtering Database (FDB)

The FDB is described in 8.8. It contains filtering information used by the Forwarding Process (8.6) in deciding through which Ports of the Bridge frames should be forwarded.

This managed resource comprises the following objects:

a) The Filtering Database (12.7.1)
b) The Static Filtering Entries (12.7.2)
c) The Dynamic Filtering Entries (12.7.3)
d) The MAC Address Registration Entries (12.7.4)
e) The Static VLAN Registration Entries (12.7.5)
f) The Dynamic VLAN Registration Entries (12.7.5)
g) The Permanent Database (12.7.6)

12.7.1 The Filtering Database object

The Filtering Database object models the operations that can be performed on, or affect, the FDB as a whole. There is a single Filtering Database object per Bridge.

The management operations that can be performed on the Database are as follows:

a) Read Filtering Database (12.7.1.1)
b) Set Filtering Database Ageing Time (12.7.1.2)
c) Read Permanent Database (12.7.6.1)
d) Create Filtering Entry (12.7.7.1)
e) Delete Filtering Entry (12.7.7.2)
f) Read Filtering Entry (12.7.7.3)
g) Read Filtering Entry Range (12.7.7.4)

12.7.1.1 Read Filtering Database

12.7.1.1.1 Purpose

To obtain general information regarding the Bridge’s FDB.

12.7.1.1.2 Inputs

None.

12.7.1.1.3 Outputs

a) Filtering Database Size—the maximum number of entries that can be held in the FDB.
b) Number of Static Filtering Entries—the number of Static Filtering Entries (8.8.1) currently in the FDB.
c) Number of Dynamic Filtering Entries—the number of Dynamic Filtering Entries (8.8.3) currently in the FDB.
d) Number of Static VLAN Registration Entries—the number of Static VLAN Registration Entries (8.8.2) currently in the FDB.
e) Number of Dynamic VLAN Registration Entries—the number of Dynamic VLAN Registration Entries (8.8.5) currently in the FDB.
f) Ageing Time—for ageing out Dynamic Filtering Entries when the Port associated with the entry is in the Forwarding state (8.8.3).
g) If Extended Filtering Services are supported, Number of MAC Address Registration Entries—the number of MAC Address Registration Entries (8.8.4) currently in the FDB.

12.7.1.2 Set Filtering Database Ageing Time

12.7.1.2.1 Purpose

To set the ageing time for Dynamic Filtering Entries (8.8.3).

12.7.1.2.2 Inputs

a) Ageing Time.

12.7.1.2.3 Outputs

None.

12.7.2 A Static Filtering Entry object

A Static Filtering Entry object models the operations that can be performed on a single Static Filtering Entry in the FDB. The set of Static Filtering Entry objects within the FDB changes only under management control.

A Static Filtering Entry object supports the following operations:

a) Create Filtering Entry (12.7.7.1)
b) Delete Filtering Entry (12.7.7.2)
c) Read Filtering Entry (12.7.7.3)
d) Read Filtering Entry Range (12.7.7.4)

12.7.3 A Dynamic Filtering Entry object

A Dynamic Filtering Entry object models the operations that can be performed on a single Dynamic Filtering Entry (i.e., one that is created by the Learning Process as a result of the observation of network traffic) in the FDB.

A Dynamic Filtering Entry object supports the following operations:

a) Delete Filtering Entry (12.7.7.2)
b) Read Filtering Entry (12.7.7.3)
c) Read Filtering Entry Range (12.7.7.4)

12.7.4 A MAC Address Registration Entry object

A MAC Address Registration Entry object models the operations that can be performed on a single MAC Address Registration Entry in the FDB. The set of MAC Address Registration Entry objects within the FDB changes only as a result of MMRP exchanges.

A MAC Address Registration Entry object supports the following operations:

a) Read Filtering Entry (12.7.7.3)
b) Read Filtering Entry Range (12.7.7.4)

12.7.5 A VLAN Registration Entry object

A VLAN Registration Entry object models the operations that can be performed on a single VLAN Registration Entry in the FDB. The set of VLAN Registration Entry objects within the FDB changes under management control and also as a result of MVRP exchanges.

12.7.5.1 Static VLAN Registration Entry object

A Static VLAN Registration Entry object supports the following operations:

a) Create Filtering Entry (12.7.7.1)
b) Delete Filtering Entry (12.7.7.2)
c) Read Filtering Entry (12.7.7.3)
d) Read Filtering Entry Range (12.7.7.4)

12.7.5.2 Dynamic VLAN Registration Entry object

A Dynamic VLAN Registration Entry object supports the following operations:

a) Read Filtering Entry (12.7.7.3)
b) Read Filtering Entry Range (12.7.7.4)

12.7.6 Permanent Database object

The Permanent Database object models the operations that can be performed on, or affect, the Permanent Database. There is a single Permanent Database per FDB.

The management operations that can be performed on the Permanent Database are as follows:

a) Read Permanent Database (12.7.6.1)
b) Create Filtering Entry (12.7.7.1)
c) Delete Filtering Entry (12.7.7.2)
d) Read Filtering Entry (12.7.7.3)
e) Read Filtering Entry Range (12.7.7.4)

12.7.6.1 Read Permanent Database

12.7.6.1.1 Purpose

To obtain general information regarding the Permanent Database (8.8.11).

12.7.6.1.2 Inputs

None.

12.7.6.1.3 Outputs

a) Permanent Database Size—maximum number of entries that can be held in the Permanent Database.
b) Number of Static Filtering Entries—number of Static Filtering Entries (8.8.1) currently in the Permanent Database.
c) Number of Static VLAN Registration Entries—number of Static VLAN Registration Entries (8.8.2) currently in the Permanent Database.

12.7.7 General FDB operations

In these operations on the FDB, the operation parameters make use of VID values, even when operating on a Dynamic Filtering Entry (8.8.3) whose structure carries an FID rather than a VID. In this case, the value used in the VID parameter can be any VID that has been allocated to the FID concerned (8.8.8).

12.7.7.1 Create Filtering Entry

12.7.7.1.1 Purpose

To create or update a Static Filtering Entry (8.8.1) or Static VLAN Registration Entry (8.8.2) in the FDB or Permanent Database. Only static entries may be created in the FDB or Permanent Database.

12.7.7.1.2 Inputs

a) Identifier—FDB or Permanent Database.
b) Address—MAC address of the entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.
d) Port Map—a set of control indicators, one for each Port, as specified in 8.8.1 and 8.8.2.

12.7.7.1.3 Outputs

a) Operation rejected because a Port identified by the Port Map includes a port already in the member set of a VID of a different type than the currently registered VID.
b) Operation rejected because the specified Static Filtering Entry is associated with and Infrastructure Protection Group (IPG) and is administered by IPS Control.
c) Operation rejected because the VID identifies an SPVID.
d) Operation accepted.

12.7.7.2 Delete Filtering Entry

12.7.7.2.1 Purpose

To delete a Filtering Entry or VLAN Registration Entry from the FDB or Permanent Database.

12.7.7.2.2 Inputs

a) Identifier—FDB or Permanent Database.
b) Address—MAC address of the desired entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.

12.7.7.2.3 Outputs

None.

12.7.7.3 Read Filtering Entry

12.7.7.3.1 Purpose

To read a Filtering Entry, MAC Address Registration Entry, or VLAN Registration Entry from the Filtering or Permanent Databases.

12.7.7.3.2 Inputs

a) Identifier—FDB or Permanent Database.
b) Address—MAC address of the desired entry (not present in VLAN Registration Entries).
c) VID—VLAN Identifier of the entry.
d) Type—Static or Dynamic entry.

12.7.7.3.3 Outputs

a) Address—MAC address of the desired entry (not present in VLAN Registration Entries).
b) VID—VLAN Identifier of the entry.
c) Type—Static or Dynamic entry.
d) Port Map—a set of control indicators as appropriate for the entry (that may include a Connection Identifier), as specified in 8.8.1 through 8.8.5.

12.7.7.4 Read Filtering Entry range

12.7.7.4.1 Purpose

To read a range of FDB entries (of any type) from the Filtering or Permanent Databases.

Since the number of values to be returned in the requested range may have exceeded the capacity of the SDU conveying the management response, the returned entry range is identified. The indices that define the range take on values from zero up to Filtering Database Size minus one.

12.7.7.4.2 Inputs

a) Identifier—FDB or Permanent Database.
b) Start Index—inclusive starting index of the desired entry range.
c) Stop Index—inclusive ending index of the desired range.

12.7.7.4.3 Outputs

a) Start Index—inclusive starting index of the returned entry range.
b) Stop Index—inclusive ending index of the returned entry range.
c) For each index returned:
    1) Address—MAC address of the desired entry (not present in VLAN Registration Entries).
    2) VID—VLAN Identifier of the entry.
    3) Type—Static or Dynamic entry.
    4) Port Map—a set of control indicators as appropriate for the entry (that may include a Connection Identifier), as specified in 8.8.1 through 8.8.5.

12.8 Bridge Protocol Entity

The Bridge Protocol Entity is described in 8.10 and Clause 13.

This managed resource comprises the following objects:

a) The Protocol Entity
b) The Ports under its control

12.8.1 The Protocol Entity

The Protocol Entity object models the operations that can be performed on, or inquire about, the operation of STP. There is a single Protocol Entity per Bridge; it can therefore be identified as a single fixed component of the Protocol Entity resource.

The management operations that can be performed on the Protocol Entity are as follows:

a) Read CIST Bridge Protocol Parameters (12.8.1.1)
b) Read MSTI Bridge Protocol Parameters (12.8.1.2)
c) Set CIST Bridge Protocol Parameters (12.8.1.3)
d) Set MSTI Bridge Protocol Parameters (12.8.1.4)

12.8.1.1 Read CIST Bridge Protocol Parameters

12.8.1.1.1 Purpose

To obtain information regarding the Bridge's Bridge Protocol Entity for the CIST.

12.8.1.1.2 Inputs

None.

12.8.1.1.3 Outputs

a) Bridge Identifier—as defined in 13.26.2. The Bridge Identifier for the CIST.
b) Time Since Topology Change—in an STP Bridge, the count in seconds of the time elapsed since the Topology Change flag parameter for the Bridge (8.5.3.12 of IEEE Std 802.1D, 1998 Edition [B11]) was last True, or in an RSTP or MSTP Bridge, the count in seconds since tcWhile timer (13.25) for any Port was nonzero.
c) Topology Change Count—in an STP Bridge, the count of the times the Topology Change flag parameter for the Bridge has been set (i.e., transitioned from False to True) since the Bridge was powered on or initialized, or in an RSTP or MSTP Bridge, the count of times that there has been at least one nonzero tcWhile timer (13.25).
d) CIST Root Identifier (13.26.10).
e) CIST External Root Path Cost (13.26.10).
f) Root Port (13.26.9).
g) Max Age (13.26.11).
h) Forward Delay (13.26.11).
i) Bridge Max Age (13.26.4).
j) Bridge Hello Time (13.25). This parameter is present only if the Bridge supports STP or RSTP.
k) Bridge Forward Delay (13.26.4).
l) Hold Time (8.5.3.14 of IEEE Std 802.1D, 1998 Edition [B11]) or Transmission Limit (TxHoldCount in 13.26.12).

The following parameter is present only if the Bridge supports RSTP or MSTP:

m) forceVersion—the value of the Force Protocol Version parameter for the Bridge (13.7.2).

The following additional parameters are present only if the Bridge supports MSTP:

n) CIST Regional Root Identifier (13.26.10). The Bridge Identifier of the current CIST Regional Root.
o) CIST Path Cost (CIST Internal Root Path Cost, in 13.26.10). The CIST path cost from the transmitting Bridge to the CIST Regional Root.
p) MaxHops (13.26.4).

12.8.1.2 Read MSTI Bridge Protocol Parameters

12.8.1.2.1 Purpose

In an MST Bridge, to obtain information regarding the Bridge's Bridge Protocol Entity for the specified spanning tree instance.

12.8.1.2.2 Inputs

a) MSTID—Identifies the set of parameters that will be returned. For Bridges that support MSTP, this parameter is the identifier of the spanning tree for which the operation is being performed. This parameter takes a value in the range 1 through 4094.

12.8.1.2.3 Outputs

a) MSTID—identifies the set of parameters that are being returned. This parameter is the identifier of the MST Instance for which the operation is being performed.
b) Bridge Identifier—as defined in 13.26.2. The Bridge Identifier for the spanning tree instance identified by the MSTID.
c) Time Since Topology Change—count in seconds of the time elapsed since tcWhile (13.25) was last nonzero for any Port for the given MSTI.
d) Topology Change Count—count of the times tcWhile has been nonzero for any Port for the given MSTI since the Bridge was powered on or initialized.
e) Topology Change (tcWhile, 13.25). True if tcWhile is nonzero for any Port for the given MST.
f) Designated Root (MSTI Regional Root Identifier, 13.26.10). The Bridge Identifier of the Root Bridge for the spanning tree instance identified by the MSTID.
g) Root Path Cost (MSTI Internal Root Path Cost, 13.26.10). The path cost from the transmitting Bridge to the Root Bridge for the spanning tree instance identified by the MSTID.
h) Root Port (13.26.9). The Root Port for the spanning tree instance identified by the MSTID.

12.8.1.3 Set CIST Bridge Protocol Parameters

12.8.1.3.1 Purpose

To modify parameters in the Bridge's Bridge Protocol Entity for the CIST, in order to force a configuration of the spanning tree and/or tune the reconfiguration time to suit a specific topology. In RSTP and MSTP implementations, this operation causes these values to be set for all Ports of the Bridge.

12.8.1.3.2 Inputs

a) Bridge Max Age—the new value (13.26.4).
b) Bridge Hello Time—the new value (13.25) This parameter is present only if the Bridge supports STP or RSTP.
c) Bridge Forward Delay—the new value (13.26.4).
d) Bridge Priority—the new value of the priority part of the Bridge Identifier (13.26.2) for the CIST.

The following parameters are present only if the Bridge supports RSTP or MSTP:

e) forceVersion—the new value of the Force Protocol Version parameter for the Bridge (13.7.2).
f) TxHoldCount—the new value of TxHoldCount (13.26.12).

The following parameter is present only if the Bridge supports MSTP:

g) MaxHops—the new value of MaxHops (13.26.4).

12.8.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Bridge Priority value (12.3).
   2) Operation rejected due to the specified Max Age, Hello Time, or Forward Delay values being outside the range specified for the parameter (see 12.8.1.3.4).
   3) Operation rejected due to the specified Max Age, Hello Time, or Forward Delay values not being in compliance with the requirements of this standard (see 12.8.1.3.4).
   4) Operation rejected due to the specified MaxHops value not being within the permitted range specified in Table 13-5.
   5) Operation accepted.

12.8.1.3.4 Procedure

In the following description, the references to Bridge Hello Time apply only to Bridges that support STP or RSTP.

The input parameter values are checked for compliance with their definitions in Clause 13. If they do not comply, or the value of Bridge Max Age or Bridge Forward Delay is less than the lower limit of the range specified in Table 13-5, then no action shall be taken for any of the supplied parameters. If the value of any of Bridge Max Age, Bridge Forward Delay, or Bridge Hello Time is outside the range specified in Table 13-5, then the Bridge need not take action.

Otherwise,

a) The Bridge's Bridge Max Age, Bridge Hello Time, and Bridge Forward Delay parameters are set to the supplied values.
b) In STP Bridges, the Set Bridge Priority procedure (8.8.4 of IEEE Std 802.1D, 1998 Edition [B11]) is used to set the priority part of the Bridge Identifier to the supplied value.
c) In RSTP and MSTP Bridges, the priority component of the Bridge Identifier (13.26.2) is updated using the supplied value. For all Ports of the Bridge, the reselect for the CIST parameter (13.27) is set TRUE, and the selected parameter for the CIST is set FALSE.

12.8.1.4 Set MSTI Bridge Protocol Parameters

12.8.1.4.1 Purpose

To modify parameters in the Bridge's Bridge Protocol Entity for the specified spanning tree instance, in order to force a configuration of the spanning tree and/or tune the reconfiguration time to suit a specific topology.

12.8.1.4.2 Inputs

a) MSTID—identifies the set of parameters upon which the operation will be performed.
b) Bridge Priority—the new value of the priority part of the Bridge Identifier (13.26.2) for the spanning tree instance identified by the MSTID.

12.8.1.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to invalid Bridge Priority value (12.3).
   2) Operation rejected due to invalid MSTID (i.e, there is currently no MST Instance with that value of MSTID supported by the Bridge).
   3) Operation accepted.

12.8.1.4.4 Procedure

The Bridge Priority parameter value is checked for compliance with its definition in Clause 13. If it does not comply, then no action shall be taken.

Otherwise, the priority part of the Bridge Identifier is set to the supplied value for the specified spanning tree instance.

12.8.2 Bridge Port

A Bridge Port object models the operations related to an individual Bridge Port in relation to the operation of STP. There are a fixed set of Bridge Ports per Bridge; each can therefore be identified by a permanently allocated Port Number, as a fixed component of the Protocol Entity resource.

The management operations that can be performed on a Bridge Port are as follows:

a) Read CIST Port Parameters (12.8.2.1)
b) Read MSTI Port Parameters (12.8.2.2)
c) Set CIST Port Parameters (12.8.2.3)
d) Set MSTI Port Parameters (12.8.2.4)
e) Force BPDU Migration Check (12.8.2.5)

12.8.2.1 Read CIST Port Parameters

12.8.2.1.1 Purpose

To obtain information regarding a specific Port within the Bridge's Bridge Protocol Entity, for the CIST.

12.8.2.1.2 Inputs

a) Port Number—the number of the Bridge Port.

12.8.2.1.3 Outputs

a) Uptime—count in seconds of the time elapsed since the Port was last reset or initialized (BEGIN, 13.26).
b) Port State—Discarding, Listening, Learning, or Forwarding (8.4).
c) Port Identifier—the unique Port identifier comprising two parts, the Port Number and the Port Priority field (13.27.46).
d) Path Cost (ExternalPortPathCost, 13.27.25).
e) Designated Root (CIST Root Identifier, 13.27.20).
f) Designated Cost (External Root Path Cost, 13.27.20).
g) Designated Bridge (13.27.20).
h) Designated Port (13.27.20).
i) Topology Change Acknowledge (13.27.72).

j) Hello Time (13.27.48).
k) adminEdgePort (13.27.1). Present in implementations that support the identification of edge ports.
l) operEdgePort (13.27.44). Present in implementations that support the identification of edge ports.
m) autoEdgePort (13.27.6). Optional and provided only in implementations that support the automatic identification of edge ports.
n) autoIsolatePort (13.27.19). Present in implementations that support detection of fragile Bridges.
o) isolatePort (13.27.27). Present in implementations that support detection of fragile Bridges.
p) MAC Enabled—the current state of the MAC Enabled parameter (IEEE Std 802.1AC). Present if the implementation supports the MAC Enabled parameter.
q) MAC Operational—the current state of the MAC Operational parameter (IEEE Std 802.1AC). Present if the implementation supports the MAC Operational parameter.
r) adminPointToPointMAC—the current state of the adminPointToPointMAC parameter (IEEE Std 802.1AC). Present if the implementation supports the adminPointToPointMAC parameter.
s) operPointToPointMAC—the current state of the operPointToPointMAC parameter (IEEE Std 802.1AC). Present if the implementation supports the operPointToPointMAC parameter.
t) restrictedRole—the current state of the restrictedRole parameter for the Port (13.27.63).
u) restrictedTcn—the current state of the restrictedTcn parameter for the Port (13.27.65).
v) Port Role—the current Port Role for the Port (i.e., Root, Alternate, Designated, or Backup)
w) Disputed—the current value of the disputed variable for the CIST for the Port (13.27.22).
x) enableBPDUrx—the value of enableBPDUrx (13.27.23).
y) enableBPDUtx—the value of enableBPDUtx (13.27.24).
z) pseudoRootId—the value of Bridge Identifier used by the L2 gateway protocol (13.27.51).
aa) isL2gp—the value of isL2gp (13.27.26).

The following additional parameters are present only if the Bridge supports MSTP:

ab) CIST Regional Root Identifier (13.26.10). The Bridge Identifier of the current CIST Regional Root.
ac) CIST Path Cost (CIST Internal Root Path Cost, in 13.26.10). The CIST path cost from the transmitting Bridge to the CIST Regional Root.
ad) Port Hello Time. The administrative value of Hello Time for the Port (13.27.48).

12.8.2.2 Read MSTI Port Parameters

12.8.2.2.1 Purpose

To obtain information regarding a specific Port within the Bridge's Bridge Protocol Entity, for a given MSTI.

12.8.2.2.2 Inputs

a) Port Number—the number of the Bridge Port.
b) MSTID—identifies the set of parameters that will be returned, in the range 1 through 4094.

12.8.2.2.3 Outputs

a) MSTID—identifies the set of parameters that are being returned. This parameter is the identifier of the spanning tree for which the operation is being performed.
b) Uptime—count in seconds of the time elapsed since the Port was last reset or initialized (BEGIN).
c) State—the current state of the Port (i.e., Disabled, Listening, Learning, Forwarding, or Blocking) (8.4, 13.38).

d) Port Identifier—the unique Port identifier comprising two parts, the Port Number and the Port Priority field (13.27.46).
e) Path Cost (13.27.20).
f) Designated Root (13.27.20).
g) Designated Cost (13.27.20).
h) Designated Bridge (13.27.20).
i) Designated Port (13.27.20).
j) Port Role—the current Port Role for the Port (i.e., Root, Alternate, Designated, or Backup, 13.27.66)
k) Disputed—the current value of the disputed variable (13.27.22).
l) pseudoRootId—the new value of Bridge Identifier used by the L2 gateway protocol (13.27.51).

12.8.2.3 Set CIST port parameters

12.8.2.3.1 Purpose

To modify parameters for a Port in the Bridge's Bridge Protocol Entity in order to force a configuration of the spanning tree for the CIST.

12.8.2.3.2 Inputs

a) Port Number—the number of the Bridge Port.
b) Path Cost—the new ExternalPortPathCost (13.27.25).
c) Port Priority—the new value of the priority field for the Port Identifier (13.27.46).
d) adminEdgePort—the new value of the adminEdgePort parameter (13.27.1). Present in implementations that support the identification of edge ports.
e) autoEdgePort—the new value of the autoEdgePort parameter (13.27.6). Optional and provided only in implementations that support the automatic identification of edge ports.
f) autoIsolatePort—the new value of the autoIsolatePort parameter (13.27.19). Present in implementations that support detection of fragile Bridges.
g) MAC Enabled—the new value of the MAC Enabled parameter (IEEE Std 802.1AC). May be present if the implementation supports the MAC Enabled parameter.
h) adminPointToPointMAC—the new value of the adminPointToPointMAC parameter (IEEE Std 802.1AC). May be present if the implementation supports the adminPointToPointMAC parameter.
i) restrictedRole—the new value of the restrictedRole parameter for the Port (13.27.63).
j) restrictedTcn—the new value of the restrictedTcn parameter for the Port (13.27.65).
k) enableBPDUrx—the new value of enableBPDUrx (13.27.23).
l) enableBPDUtx—the new value of enableBPDUtx (13.27.24).
m) pseudoRootId—the new value of Bridge Identifier used by the L2 gateway protocol (13.27.51).
n) isL2gp—the new value of isL2gp (13.27.26).

12.8.2.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to invalid Port Priority value (12.3)
    2) Operation accepted

12.8.2.3.4 Procedure

In STP Bridges, the Set Path Cost procedure (8.8.6 of IEEE Std 802.1D, 1998 Edition [B11]) is used to set the Path Cost parameter for the specified Port for the specified spanning tree instance. The Set Port Priority procedure (8.8.5 of IEEE Std 802.1D, 1998 Edition [B11]) is used to set the priority part of the Port Identifier (8.5.5.1 of IEEE Std 802.1D, 1998 Edition [B11]) for the CIST to the supplied value.

In RSTP and MSTP Bridges, the Path Cost (13.27.25) and Port Priority (13.27.47) parameters for the Port are updated using the supplied values. The reselect parameter value for the CIST for the Port (13.27.62) is set TRUE, and the selected parameter for the CIST for the Port (13.27.67) is set FALSE.

12.8.2.4 Set MSTI port parameters

12.8.2.4.1 Purpose

To modify parameters for a Port in the Bridge's Bridge Protocol Entity in order to force a configuration of the spanning tree for the specified spanning tree instance.

12.8.2.4.2 Inputs

a) MSTID—identifies the set of parameters upon which the operation will be performed. This parameter is the identifier of the spanning tree for which the operation is being performed.
b) Port Number—the number of the Bridge Port.
c) Path Cost—the new value (13.27.25).
d) Port Priority—the new value of the priority field for the Port Identifier (13.27.46).
e) pseudoRootId—the new value of Bridge Identifier used by the L2 gateway protocol (13.27.51).

12.8.2.4.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to invalid Port Priority value (12.3).
    2) Operation rejected due to invalid MSTID (i.e, there is currently no spanning tree instance with that value of MSTID supported by the Bridge).
    3) Operation accepted.

12.8.2.4.4 Procedure

The Path Cost (13.27.25) and Port Priority (13.27.47) parameters for the specified MSTI and Port are updated using the supplied values. The reselect parameter value for the MSTI for the Port (13.27.62) is set TRUE, and the selected parameter for the MSTI for the Port (13.27.67) is set FALSE.

12.8.2.5 Force BPDU Migration Check

This operation is available only in Bridges that support RSTP or MSTP, as specified in Clause 13.

12.8.2.5.1 Purpose

To force the specified Port to transmit Rapid Spanning Tree (RST) or MST BPDUs (see 13.32).

12.8.2.5.2 Inputs

a) Port Number—the number of the Bridge Port.

12.8.2.5.3 Outputs

None.

12.8.2.5.4 Procedure

The mcheck variable (13.27.38) for the specified Port is set to the value TRUE if the value of the forceVersion variable (13.7.2) is greater than or equal to 2.

12.9 MRP Entities

The operation of MRP is described in Clause 10.

This managed resource comprises the following objects:

a) The MRP Timer objects (12.9.1)
b) The MRP Attribute Type objects (12.9.2)
c) The Periodic State Machine objects (12.9.3)

12.9.1 The MRP Timer object

The MRP Timer object models the operations that can be performed on, or inquire about, the current settings of the timers used by MRP on a given Port. The management operations that can be performed on the MRP Participant are as follows:

a) Read MRP Timers (12.9.1.1)
b) Set MRP Timers (12.9.1.2)

NOTE—The MRP timer values modeled by this object are the values used to initialize timer instances that are used within the MRP state machines, not the timer instances themselves. Hence, there is a single MRP Timer object per Port, regardless of whether the Bridge supports single or multiple spanning trees.

12.9.1.1 Read MRP Timers

12.9.1.1.1 Purpose

To read the current MRP Timers for a given Port.

12.9.1.1.2 Inputs

a) The Port identifier.

12.9.1.1.3 Outputs

a) Current value of JoinTime—Centiseconds, *Persistent*. (10.7.4.1 and 10.7.11).
b) Current value of LeaveTime—Centiseconds, *Persistent*. (10.7.4.2 and 10.7.11).
c) Current value of LeaveAllTime—Centiseconds, *Persistent*. (10.7.4.3 and 10.7.11).

12.9.1.2 Set MRP Timers

12.9.1.2.1 Purpose

To set new values for the MRP Timers for a given Port.

12.9.1.2.2 Inputs

a) The Port identifier.
b) New value of JoinTime—Centiseconds (10.7.4.1 and 10.7.11).
c) New value of LeaveTime—Centiseconds (10.7.4.2 and 10.7.11).
d) New value of LeaveAllTime—Centiseconds (10.7.4.3 and 10.7.11).

12.9.1.2.3 Outputs

None.

12.9.2 The MRP Attribute Type object

The MRP Attribute Type object models the operations that can be performed on, or inquire about, the operation of MRP for a given Attribute Type (10.8.2.2). The management operations that can be performed on an MRP Attribute Type are as follows:

a) Read MRP Applicant Controls (12.9.2.1)
b) Set MRP Applicant Controls (12.9.2.2)

12.9.2.1 Read MRP Applicant Controls

12.9.2.1.1 Purpose

To read the current values of the MRP Applicant Administrative control parameters (10.7.3) and Transmit Zero parameters (11.2.3.1.7) associated with all MRP Participants for a given Port, MRP Application, and Attribute Type.

12.9.2.1.2 Inputs

a) The Port identifier.
b) The MRP Application.
c) The Attribute Type (10.8.2.2).

12.9.2.1.3 Outputs

a) The current Applicant Administrative Control Value, *Persistent*. (10.7.3);
b) Failed Registrations—count of the number of times that this MRP Application has failed to register an attribute of this type due to lack of space in the FDB, *Persistent*. (12.10.1.6).
c) Transmit zero enable—whether the transmission of 0 as an Attribute value is currently enabled (MVRP only). (11.2.3.1.7).

12.9.2.2 Set MRP Applicant Controls

12.9.2.2.1 Purpose

To set new values for the MRP Applicant Administrative control parameters (10.7.3) and Transmit Zero parameters (11.2.3.1.7) associated with all MRP Participants for a given Port, MRP Application, and Attribute Type.

12.9.2.2.2 Inputs

a) The Port identifier
b) The MRP Application
c) The Attribute Type (10.8.2.2) associated with the state machine
d) The desired Applicant Administrative Control Value (10.7.3)
e) The desired Transmit zero enable value (MVRP only) (11.2.3.1.7)

12.9.2.2.3 Outputs

None.

12.9.2.2.4 Procedures

A Bridge shall not allow both MIRP and MVRP to be enabled on the same VIP.

12.9.3 Periodic state machine objects

The Periodic state machine object models the operations that can be performed upon, or inquire about, the operation of the Periodic state machine for a given Port.

The management operations that can be performed on a Periodic state machine are Read Periodic state machine state and Set Periodic state machine state.

12.9.3.1 Read Periodic state machine state

12.9.3.1.1 Purpose

To inquire whether a particular Periodic state machine is enabled or disabled.

12.9.3.1.2 Inputs

a) The Port identifier.

12.9.3.1.3 Outputs

a) The Port identifier.
b) The state of the Periodic state machine. This can take either of the values “enabled” or “disabled.”

12.9.3.2 Set Periodic state machine state

12.9.3.2.1 Purpose

To enable or disable a particular Periodic state machine.

12.9.3.2.2 Inputs

a) The Port identifier.
b) The desired state of the Periodic state machine. This can take either of the values “enabled” or “disabled.”

12.9.3.2.3 Outputs

None.

12.10 Bridge VLAN managed objects

The following managed objects define the semantics of the management operations that can be performed on the VLAN aspects of a Bridge:

a) The Bridge VLAN Configuration managed object (12.10.1)
b) The VLAN Configuration managed object (12.10.2)
c) The VID to FID allocation managed object (12.10.3)

12.10.1 Bridge VLAN Configuration managed object

The Bridge VLAN Configuration managed object models operations that modify, or inquire about, the overall configuration of the Bridge's VLAN resources. There is a single Bridge VLAN Configuration managed object per Bridge Component.

The management operations that can be performed on the Bridge VLAN Configuration managed object are as follows:

a) Read Bridge VLAN Configuration (12.10.1.1)
b) Configure PVID and VID Set values (12.10.1.2)
c) Configure Acceptable Frame Types parameters (12.10.1.3)
d) Configure Enable Ingress Filtering parameters (12.10.1.4)
e) Reset Bridge (12.10.1.5)
f) Configure Restricted_VLAN_Registration parameters (12.10.1.6)
g) Configure Protocol Group Database (12.10.1.7)
h) Configure VID to FID allocation (12.10.3)
i) Configure VID Translation Table (12.10.1.8)
j) Configure Egress VID Translation Table (12.10.1.9)

12.10.1.1 Read Bridge VLAN Configuration

12.10.1.1.1 Purpose

To obtain general VLAN information from a Bridge.

12.10.1.1.2 Inputs

None.

12.10.1.1.3 Outputs

a) The IEEE 802.1Q VLAN Version number. Reported as "1" by Bridges that support only SST operation, and reported as "2" by Bridges that support MST operation.

   NOTE—No IEEE 802.1Q VLAN version numbers other than 1 and 2 are specified.

b) The optional VLAN features supported by the implementation:
   1) The maximum number of VIDs supported.
   2) Whether the implementation supports the ability to override the default PVID setting, and its egress status (VLAN-tagged or untagged) on each Port.
   3) For a Bridge that supports Port-and-Protocol-based VLAN classification, which of the Protocol Template formats (6.12.1) are supported by the implementation.
   4) For MST Bridges, the maximum number of MSTIs supported within an MST Region (i.e., the number of spanning tree instances that can be supported in addition to the CIST). For SST Bridges, this parameter may be either omitted or reported as "0."
c) For each Port:
   1) The Port number.
   2) The PVID value (6.9) currently assigned to that Port.
   3) For a Bridge that supports Port-and-Protocol-based VLAN classification, whether the implementation supports Port-and-Protocol-based VLAN classification on that Port.
   4) For a Bridge that supports Port-and-Protocol-based VLAN classification on that Port, the maximum number of entries supported in the VID Set on that Port; the VID value and Protocol Group Identifier currently assigned to each entry in the VID Set (8.6.2) on that Port.

5) The state of the Acceptable Frame Types parameter (6.9). The permissible values for this parameter are as follows:
   i) *Admit Only VLAN-tagged frames*
   ii) *Admit Only Untagged and Priority Tagged frames*
   iii) *Admit All frames*
6) The state of the Enable Ingress Filtering parameter (6.9); Enabled or Disabled;
7) The state of the Restricted_VLAN_Registration parameter (11.2.3.2.3), TRUE or FALSE.
8) Whether the Bridge supports a VID Translation Table on that Port; whether the Bridge supports an Egress VID Translation Table on that Port;
9) For a Bridge that supports a VID Translation Table on that Port, a set of (Local VID, Relay VID) bindings (6.9);
10) For a Bridge that supports an Egress VID Translation Table on that Port, a set of (Relay VID, Local VID) bindings (6.9).

d) For a Bridge that supports Port-and-Protocol-based VLAN classification: the contents of the Protocol Group Database comprising a set of {Protocol Template, Protocol Group Identifier} bindings (6.12.1, 6.12.2, and 6.12.3); the maximum number of entries supported in the Protocol Group Database.

12.10.1.2 Configure PVID and VID Set values

12.10.1.2.1 Purpose

To configure the PVID and VID Set value(s) (6.9) associated with one or more Ports.

12.10.1.2.2 Inputs

a) For each Port to be configured, a Port number and the PVID value to be associated with that Port.
b) In addition, for a Bridge that supports Port-and-Protocol-based VLAN classification: for each Port to be configured, a Port number, a Protocol Group Identifier, and a VID value for the member of the Port's VID Set that is to be configured.

12.10.1.2.3 Outputs

a) Operation status for each Port to be configured. This takes one of the following values:
   1) Operation rejected due to there being no spare VID Set entries on this Port
   2) Operation rejected due to the PVID or VID being out of the supported range for this Port
   3) Operation accepted

12.10.1.3 Configure Acceptable Frame Types parameters

12.10.1.3.1 Purpose

To configure the Acceptable Frame Types parameter (6.9) associated with one or more Ports.

12.10.1.3.2 Inputs

a) For each Port to be configured, a Port number and the value of the Acceptable Frame Types parameter to be associated with that Port. The permissible values of this parameter are (as defined in 6.9) as follows:
   1) *Admit Only VLAN-tagged frames*
   2) *Admit Only Untagged and Priority Tagged frames*
   3) *Admit All frames*

12.10.1.3.3 Outputs

None.

12.10.1.4 Configure Enable Ingress Filtering parameters

12.10.1.4.1 Purpose

To configure the Enable Ingress Filtering parameter(s) (8.6.2) associated with one or more Ports.

12.10.1.4.2 Inputs

a) For each Port to be configured, a Port number and the value of the Enable Ingress Filtering parameter to be associated with that Port. The permissible values for the parameter are as follows:
   1) Enabled
   2) Disabled

12.10.1.4.3 Outputs

None.

12.10.1.5 Reset Bridge

12.10.1.5.1 Purpose

To reset all statically configured VLAN-related information in the Bridge to its default state. This operation:

a) Deletes all VLAN Configuration managed objects.
b) Resets the PVID associated with each Bridge Port to the Default PVID value (Table 9-2).
c) Removes all entries in the Protocol Group Database and removes all members of the VID Set on each port, for a Bridge that supports Port-and-Protocol-based VLAN classification.
d) Resets the Acceptable Frame Types parameter value associated with each Port to the default value (6.9).

12.10.1.5.2 Inputs

None.

12.10.1.5.3 Outputs

None.

12.10.1.6 Configure Restricted_VLAN_Registration parameters

12.10.1.6.1 Purpose

To configure the Restricted_VLAN_Registration parameter (11.2.3.2.3) associated with one or more Ports.

12.10.1.6.2 Inputs

a) For each Port to be configured, a Port number and the value of the Restricted_VLAN_Registration parameter. The permissible values of this parameter are (as defined in 11.2.3.2.3) as follows:
   1) TRUE
   2) FALSE

12.10.1.6.3 Outputs

None.

12.10.1.7 Configure Protocol Group Database

To configure a Protocol Group Database (6.12.3) entry. This operation is not applicable to a Bridge that does not support Port-and-Protocol-based VLAN classification.

NOTE—Implementation of the Configure Protocol Group Database operation is not mandatory; conformant implementations may implement a fixed set of Protocol Group Database entries.

12.10.1.7.1 Inputs

a) A value representing the frame format to be matched: Ethernet, RFC_1042, SNAP_8021H, SNAP_Other, or LLC_Other (6.12.1).
b) One of:
    1) An IEEE 802.3 EtherType value, for matching frame formats of Ethernet, RFC_1042, or SNAP_8021H.
    2) A 40-bit Protocol Identifier (PID), for matching frame formats of SNAP_Other.
    3) A pair of ISO/IEC 8802-2 DSAP and SSAP address field values, for matching frame formats of LLC_Other.
c) A Protocol Group Identifier (6.12.2).

NOTE—While the intent is to identify VID traffic, an ID of 0 may be used to indicate untagged traffic that needs prioritization.

12.10.1.7.2 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to there being no spare Protocol Group Database entries.
    2) Operation rejected due to an unsupported frame format.
    3) Operation rejected due to an unsupported value for an IEEE 802.3 EtherType value, PID, DSAP, or SSAP.
    4) Operation accepted.

12.10.1.8 VID Translation Configuration managed object

To configure the VID Translation Table (6.9) associated with a Port. This object is not applicable to Ports that do not support a VID Translation Table. The default configuration of the table has the value of the Relay VID equal to the value of the Local VID for all Local VID values. If the port supports an Egress VID translation table, the VID Translation Configuration object configures the Local VID to Relay VID mapping on ingress only. If an Egress VID translation is not supported, the VID Translation Configuration object defines a single bidirectional mapping.

The management operations that can be performed are as follows:

a) Read VID Translation Table Entry (12.10.1.8.1)
b) Configure VID Translation Table Entry (12.10.1.8.2)

12.10.1.8.1 Read VID Translation Table Entry

12.10.1.8.1.1 Purpose

To read the relay VID associated with the local VID.

12.10.1.8.1.2 Inputs

a) Port Number: the number of the port that is capable of performing VID translation.
b) Local VLAN Identifier: a 12-bit VID.

12.10.1.8.1.3 Outputs

a) Relay VLAN Identifier: a 12-bit VID.

12.10.1.8.2 Configure VID Translation Table Entry

12.10.1.8.2.1 Purpose

To modify an entry in the VID Translation Table.

12.10.1.8.2.2 Inputs

a) Port Number: the number of the port that is capable of performing VID translation. This port should be at the edge of an administrative or a control protocol domain (6.9).
b) Local VLAN Identifier: a 12-bit VID.
c) Relay VLAN Identifier: a 12-bit VID.

12.10.1.8.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the port does not have Egress VID translation capabilities
    2) Operation accepted

12.10.1.9 Egress VID Translation Configuration managed object

To configure the Egress VID Translation Table (6.9) associated with a Port. This object is not applicable to Ports that do not support an Egress VID Translation Table. The default configuration of the table has the value of the Local VID equal to the value of the Relay VID for all Relay VID values.

The management operations that can be performed are as follows:

a) Read Egress VID Translation Table Entry (12.10.1.9.1)
b) Configure Egress VID Translation Table Entry (12.10.1.9.2)

12.10.1.9.1 Read Egress VID Translation Table Entry

12.10.1.9.1.1 Purpose

To read the local VID associated with the relay VID.

12.10.1.9.1.2 Inputs

a) Port Number: the number of the port that is capable of performing Egress VID translation.
b) Relay VLAN Identifier: a 12-bit VID.

12.10.1.9.1.3 Outputs

a) Local VLAN Identifier: a 12-bit VID.

12.10.1.9.2 Configure Egress VID Translation Table Entry

12.10.1.9.2.1 Purpose

To modify an entry in the Egress VID Translation Table.

12.10.1.9.2.2 Inputs

a) Port Number: the number of the port that is capable of performing Egress VID translation. This port should be at the edge of an administrative or a control protocol domain (6.9).
b) Relay VLAN Identifier: a 12-bit VID.
c) Local VLAN Identifier: a 12-bit VID.

12.10.1.9.2.3 Outputs

a) Operation rejected because the port does not have Egress VID translation capabilities.
b) Operation accepted.

12.10.2 VLAN Configuration managed object

The VLAN Configuration object models operations that modify, or inquire about, the configuration of a particular VID within a Bridge. There are multiple VLAN Configuration objects per Bridge; only one such object can exist for a given VID.

The management operations that can be performed on the VLAN Configuration are as follows:

a) Read VLAN Configuration (12.10.2.1)
b) Create VLAN Configuration (12.10.2.2)
c) Delete VLAN Configuration (12.10.2.3)

12.10.2.1 Read VLAN Configuration

12.10.2.1.1 Purpose

To obtain general information regarding a specific VLAN Configuration.

12.10.2.1.2 Inputs

a) VLAN Identifier: a 12-bit VID.

12.10.2.1.3 Outputs

a) VLAN Name: A text string of up to 32 characters of locally determined significance.
b) List of Untagged Ports: The set of Port numbers in the untagged set (8.8.2) for this VID.
c) List of Egress Ports: The set of Port numbers in the member set (8.8.10) for this VID.

NOTE—The values of the member set and the untagged set are determined by the values held in VLAN Registration Entries in the FDB (8.8.2, 8.8.5, and 8.8.10).

12.10.2.2 Create VLAN Configuration

12.10.2.2.1 Purpose

To create or update a VLAN Configuration managed object.

12.10.2.2.2 Inputs

a) VLAN Identifier: a 12-bit VID.
b) VLAN Name: a text string of up to 32 characters of locally determined significance.

NOTE—Static configuration of the member set and the Untagged set is achieved by means of the management operations for manipulation of VLAN Registration Entries (12.7.5).

12.10.2.2.3 Outputs

None.

12.10.2.3 Delete VLAN Configuration

12.10.2.3.1 Purpose

To delete a VLAN Configuration managed object.

12.10.2.3.2 Inputs

a) VLAN Identifier: a 12-bit VID.

12.10.2.3.3 Outputs

None.

12.10.3 The VID to FID allocation managed object

The VID to FID allocations managed object models operations that modify, or inquire about VID to FID allocations (8.8.8) that apply to the operation of the Learning Process and the FDB. The object is modeled as a fixed-length table, as follows:

a) A VID to FID allocation table (8.8.8) with an entry per VID supported by the implementation. Each table entry indicates, for that VID, that there is currently:
   1) No allocation defined or
   2) A fixed allocation to FID X or
   3) A dynamic allocation to FID X.

The management operations that can be performed on the VID to FID allocations managed object are as follows:

b) Read VID to FID allocations (12.10.3.1)
c) Read FID allocation for VID (12.10.3.2)
d) Read VIDs allocated to FID (12.10.3.3)
e) Set VID to FID allocation (12.10.3.4)
f) Delete VID to FID allocation (12.10.3.5)

12.10.3.1 Read VID to FID allocations

12.10.3.1.1 Purpose

To read the contents of a range of one or more entries in the VID to FID allocation table.

12.10.3.1.2 Inputs

a) First Entry—VID of first entry to be read.
b) Last Entry—VID of last entry to be read.

12.10.3.1.3 Outputs

a) List of Entries—For each entry that was read:
   1) VID—the VLAN Identifier for this entry.
   2) Allocation Type—the type of the allocation: Undefined, Fixed, or Dynamic.
   3) FID—the FID to which the VID is allocated (if not of type Undefined).

NOTE 1—Where this operation is implemented using a remote management protocol, PDU size constraints may restrict the number of entries that are actually read to fewer than was requested in the input parameters. In such cases, retrieving the remainder of the desired entry range can be achieved by repeating the operation with a modified entry range specification.

NOTE 2—The Allocation Type of Dynamic is applicable only for SPT Bridges and VIDs that have been reserved for use as SPVIDs.

12.10.3.2 Read FID allocation for VID

12.10.3.2.1 Purpose

To read the FID to which a specified VID is currently allocated.

12.10.3.2.2 Inputs

a) VID—the VLAN Identifier to which the read operation applies.

12.10.3.2.3 Outputs

a) VID—the VLAN Identifier to which the read operation applies.
b) Allocation Type—the type of the allocation: Undefined, Fixed, or Dynamic.
c) FID—the FID to which the VID is allocated (if not of type Undefined).

NOTE—The Allocation Type of Dynamic is applicable only for SPT Bridges and VIDs that have been reserved for use as SPVIDs.

12.10.3.3 Read VIDs allocated to FID

12.10.3.3.1 Purpose

To read all VIDs currently allocated to a given FID.

12.10.3.3.2 Inputs

a) FID—the Filtering Identifier to which the read operation applies.

12.10.3.3.3 Outputs

a) FID—the Filtering Identifier to which the read operation applies.
b) Allocation List—a list of allocations for this FID. For each element in the list:
    1) Allocation Type—the type of the allocation: Fixed or Dynamic.
    2) VID—the VID that is allocated.

NOTE—The Allocation Type of Dynamic is applicable only for SPT Bridges and VIDs that have been reserved for use as SPVIDs.

12.10.3.4 Set VID to FID allocation

12.10.3.4.1 Purpose

To establish a fixed allocation of a VID to an FID.

12.10.3.4.2 Inputs

a) VID—the VID of the entry to be set.
b) FID—the FID to which the VID is to be allocated.

12.10.3.4.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to VID exceeding the maximum VID supported by the allocation table
    2) Operation rejected due to FID exceeding the maximum ID supported by the implementation
    3) Operation accepted

12.10.3.4.4 Procedure

In MST Bridges, the Configuration Digest element of the MCID is recalculated, in accordance with the definition in 13.8, following any change in the allocation of VIDs to FIDs that results in a change in the allocation of VIDs to spanning trees.

12.10.3.5 Delete VID to FID allocation

12.10.3.5.1 Purpose

To remove a fixed VID to FID allocation from the VID to FID allocation table. This operation has the effect of setting the value of the specified table entry to "Undefined."

NOTE—If the VID concerned represents a currently active VID, then removal of a fixed allocation may result in the "Undefined" value in the table immediately being replaced by a dynamic allocation to an FID.

12.10.3.5.2 Inputs

a) VID—VID of the allocation to be deleted.

12.10.3.5.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to VID exceeding the maximum value supported by the allocation table
   2) Operation accepted

12.10.3.5.4 Procedure

In MST Bridges, the Configuration Digest element of the MCID is recalculated, in accordance with the definition in 13.8, and the MSTP state machine variables are reinitialized by asserting BEGIN, following any change in the allocation of VIDs to FIDs that results in a change in the allocation of VIDs to spanning trees.

12.11 MMRP entities

The following managed object defines the semantics of the management operations that can be performed on the operation of MMRP in a Bridge:

a) The MMRP Configuration managed object (12.11.1)

12.11.1 MMRP Configuration managed object

The MMRP Configuration managed object models operations that modify, or inquire about, the overall configuration of the operation of MMRP. There is a single MMRP Configuration managed object per Bridge.

The management operations that can be performed on the MMRP Configuration managed object are as follows:

a) Read MMRP Configuration (12.11.1.1)
b) Notify MAC address registration failure (12.11.1.2)
c) Configure Restricted_MAC_Address_Registration parameters (12.11.1.3)

12.11.1.1 Read MMRP Configuration

12.11.1.1.1 Purpose

To obtain general MMRP configuration information from a Bridge.

12.11.1.1.2 Inputs

None.

12.11.1.1.3 Outputs

a) For each Port:
   1) The Port number.
   2) The state of the Restricted_MAC_Address_Registration parameter, *Persistent*. (10.12.2.3), TRUE or FALSE.

12.11.1.2 Notify MAC address registration failure

12.11.1.2.1 Purpose

To notify a manager that MMRP has failed to register a given MAC address owing to lack of resources in the FDB for the creation of a MAC Address Registration Entry (8.8.4) or to the Restricted_MAC_Address_Registration parameter.

12.11.1.2.2 Inputs

None.

12.11.1.2.3 Outputs

a) The MAC address that MMRP failed to register
b) The Port number of the Port on which the registration request was received
c) The reason for the failure:
   1) Lack of Resources or
   2) Registration Restricted

12.11.1.3 Configure Restricted_MAC_Address_Registration parameters

12.11.1.3.1 Purpose

To configure the Restricted_MAC_Address_Registration parameter (10.12.2.3) associated with one or more Ports.

12.11.1.3.2 Inputs

a) For each Port to be configured, a Port number and the value of the Restricted_MAC_Address_Registration parameter. The permissible values of this parameter are as follows (as defined in 10.12.2.3):
   1) TRUE
   2) FALSE

12.11.1.3.3 Outputs

None.

12.12 MST configuration entities

The following managed objects define the semantics of the management operations that can be performed on the MST configuration in a Bridge:

a) The MSTI List object (12.12.1)
b) The FID to MSTID Allocation Table object (12.12.2)
c) The MST Configuration Table object (12.12.3)

12.12.1 The MSTI List

For MST Bridges, the MSTI List object models the operations that modify, or inquire about, the list of MST spanning tree instances supported by the Bridge. The object is modeled as a list of MSTIDs corresponding to the MSTIs supported by the Bridge.

The MSTID List object supports the following operations:

a) Read MSTI List (12.12.1.1)
b) Create MSTI (12.12.1.2)
c) Delete MSTI (12.12.1.3)

12.12.1.1 Read MSTI List

12.12.1.1.1 Purpose

To read the list of MSTIDs that are currently supported by the Bridge.

12.12.1.1.2 Inputs

None.

12.12.1.1.3 Outputs

a) MSTID list. The list of MSTID values that are currently supported by the Bridge.

12.12.1.2 Create MSTI

12.12.1.2.1 Purpose

To create a new MSTI and its associated state machines and parameters, and to add its MSTID to the MSTI List.

12.12.1.2.2 Inputs

a) The MSTID of the MSTI to be created.

12.12.1.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to the number of MSTIs currently supported by the Bridge being equal to the maximum number of MSTIs that the Bridge is able to support.
    2) Operation rejected as the MSTID value supplied in the input parameters is already present in the MSTI List.
    3) Operation rejected as the MSTID value supplied in the input parameters is one of the reserved MSTID values (8.9.3).
    4) Operation accepted.

12.12.1.3 Delete MSTI

12.12.1.3.1 Purpose

To delete an existing MSTI and its associated state machines and parameters, and to remove its MSTID from the MSTI List.

12.12.1.3.2 Inputs

a) The MSTID of the MSTI to be deleted.

12.12.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected as the MSTID value supplied in the input parameters is not present in the MSTI List.
   2) Operation rejected as the MSTID value supplied in the input parameter currently has one or more FIDs allocated to it in the FID to MSTID Allocation Table.
   3) Operation accepted.

12.12.2 The FID to MSTID Allocation Table

For MST Bridges, the FID to MSTID Allocation Table object models the operations that modify, or inquire about, the assignment of FIDs to spanning tree instances currently supported by the Bridge (8.9.3). The object is modeled as a fixed-length table in which each entry in the table corresponds to a FID, and the value of the entry specifies the MSTID of the spanning tree to which the set of VIDs supported by that FID are assigned. A value of zero in an entry specifies that the set of VIDs supported by that FID are assigned to the CST.

The MSTID Allocation Table object supports the following operations:

a) Read FID to MSTID allocations (12.12.2.1).
b) Set FID to MSTID allocation (12.12.2.2).

12.12.2.1 Read FID to MSTID allocations

12.12.2.1.1 Purpose

To read a range of one or more entries in the FID to MSTID Allocation Table.

12.12.2.1.2 Inputs

a) First FID—the FID of the first entry to be read.
b) Last FID—the FID of the last entry to be read.

If the value of Last FID is numerically equal to, or smaller than, the value of First FID, then a single table entry is read, corresponding to the value of First FID.

12.12.2.1.3 Outputs

a) List of entries—for each entry that was read:
   1) The FID of the entry
   2) The MSTID to which that FID is allocated

12.12.2.2 Set FID to MSTID allocation

12.12.2.2.1 Purpose

To change the contents of an entry in the FID to MSTID Allocation Table.

12.12.2.2.2 Inputs

a) FID—the FID of the entry to be changed.
b) MSTID—the MSTID to which the FID is to be allocated.

12.12.2.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected as the MSTID value supplied in the input parameters is not present in the MSTI List.
    2) Operation rejected as the FID value supplied in the input parameters is invalid or is not supported.
    3) Operation accepted.

12.12.2.2.4 Procedure

The Configuration Digest element of the MCID is recalculated, in accordance with the definition in 13.8, following any change in the allocations of FIDs to MSTIDs.

12.12.3 The MST Configuration Table

The MST Configuration Table managed object models the operations that can be performed on the MST Configuration Table for the Bridge (3.164, 8.9.1, and 13.8). Associated with the table is the MCID for the Bridge (8.9.2, 13.8).

The MST Configuration Table is a read-only table, its elements derived from other configuration information held by the Bridge; specifically, the current state of the VID to FID allocation table (8.8.8, 12.10.3), and the FID to MSTID allocation table (8.9.3, 12.12.2). Hence, changes made to either of these tables can in turn affect the contents of the MST Configuration Table, and also affect the value of the "digest" element of the MCID. The MST Configuration Table is modeled as a fixed table of 4096 elements, as described in 13.8.

The MST Configuration Table managed object supports the following operations:

a) Read MST Configuration Table Element (12.12.3.1).
b) Read VIDs assigned to MSTID (12.12.3.2).
c) Read MST Configuration Identifier (12.12.3.3).
d) Set MST Configuration Identifier Elements (12.12.3.4).

12.12.3.1 Read MST Configuration Table Element

12.12.3.1.1 Purpose

To read a single element of the current MST Configuration Table for the Bridge (13.8).

12.12.3.1.2 Inputs

a) A VID value, in the range 0 through 4094.

12.12.3.1.3 Outputs

a) A VID value, in the range 0 through 4094.
b) The MSTID value corresponding to that VID.

12.12.3.2 Read VIDs assigned to MSTID

12.12.3.2.1 Purpose

To read the list of VIDs that are currently assigned to a given MSTID in the MST Configuration Table for the Bridge (13.8).

12.12.3.2.2 Inputs

a) An MSTID value, in the range 0 through 4095.

12.12.3.2.3 Outputs

a) A MSTID value, in the range 0 through 4095.
b) A 4096-bit vector in which bit N is set TRUE if VID N is assigned to the given MSTID and is otherwise set FALSE.

12.12.3.3 Read MST Configuration Identifier

12.12.3.3.1 Purpose

To read the current value of the MCID for the Bridge (13.8).

12.12.3.3.2 Inputs

None.

12.12.3.3.3 Outputs

a) The MCID (13.8), consisting of:
    1) The Configuration Identifier Format Selector in use by the Bridge. This has a value of 0 to indicate the format specified in this standard.
    2) The Configuration Name.
    3) The Revision Level.
    4) The Configuration Digest.

12.12.3.4 Set MST Configuration Identifier Elements

12.12.3.4.1 Purpose

To change the current values of the modifiable elements of the MCID for the Bridge (13.8).

NOTE—The Configuration Digest element of the MCID is read-only; its value is recalculated whenever configuration changes occur that result in a change in the allocation of VIDs to MSTIs.

12.12.3.4.2 Inputs

a) The MCID (13.8) Format Selector in use by the Bridge. This has a value of 0 to indicate the format specified in this standard.
b) The Configuration Name.
c) The Revision Level.

12.12.3.4.3 Outputs

a) Operation Status. This can take the following values:
   1) Operation rejected due to unsupported Configuration Identifier Format Selector value
   2) Operation accepted

12.13 Provider Bridge management

The conformance requirements of Provider Bridges are specified in 5.10. The S-VLAN component and the externally accessible ports of all Provider Bridges, including Provider Edge Bridges, are managed using the managed objects defined in 12.4 through 12.12. This subclause defines additional managed objects specific to the operation of Provider Bridges.

The internal ports, LANs, C-VLAN components, and Port-mapping S-VLAN components of a Provider Edge Bridge are not managed directly using the managed objects defined in 12.4 through 12.12. Their operation is controlled and monitored through managed objects defined in this subclause.

Each externally accessible Bridge Port on a Provider Bridge is designated as a PNP, CNP, CEP, or RCAP. Designating a port as a CEP implies Provider Edge Bridge functionality and, specifically, the existence of a C-VLAN component associated with that port. This C-VLAN component is uniquely identified within the Bridge by the port number of the associated CEP. The management of the forwarding process, filtering data base, and C-VLANs of the C-VLAN component and the internal connections are achieved through the Customer Edge Port Configuration managed object defined here (12.13.2).

Designating a port as a RCAP implies the existence of a Port-mapping S-VLAN component associated with that port. The Port-mapping S-VLAN component is uniquely identified within the Bridge by the port number of the associated RCAP. Designating an internal port on the Port-mapping S-VLAN component as a C-tagged RCSI implies a C-VLAN component with a CEP connected via an internal LAN to that internal port (PAP). This C-VLAN component and internal connection are uniquely identified by the port number of the RCAP and the S-VID associated with the PAP or by the port number of the internal CEP. Designating an internal port on the Port-mapping S-VLAN component as a Port-based RCSI or a PNP implies an internal LAN connecting this port with a CNP or PNP, respectively. These ports and internal connections are uniquely identified by the port number of the RCAP and the S-VID associated with the PAP or by the port number of the CNP or PNP. The management of the forwarding process, filtering data base, and S-VLANs of Port-mapping S-VLAN components and their internal connections are achieved through the Remote Customer Access Port Configuration managed object defined here (12.13.3).

An internal connection between a CNP on the S-VLAN component and a PEP on the C-VLAN component is instantiated for each service instance. The CNP is identified by the CEP identifier and the S-VID value used for the PVID of the CNP. The PEP is identified by the CEP identifier and the C-VLAN Identifier (C-VID) value used for the PVID of the PEP. These PVID values and the connection between the CNP and PEP are established by reciprocal entries in the C-VID Registration Table (12.13.2.2) and the PEP Configuration Table (12.13.2.4) as follows:

a) An entry in the C-VID Registration Table is created for each C-VLAN supported in the C-VLAN component associated with a CEP. The CEP identifier and C-VID combination identify a PEP. The entry contains (among other parameters) an S-VID value corresponding to the PVID of the CNP, which associates the PEP with a specific CNP. Note that the CEP/C-VID combination identifies a single PEP; however, multiple CEP/C-VID combinations can identify the same PEP if the entries for those CEP/C-VID combinations contain the same S-VID value. This many-to-one mapping of CEP/C-VID to PEP permits “bundling”, i.e., mapping multiple C-VLANs to the same service instance.
b) An entry in the PEP Configuration Table is created for each S-VID corresponding to a service instance accessed by the C-VLAN component. The CEP identifier and S-VID combination identify

a CNP. The entry contains (among other parameters) a C-VID value corresponding to the PVID of the PEP, which associates the CNP with a specific PEP. Note that the CEP/S-VID combination identifies a single CNP; however, multiple CEP/S-VID combinations can identify the same CNP if the entries for those CEP/S-VID combinations contain the same C-VID value. This many-to-one mapping of CEP/S-VID to CNP permits configuration of asymmetric VLANs and can be used to establish rooted-multipoint connectivity (F.1.3.2).

Management control of the member sets and untagged sets for C-VIDs in the C-VLAN component is provided in C-VID Registration Table entries rather than through Static VLAN Registration Entries (thus eliminating the need for Filtering Database managed objects for the C-VLAN component). Management control of the member sets and untagged sets for S-VIDs in the S-VLAN component is provided through Static VLAN Registration Entries in the FDB. Creating an entry for an S-VID in the PEP Configuration Table does not automatically modify the Static VLAN Registration Entries for the corresponding S-VLAN. A CNP is added to the member set and untagged set of an S-VLAN by including the CEP identifier (since the CEP identifier and S-VID combination identifies the CNP) in the Port Map of a Static VLAN Registration Entry for that S-VLAN (12.7.7.1, 8.8.2).

A C-VLAN component with more than one PEP (i.e., supporting more than one service instance) participates in the customer network spanning tree protocol by running an instance of RSTP with the enhancements specified in 13.41. This protocol instance is managed using the managed objects defined in 12.8 and 12.12. All BPDUs generated by this protocol instance use the MAC address of the CEP as a source address and as the Bridge address portion of Bridge Identifier. For each PEP, the protocol uses the S-VID value that is the PVID of the associated CNP as the port number. For the CEP, the protocol uses the value 0xFFF as the port number.

The following managed objects define the semantics of the management operations specific to Provider Bridges:

c) The Provider Bridge Port Type managed object (12.13.1)
d) The Customer Edge Port Configuration managed object (12.13.2)
e) The Remote Customer Access Port Configuration managed object (12.13.3)

12.13.1 Provider Bridge Port Type managed object

The management operations that can be performed on the Provider Bridge Port Type managed object are as follows:

a) Read Provider Bridge Port Type (12.13.1.1)
b) Configure Provider Bridge Port Type (12.13.1.2)

12.13.1.1 Read Provider Bridge Port Type

12.13.1.1.1 Purpose

To obtain information regarding the designated type of an externally accessible port on a Provider Bridge.

12.13.1.1.2 Inputs

a) Port Number: the number of the Bridge Port.

12.13.1.1.3 Outputs

a) Port Type. This takes one of the following values:
   1) PNP
   2) CNP
   3) CEP
   4) RCAP

12.13.1.2 Configure Provider Bridge Port Type

12.13.1.2.1 Purpose

To designate the type of an externally accessible port on a Provider Bridge.

12.13.1.2.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Port Type. This takes one of the following values:
    1) PNP
    2) CNP
    3) CEP
    4) RCAP

12.13.1.2.3 Outputs

None.

12.13.2 Customer Edge Port Configuration managed object

The Customer Edge Port Configuration managed object applies to each externally accessible CEP on a Provider Edge Bridge. It includes:

a) The C-VID Registration Table, which provides a mapping between a C-VID and the service instance represented by an S-VID selected for that C-VLAN. This table provides the equivalent functionality of :
    1) configuring the PVID of the internal CNP on the S-VLAN component;
    2) adding the corresponding PEP on the C-VLAN component to the member set of the C-VLAN;
    3) adding the PEP and/or CEP to the untagged set of the C-VLAN (if it is desired that frames forwarded to that port are transmitted untagged for this C-VLAN).
b) The PEP configuration parameters, which provide the subset of the Bridge VLAN Configuration managed object (12.10.1) that is relevant for the internal ports of the C-VLAN component associated with the CEP.
c) The Service Priority Regeneration Table, which provides the Priority Regeneration Table (12.6.2) for each internal CNP connected to the C-VLAN component associated with the CEP.

The management operations that can be performed are as follows:

d) Read C-VID Registration Table Entry (12.13.2.1)
e) Configure C-VID Registration Table Entry (12.13.2.2)
f) Read Provider Edge Port Configuration (12.13.2.3)
g) Set Provider Edge Port Configuration (12.13.2.4)
h) Read Service Priority Regeneration Table (12.13.2.5)
i) Set Service Priority Regeneration Table (12.13.2.6)

12.13.2.1 Read C-VID Registration Table Entry

12.13.2.1.1 Purpose

To read the VID of the service associated with a specific Customer VLAN in the C-VLAN component of a Provider Edge Bridge.

12.13.2.1.2 Inputs

a) Port Number: the number of the CEP.
b) Customer VLAN Identifier: a 12-bit C-VID.

12.13.2.1.3 Outputs

a) Service VLAN Identifier: a 12-bit S-VID.
b) Untagged PEP: a boolean indicating frames for this C-VLAN should be forwarded untagged through the Provider Edge Port.
c) Untagged CEP: a boolean indicating frames for this C-VLAN should be forwarded untagged through the Customer Edge Port.

12.13.2.2 Configure C-VID Registration Table Entry

12.13.2.2.1 Purpose

To modify an entry in the C-VID Registration Table.

12.13.2.2.2 Inputs

a) Port Number: the number of the CEP.
b) Customer VLAN Identifier: a 12-bit C-VID.
c) Service VLAN Identifier: a 12-bit S-VID.
d) Untagged PEP: a boolean indicating frames for this C-VLAN should be forwarded untagged through the Provider Edge Port.
e) Untagged CEP: a boolean indicating frames for this C-VLAN should be forwarded untagged through the Customer Edge Port.

12.13.2.2.3 Outputs

None.

12.13.2.3 Read Provider Edge Port Configuration

12.13.2.3.1 Purpose

To read the current configuration of an internal PEP in the C-VLAN component of a Provider Edge Bridge.

12.13.2.3.2 Inputs

a) Port Number: the number of the CEP.
b) Service VLAN Identifier: a 12-bit S-VID.

12.13.2.3.3 Outputs

a) PVID: a 12-bit C-VID to be used for untagged frames received at the PEP.
b) Default priority: an integer range 0–7 to be used for untagged frames received at the PEP.

c) Acceptable Frame Types: the Acceptable Frame Types (8.6.2) for frames received at the PEP. The permissible values for the parameter are as follows:
   1) *Admit only VLAN-tagged frames*
   2) *Admit only Untagged and Priority-tagged frames*
   3) *Admit all frames*
d) Enable Ingress Filtering: the Enable Ingress Filtering parameter for frames received at the PEP. The permissible values for the parameter are as follows:
   1) Enabled
   2) Disabled

12.13.2.4 Set Provider Edge Port Configuration

12.13.2.4.1 Purpose

To modify the configuration of a PEP in the C-VLAN component of a Provider Edge Bridge.

12.13.2.4.2 Inputs

a) Port Number: the number of the CEP.
b) Service VLAN Identifier: a 12-bit S-VID.
c) PVID: a 12-bit C-VID to be used for untagged frames received at the PEP.
d) Default priority: an integer range 0–7 to be used for untagged frames received at the PEP.
e) Acceptable Frame Types: the Acceptable Frame Types (8.6.2) for frames received at the PEP. The permissible values for the parameter are as follows:
   1) *Admit only VLAN-tagged frames*
   2) *Admit only Untagged and Priority-tagged frames*
   3) *Admit all frames*
f) Enable Ingress Filtering: the Enable Ingress Filtering parameter for frames received at the PEP. The permissible values for the parameter are as follows:
   1) Enabled
   2) Disabled

12.13.2.4.3 Outputs

None.

12.13.2.5 Read Service Priority Regeneration Table

12.13.2.5.1 Purpose

To read the current contents of the Priority Regeneration Table (6.9.3) for an internal CNP connected to the C-VLAN component associated with a CEP.

12.13.2.5.2 Inputs

a) Port Number: the number of the CEP.
b) Service VLAN Identifier: a 12-bit S-VID.

12.13.2.5.3 Outputs

a) Regenerated Priority value for Received Priority 0: Integer in range 0–7.
b) Regenerated Priority value for Received Priority 1: Integer in range 0–7.
c) Regenerated Priority value for Received Priority 2: Integer in range 0–7.
d) Regenerated Priority value for Received Priority 3: Integer in range 0–7.

e) Regenerated Priority value for Received Priority 4: Integer in range 0–7.
f) Regenerated Priority value for Received Priority 5: Integer in range 0–7.
g) Regenerated Priority value for Received Priority 6: Integer in range 0–7.
h) Regenerated Priority value for Received Priority 7: Integer in range 0–7.

12.13.2.6 Set Service Priority Regeneration Table

12.13.2.6.1 Purpose

To modify the contents of the Priority Regeneration Table (6.9.3) for an internal CNP connected to the C-VLAN component associated with a CEP.

12.13.2.6.2 Inputs

a) Port Number: the number of the CEP.
b) Service VLAN Identifier: a 12-bit S-VID.
c) Regenerated Priority value for Received Priority 0: Integer in range 0–7.
d) Regenerated Priority value for Received Priority 1: Integer in range 0–7.
e) Regenerated Priority value for Received Priority 2: Integer in range 0–7.
f) Regenerated Priority value for Received Priority 3: Integer in range 0–7.
g) Regenerated Priority value for Received Priority 4: Integer in range 0–7.
h) Regenerated Priority value for Received Priority 5: Integer in range 0–7.
i) Regenerated Priority value for Received Priority 6: Integer in range 0–7.
j) Regenerated Priority value for Received Priority 7: Integer in range 0–7.

12.13.2.6.3 Outputs

None.

12.13.3 Remote Customer Access managed object

Designating an external port as a RCAP automatically creates a Port-mapping S-VLAN component associated with that port. This Port-mapping S-VLAN component includes one internal PNP.

The Remote Customer Access managed object applies to each externally accessible RCAP on a Provider Edge Bridge. It includes the following:

a) The Internal Interface Table, which configures the internal interfaces between the Port-mapping S-VLAN component and the S-VLAN or C-VLAN components. This table provides the following equivalent functionality:
    1) For an RCSI supporting a Port-based service interface:
        i) Creating an internal PAP connected to a CNP on the S-VLAN component.
        ii) Configuring both the PAP and CNP to accept only untagged frames.
        iii) Setting the member set for the external S-VID to include the PAP and RCAP.
        iv) Setting the PAP’s PVID to the external S-VID and adding that port to that S-VID’s untagged set.
        v) Setting the CNP’s PVID to the internal S-VID for the Port-based service instance and adding the port to that S-VID’s untagged set.
    2) For an RCSI supporting a C-tagged service interface:
        i) Creating a PAP connected to a CEP on a C-VLAN component.
        ii) Setting the member set for the external S-VID to include the PAP and RCAP.
        iii) Configuring the PAP’s PVID to the external S-VID and adding the port to that S-VID’s untagged set.

3) For a PNP:
   i) Setting the member set for the external S-VID to include the PNP and RCAP.
   ii) Adding the associated primary S-VLAN component PNP to the member set of the internal S-VLAN.
   iii) Configuring the associated primary S-VLAN component PNP's VID translation table to translate between the external S-VID and the internal S-VID for the selected service instance.

Note that in the case of an RCSI supporting a C-tagged service interface the C-VLAN component can be further configured using the Customer Edge managed object. This configuration includes the following:

— The parameters to set the C-VID Registration Table entries (12.13.2.2)
— The PEP configuration parameters (12.13.2.4)
— The Service Priority Regeneration Table entries (12.13.2.6)

all associated with the configuration of the internal CEP, which is directly connected to the internal PAP identified by the external S-VID and the RCAP.

The management operations that can be performed on the Remote Customer Access managed object are as follows:

b) Read Internal Interface Table Entry (12.13.3.1)
c) Configure Internal Interface Table Entry (12.13.3.2)

Further configuration related to a C-VLAN component associated with an RCSI supporting a C-tagged service interface is accomplished using the Customer Edge managed object (12.13.2).

12.13.3.1 Read Internal Interface Table Entry

12.13.3.1.1 Purpose

To read the Internal Interface Table entry associated with a specific external S-VID in a Port-mapping S-VLAN component of a RCAP.

12.13.3.1.2 Inputs

a) External Port Number: the number of the RCAP.
b) External S-VLAN Identifier: a 12-bit S-VID.

12.13.3.1.3 Outputs

a) Internal Port Number: the port number used to reference the internal interface.
b) A value indicating the type of internal interface associated with the external S-VID, one of the following:
   1) Port-based RCSI
   2) C-tagged RCSI
   3) PNP
   4) Discard (external S-VID is not associated with an internal port)
c) Internal S-VLAN Identifier: a 12-bit S-VID (not applicable for a C-tagged RCSI).

12.13.3.2 Configure Internal Interface Table Entry

12.13.3.2.1 Purpose

To add or delete an entry in the Internal Interface Table.

12.13.3.2.2 Inputs

a) External Port Number: the number of the RCAP.
b) External S-VLAN Identifier: a 12-bit S-VID.
c) Internal Port Number (optional): the port number used to reference the internal interface;
d) A value indicating the type of internal interface associated with the external S-VID, one of the following:
    1) Port-based RCSI
    2) C-tagged RCSI
    3) PNP
    4) Discard (delete entry for the external S-VID)
e) Internal S-VLAN Identifier: a 12-bit S-VID (not applicable for a C-tagged RCSI).

12.13.3.2.3 Outputs

None

12.14 CFM entities

The CFM managed objects model operations that modify, or inquire about, the configuration and the operation of CFM. Figure 12-1 illustrates the simple hierarchical relationships among the various CFM managed objects, including the control of access to those objects. See 17.4.7 for an explanation of methods available to distinguish between an Owner and a Maintenance Domain administrator. See Clause 18 for an explanation of the use of Maintenance Domains and Maintenance Associations (MAs). The following are the CFM managed objects in a Bridge:

a) Maintenance Domain list managed object (12.14.1)
b) CFM Stack managed object (12.14.2)
c) Default MD Level managed object (12.14.3)
d) Configuration Error List managed object (12.14.4)
e) Maintenance Domain managed objects (12.14.5)
f) Maintenance Association managed objects (12.14.6)
g) Maintenance association Endpoint managed objects (12.14.7)

12.14.1 Maintenance Domain list managed object

There is one Maintenance Domain list managed object per Bridge. It contains a list of the Maintenance Domains that have been configured on the Bridge.

The management operations that can be performed on the Maintenance Domain list managed object are as follows:

a) Read Maintenance Domain list (12.14.1.1)
b) Create Maintenance Domain managed object (12.14.1.2)
c) Delete Maintenance Domain managed object (12.14.1.3)

NOTE—In Provider Bridge applications, each Maintenance Domain, and thus each Maintenance Domain managed object, can be controlled by a different administrative organization. Some or all of these administrative organizations can be different from that which controls the Maintenance Domain list managed object or the managed objects in Clause 12 other than those in 12.14. See 17.3.7 for a discussion of the means by which control of and access to different instances of the Maintenance Domain managed object are allocated to these different administrative organizations.

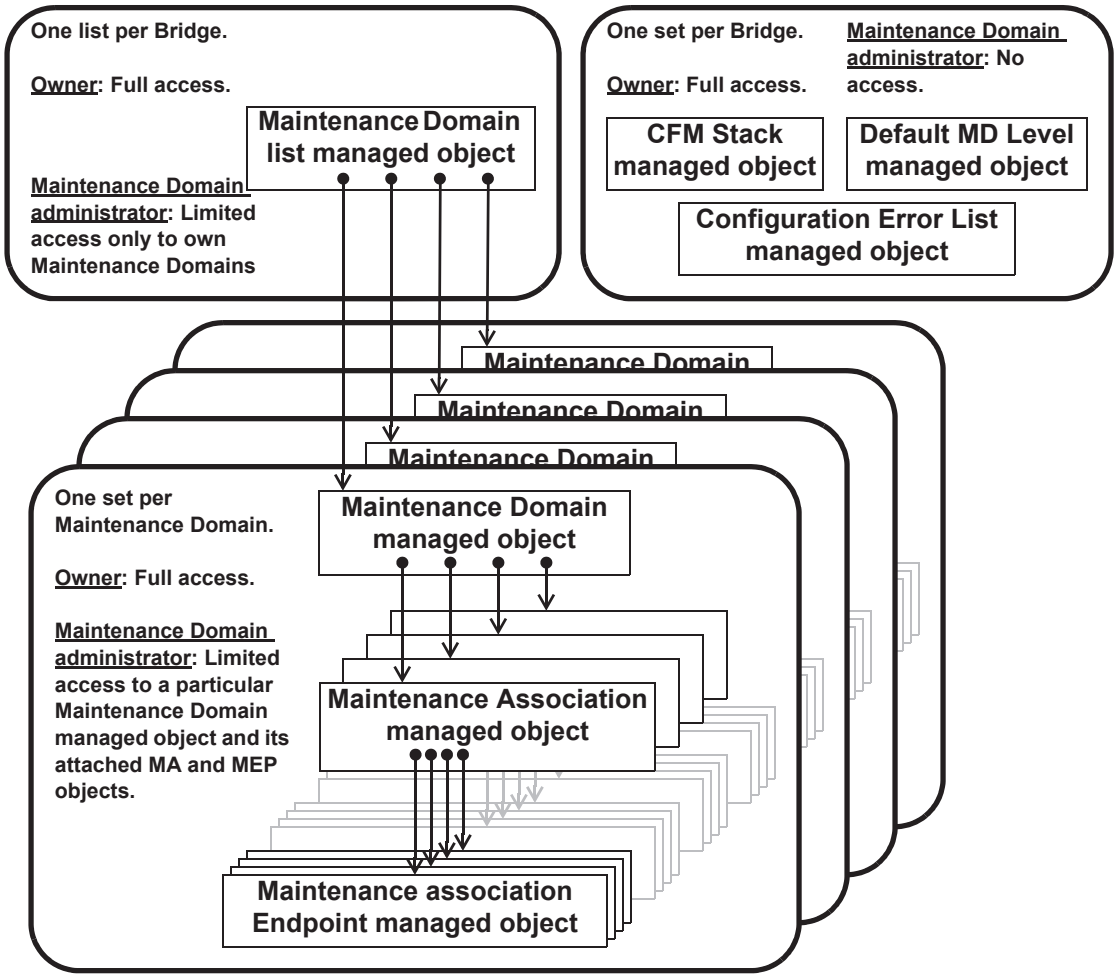


Figure 12-1—Relationships among CFM managed objects

12.14.1.1 Read Maintenance Domain list

12.14.1.1.1 Purpose

To obtain information about all of the Maintenance Domains in a Bridge.

12.14.1.1.2 Inputs

None.

12.14.1.1.3 Outputs

a) A list, perhaps empty, of the Maintenance Domain managed objects configured on the Bridge. For each item in the list, the Read Maintenance Domain list command returns the following:
   1) A Maintenance Domain Name, including the format specifier from Table 21-18 (21.6.5.1)
   2) A reference to that Maintenance Domain's Maintenance Domain managed object (12.14.5)

12.14.1.2 Create Maintenance Domain managed object

12.14.1.2.1 Purpose

To create a new Maintenance Domain managed object in a Bridge, and add it to the Bridge's Maintenance Domain list managed object.

12.14.1.2.2 Inputs

a) A Maintenance Domain Name, including the format specifier from Table 21-18 (21.6.5.1); default value is the character string (format 4) "DEFAULT."
b) The MD Level at which the Maintenance Domain is to be created; default value is 0.

12.14.1.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to invalid Maintenance Domain Name (21.6.5.1)
    2) Operation rejected because Maintenance Domain Name already exists
    3) Operation rejected due to invalid MD Level
    4) Operation accepted

12.14.1.3 Delete Maintenance Domain managed object

12.14.1.3.1 Purpose

To delete a specific Maintenance Domain managed object from a Bridge and from the Bridge's Maintenance Domain list managed object.

12.14.1.3.2 Inputs

a) A reference to a particular Maintenance Domain managed object (12.14.5).

12.14.1.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to invalid or nonexistent Maintenance Domain
    2) Operation accepted

12.14.2 CFM Stack managed object

There is one CFM Stack managed object per Bridge. It permits retrieval of information about the MPs configured on a particular Bridge Port or aggregated port. The management operation that can be performed is as follows:

a) Read CFM Stack managed object (12.14.2.1)

12.14.2.1 Read CFM Stack managed object

12.14.2.1.1 Purpose

To obtain the contents of the CFM Stack managed object, which allows a network administrator to discover the relationships among MEPs and MHFs configured on a particular Bridge Port or aggregated port.

12.14.2.1.2 Inputs

a) An interface, either a Bridge Port, or an aggregated IEEE 802.3 port within a Bridge Port, on which MPs might be configured.
b) An MD Level.

c) A value indicating the direction in which any reported MP faces, either:
   1) Down (Active SAP is further away from the Frame filtering entity) or
   2) Up (Active SAP is closer to the Frame filtering entity).

d) A specific VID, I-SID, Traffic Engineering service instance Identifier (TE-SID), or Segment Identifier (SEG-ID) associated with an MP, or 0, in the case that the MP is associated with no VID, I-SID, TE-SID, or SEG-ID.

12.14.2.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to illegal inputs.
   2) No MP is configured on the indicated Bridge Port or aggregated port at the indicated MD Level and direction.
   3) A MEP is configured.
   4) An MHF is configured.

b) Either the Maintenance Domain managed object (12.14.5) to which the MP's MA is associated, or an indication that there is no Maintenance Domain associated with the MP.

c) Either the Maintenance Association managed object (12.14.6) to which the MP is associated, or an indication that there is no MA associated with the MP.

d) If a MEP is configured, its MA Endpoint Identifier (MEPID), else 0.

e) The MAC address of the MP.

12.14.3 Default MD Level managed object

There is a single Default MD Level managed object per Bridge component. It controls MIP Half Function (MHF) creation for VIDs or I-SIDs of I- or B-components that are not contained in the list of VIDs attached to any specific Maintenance Association managed object [item c) in 12.14.5.3.2], and the transmission of the Sender ID TLV (21.5.3) by those MHFs.

The management commands that can be performed on the Default MD Level managed object are as follows:

a) Read Default MD Level managed object (12.14.3.1).

b) Write Default MD Level managed object (12.14.3.2).

12.14.3.1 Read Default MD Level managed object

12.14.3.1.1 Purpose

To read the table of default parameters for controlling MHFs not associated with any MA configured on the Bridge component.

12.14.3.1.2 Input

a) A VID or I-SID in an I- or B-component.

12.14.3.1.3 Output

a) A list of VIDs associated with any MHF on the VID named in item a) in 12.14.3.1.2, always including that VID, or the Backbone-SID of the B-component or VIP-SID of the I-component

associated with any MHF on the I-SID named in item a) in 12.14.3.1.2. The first VID is the MAs' Primary VID. List is empty if no VID specified in 12.14.3.1.2.

b) A Boolean value indicating whether this entry is in effect or has been overridden by the existence of a Maintenance Association managed object associated with the same VID or I-SID of I- or B-components and MD Level, and on which is configured an Up MEP. True if this Maintenance Domain managed object is in effect.

c) (writable) The MD Level at which MHFs are to be created.

d) (writable) An enumerated value indicating whether the management entity can create MHFs for this VID(s) or I-SID(s) of I- or B-components: defMHFnone: [item n) in 22.2.3, the default], defMHFdefault [item o)], or defMHFexplicit [item q)].

e) (writable) An enumerated value indicating what, if anything, is to be included in the Sender ID TLV (21.5.3) transmitted by MPs configured in the Default Maintenance Domain: sendIdNone (1, the default value), sendIdChassis (2), sendIdManage (3), or sendIdChassisManage (4).

12.14.3.2 Write Default MD Level managed object

12.14.3.2.1 Purpose

To write entries in the table of default parameters for controlling MHFs on VIDs or on I-SIDs used in an I- or B-component not associated with any MA.

12.14.3.2.2 Inputs

a) A list of VIDs or the VIP-SIDs used in the I-component or Backbone-SID used in the B-component, or 0, indicating no VID or I-SID. The first VID in the list is the Primary VID.

b) One of the writable managed object in 12.14.3.1.3.

12.14.3.2.3 Outputs

a) Operation status. This takes one of the following values:

1) Operation rejected because creating or assigning these VIDs or I-SIDs to this MD Level would exceed the number of MD Levels supported by some Bridge Port [item c) in 22.2.4].

2) Operation rejected because the VID list provided [item a) in 12.14.3.2.2] specifies a different Primary VID, or contains one or more but not all of the VIDs, in the definition of an MA or some other entry in the Default MD Level managed object.

3) Operation accepted.

12.14.4 Configuration Error List managed object

The Configuration Error List managed object is a list of {identifier, port} pairs configured in error together with the identity of the configuration error. The identifier is a VID, I-SID, TE-SID, or SEG-ID and the port is a simple Bridge Port or aggregated Bridge Port.

12.14.4.1 Read Configuration Error List managed object

12.14.4.1.1 Purpose

To list the entries in the Configuration Error List where each entry describes the identifier and port pair that identifies the entry, together with a description of the particular configuration error.

12.14.4.1.2 Inputs

a) A VID, I-SID, or TE-SID, specifying which service instance to check for ports in error or a SEG-ID specifying which Infrastructure Segment to check for ports in error.

b) An interface, either a Bridge Port or an aggregated IEEE 802.3 port within a Bridge Port.

12.14.4.1.3 Outputs

a) An indication of the result of the operation:
   1) Operation rejected due to illegal vlan_identifier
   2) Operation rejected due to illegal or nonexistent Bridge Port or aggregated port
   3) Operation accepted
b) If the operation was accepted, a vector of Boolean error conditions from 22.2.4, any of which may be true:
   1) CFMleak
   2) ConflictingVIDs
   3) ExcessiveLevels and/or
   4) OverlappedLevels

12.14.5 Maintenance Domain managed object

There can be any number of Maintenance Domain managed objects per Bridge. A Maintenance Domain managed object is required in order to create an MA with a Maintenance Association Identifier (MAID) that includes that Maintenance Domain's Name. From this Maintenance Domain managed object, all Maintenance Association managed objects associated with that Maintenance Domain managed object can be accessed, and thus controlled.

The management operations that can be performed on the Maintenance Domain managed object are as follows:

a) Read Maintenance Domain managed object (12.14.5.1)
b) Write Maintenance Domain managed object (12.14.5.2)
c) Create Maintenance Association managed object (12.14.5.3)
d) Delete Maintenance Association managed object (12.14.5.4)

NOTE 1—The Maintenance Domain managed object is defined in such a manner that it can be configured identically in all of the Bridges in that Bridged Network. All of the information local to a particular MA or a particular Bridge is contained in other managed objects, e.g., the Maintenance Association managed object (12.14.6) or the Maintenance association Endpoint managed object (12.14.7).

NOTE 2—A single Maintenance Domain managed object can be used to manage any number of separate Maintenance Domains, as Maintenance Domains are defined in 18.1. For example, the Maintenance Association managed object for all of the physical links in a Bridged Network that are protected by MAs can be grouped together under a single Maintenance Domain managed object for the convenience of the network administrator.

NOTE 3—Multiple Maintenance Domain managed objects can be used to manage a single Maintenance Domain, as Maintenance Domains are defined in 18.1. For example, a PBN's Domain Service Access Points (DoSAPs) could be split among two Maintenance Domain managed objects, one for point-to-point services and one for multipoint services.

12.14.5.1 Read Maintenance Domain managed object

12.14.5.1.1 Purpose

To obtain information from a Bridge about a specific Maintenance Domain managed object.

12.14.5.1.2 Inputs

a) A reference to a particular Maintenance Domain managed object (12.14.5).

12.14.5.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent Maintenance Domain
   2) Operation accepted

b) The MD Level of the specific Maintenance Domain identified by the Input.

c) (writable) An enumerated value indicating whether the management entity can create MHFs for this Maintenance Domain: defMHFnone: [item n) in 22.2.3, the default], defMHFdefault [item o)], or defMHFexplicit [item p)].

d) (writable) An enumerated value indicating what, if anything, is to be included in the Sender ID TLV (21.5.3) transmitted by MPs configured in this Maintenance Domain: sendIdNone (1, the default value), sendIdChassis (2), sendIdManage (3), or sendIdChassisManage (4) [item d) in 12.14.6.1.3].

e) (writable) The network address to which Fault Alarms (12.14.7.7) are to be transmitted, or a value indicating "Fault Alarms are not to be transmitted." Default value is "not transmitted."

NOTE—The variables item c) through item e) could be writable by the organization operating the Maintenance Domain.

f) A list of references to the Maintenance Association managed objects (12.14.6) attached to the indicated Maintenance Domain managed object.

12.14.5.2 Write Maintenance Domain managed object

12.14.5.2.1 Purpose

To alter a value of a specific Maintenance Domain managed object.

12.14.5.2.2 Inputs

a) A reference to a particular Maintenance Domain managed object (12.14.5).

b) A reference to a writable managed object in 12.14.5.1.3 to be altered.

c) A new value for the managed object.

12.14.5.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent Maintenance Domain
   2) Operation rejected due to the selected managed object being Read-Only
   3) Operation rejected due to invalid value for the selected managed object
   4) Operation accepted

12.14.5.3 Create Maintenance Association managed object

12.14.5.3.1 Purpose

To create a new Maintenance Association managed object within a Maintenance Domain managed object.

12.14.5.3.2 Inputs

a) A reference to a particular Maintenance Domain managed object (12.14.5).

b) The Short MA Name of an MA within that Maintenance Domain, including the format specifier from Table 21-19 (21.6.5.4). In the case of a PBB-TE, VID-based, or Infrastructure Segment MA, the default value is a 2-octet integer (format 3) containing the primary VID, or 0, if the MA is not attached to a VID.

c) The list of VIDs, the I-SID, the TE-SID, or the SEG-ID monitored by this MA, or 0, if the MA is not attached to any VID, I-SID, TE-SID, or SEG-ID. In the case that a list of VIDs is specified, the first VID in the list is the MA's Primary VID (default none). The specification of I-SID is allowed only in the case of I- or B-components. The TE-SID is allowed only in the case that PBB-TE or SPBM is supported. The SEG-ID is allowed only in the case that IPS is supported.

12.14.5.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent Maintenance Domain.
   2) Operation rejected due to invalid Short MA Name (21.6.5.4).
   3) Operation rejected due to the existence of another MA in the same Maintenance Domain with the same Short MA Name.
   4) Operation rejected because creation of this MA would exceed the number of MD Levels supported by some Bridge Port [item c) in 22.2.4].
   5) Operation rejected because the VID list provided [item c) in 12.14.5.3.2] specifies a different Primary VID, or contains one or more, but not all, of the VIDs, in the definition of another MA or an entry in the Default MD Level managed object.
   6) Operation rejected because the I-SID value specified does not correspond to a valid backbone service instance.
   7) Operation rejected because the TE-SID value specified does not correspond to a valid TESI or set of SPBM path endpoints.
   8) Operation rejected because the SEG-ID value specified does not correspond to a valid Infrastructure Segment.
   9) Operation accepted.

12.14.5.4 Delete Maintenance Association managed object

12.14.5.4.1 Purpose

To delete a specific Maintenance Association managed object from a Maintenance Domain managed object.

12.14.5.4.2 Inputs

a) A reference to a particular Maintenance Association managed object (12.14.6).

12.14.5.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent MA
   2) Operation accepted

12.14.6 Maintenance Association managed object

There can be any number of Maintenance Association managed objects per Bridge, one for each service instance for which an MP is defined on that Bridge. From this Maintenance Association managed object, all Maintenance association Endpoint managed objects associated with that Maintenance Association managed object can be accessed, and thus controlled.

The management operations that can be performed on the Maintenance Association managed object are as follows:

a) Read Maintenance Association managed object (12.14.6.1)
b) Write Maintenance Association managed object (12.14.6.2)
c) Create Maintenance association Endpoint managed object (12.14.6.3)
d) Delete Maintenance association Endpoint managed object (12.14.6.4)

NOTE 1—The Maintenance Association managed object is defined in such a manner that it can be configured identically in all of the Bridges in its Maintenance Domain. All information local to a particular Bridge is contained in other managed objects, e.g., the Maintenance association Endpoint managed object (12.14.7).

NOTE 2—Although MHFs are created via the Maintenance Domain managed object, the Default MD Level managed object, and the Maintenance Association managed object, and although there is a Maintenance association Endpoint

managed object, there is no "MIP Half Function managed object." One reason for this omission is that no controls over the behavior of the MHF beyond its existence is required. Another is that the burden of implementing, providing access to, and providing the maintenance capabilities to access the counters and similar managed objects appropriate to an MHF Managed Object seemed to the developers of this standard to outweigh the benefits of having that information available.

12.14.6.1 Read Maintenance Association managed object

12.14.6.1.1 Purpose

To obtain information from a Bridge about a specific Maintenance Association managed object.

12.14.6.1.2 Inputs

a) A reference to a particular Maintenance Association managed object (12.14.6).

12.14.6.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent MA
   2) Operation accepted

b) The VID(s), I-SID, TE-SID, or SEG-ID monitored by this MA, or 0, if the MA is not attached to any VID, I-SID, TE-SID, or SEG-ID. In the case of a list of VIDs, the first VID returned is the MA's Primary VID.

c) (writable) An enumerated value indicating whether the management entity can create MHFs for this MA: defMHFnone: [item n) in 22.2.3], defMHFdefault [item o)], or defMHFexplicit [item p)] or defMHFdefer [item q)], default value is defMHFdefer.

d) (writable) An enumerated value indicating what, if anything, is to be included in the Sender ID TLV (21.5.3) transmitted by MPs configured in this MA:
   1) **sendIdNone**: The Sender ID TLV is not to be sent.
   2) **sendIdChassis**: The Chassis ID Length, Chassis ID Subtype, and Chassis ID fields of the Sender ID TLV are to be sent, but not the Management Address Length or Management Address fields.
   3) **sendIdManage**: The Management Address Length and Management Address of the Sender ID TLV are to be sent, but the Chassis ID Length is to be transmitted with a 0 value, and the Chassis ID Subtype and Chassis ID fields not sent.
   4) **sendIdChassisManage**: The Chassis ID Length, Chassis ID Subtype, Chassis ID, Management Address Length, and Management Address fields are all to be sent.
   5) **sendIdDefer**: (the default value) The contents of the Sender ID TLV are determined by the Maintenance Domain managed object, item d) in 12.14.5.1.3.

e) (writable) An enumerated value, other than 0, indicating the interval between CCM transmissions to be used by all MEPs in the MA (20.8.1, 21.6.1.3) (default 1 s).

f) (writable) The network address to which Fault Alarms (12.14.7.7) are to be transmitted, a value indicating "not specified," or a value indicating "Fault Alarms are not to be transmitted." If "not specified," the address used is that from the Maintenance Domain managed object [item e) in 12.14.5.1.3].

g) (writable) A list of the MEPIDs of the MEPs in the MA.

12.14.6.2 Write Maintenance Association managed object

12.14.6.2.1 Purpose

To alter a value of a specific Maintenance Association managed object.

12.14.6.2.2 Inputs

a) A reference to a particular Maintenance Association managed object (12.14.6).
b) A reference to one of the writable managed objects in 12.14.6.1.3 is to be altered.
c) A new value for the managed object.

12.14.6.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent MA
    2) Operation rejected due to the selected managed object being Read-Only
    3) Operation rejected due to lack of authority to set this variable
    4) Operation rejected due to invalid value for the selected managed object
    5) Operation accepted

12.14.6.3 Create Maintenance association Endpoint managed object

12.14.6.3.1 Purpose

To create a new Maintenance association Endpoint managed object within a Maintenance Association managed object on a specific Bridge Port or aggregated port.

12.14.6.3.2 Inputs

a) A reference to a particular Maintenance Association managed object (12.14.6).
b) A MEPID for the created MEP.
c) A value indicating the direction in which the MEP faces on the Bridge Port or aggregated port, either:
    1) Down (Active SAP is further away from the Frame filtering entity) (the default) or
    2) Up (Active SAP is closer to the Frame filtering entity).
d) An interface, either a Bridge Port or an aggregated IEEE 802.3 port within a Bridge Port.

12.14.6.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent MA.
    2) Operation rejected because the specified MEPID already exists in this MA in this Bridge.
    3) Operation rejected because MEPID is not in the MA's list of MEPIDs [item g) in 12.14.6.1.3].
    4) Operation rejected due to the existence of a MEP in the same direction (Up or Down) at that same MD Level, for the same VID(s), I-SID, TE-SID, or SEG-ID as this MEP (or for no VID, I-SID, TE-SID, or SEG-ID, if this MEP's MA has no VID, I-SID, TE-SID, or SEG-ID), on that Bridge Port or aggregated port.
    5) Operation failed because one or more of the listed VIDs, I-SID, or TE-SID in this MA are assigned to some other MA on which Up MEPs are configured on any Bridge Port.
    6) Operation rejected because the Bridge is incapable of instantiating a MEP on that Bridge Port or aggregated IEEE 802.3 port.
    7) Operation rejected because an Up MEP cannot be configured for an MA that has no VID, I-SID, or TE-SID.
    8) Operation rejected because a MEP exists on this MA that has a different value for its Up/Down parameter [item c) in 12.14.6.3.2].
    9) Operation accepted.

12.14.6.4 Delete Maintenance association Endpoint managed object

12.14.6.4.1 Purpose

To delete an existing Maintenance association Endpoint managed object from a Maintenance Association managed object.

12.14.6.4.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).

12.14.6.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent MEP
   2) Operation accepted

12.14.7 Maintenance association Endpoint managed object

There can be any number of Maintenance association Endpoint managed objects per Bridge, one for each MEP defined within that Bridge. From this Maintenance association Endpoint managed object, all management objects related to that MEP can be controlled.

The management operations that can be performed on the Maintenance association Endpoint managed object are as follows:

a) Read Maintenance association Endpoint managed object (12.14.7.1)
b) Write Maintenance association Endpoint managed object (12.14.7.2)
c) Transmit Loopback Messages (12.14.7.3)
d) Transmit Linktrace Message (12.14.7.4)
e) Read Linktrace Reply (12.14.7.5)
f) Read MEP Database (12.14.7.6)
g) Transmit MEP Fault Alarm (12.14.7.7)

12.14.7.1 Read Maintenance association Endpoint managed object

12.14.7.1.1 Purpose

To obtain information from a Bridge about a specific Maintenance association Endpoint managed object.

12.14.7.1.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).

12.14.7.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent MEP
   2) Operation accepted
b) An interface, either a Bridge Port or an aggregated IEEE 802.3 port within a Bridge Port, to which the MEP is attached.
c) A value indicating the direction in which the MEP faces on the interface, either:
   1) Down (Active SAP is further away from Frame filtering entity) or
   2) Up (Active SAP is closer to the Frame filtering entity).

d) (writable) An integer indicating the Primary VID of the MEP, always one of the VIDs assigned to the MEP's MA. The value 0 indicates either that the Primary VID is that of the MEP's MA or that the MEP's MA is associated with no VID. In the case of a PBB-TE associated MEP, the Primary VID is not writable but is always associated with the value of the ESP-VID parameter identifying the MA's ESP that has the MEP's MAC address in its ESP-SA field (MEPprimaryVID, 20.9.7). In the case of an Infrastructure Segment associated MEP, the Primary VID (MEPprimaryVID, 20.9.7) is not writable but is always associated with the value of the SMP-VID parameter identifying the MA's SMP that has the MEP's MAC address in its SMP-SA field. In the case of an SPB associated MEP, the Primary VID is not writable but is always associated with the value of the SPVID for the node on which the MEP is configured (for SPBV) or the Base VID (for SPBM).

e) (writable) A Boolean flag indicating the administrative state of the MEP (20.9.1) (default FALSE).

f) A value indicating the current state of the MEP Fault Notification Generator state machine (20.37).

g) (writable) A Boolean flag indicating whether the MEP is or is not to generate CCMs (CCIenabled, 20.10.1) (default FALSE, no CCMs).

h) (writable) The priority parameter for CCMs and LTMs transmitted by the MEP (default value: the highest priority, i.e., that with the highest numerical value, allowed to pass through the Bridge Port for any of this MEP's VIDs, I-SID, TE-SID, or SEG-ID).

NOTE—The management entity can obtain the default value for this variable from the Priority regeneration table in 6.9.3 by extracting the highest priority value in the table on this MEP's Bridge Port (1 is lowest, then 2, then 0, then 3–7), appropriate to the direction in which frames are emitted from the MEP's Active SAP.

i) The MAC address of the MEP (19.4). In the case of a MEP that is associated with a TESI, the MAC address of the CBP upon which the MEP is operating. In the case of a MEP that is associated with an Infrastructure Segment, the MAC address of the PNP upon which the MEP is operating.

j) (writable) The network address to which Fault Alarms (12.14.7.7) are to be transmitted, a value indicating "not specified," or a value indicating "Fault Alarms are not to be transmitted." If "not specified," the address used is that from the Maintenance Association managed object [item f) in12.14.6.1.3].

k) (writable) An integer value specifying the lowest priority defect that is allowed to generate a Fault Alarm (20.9.5):

1) All defects: DefRDICCM, DefMACstatus**,** DefRemoteCCM, DefErrorCCM, and DefXconCCM.
2) Only DefMACstatus**,** DefRemoteCCM, DefErrorCCM, and DefXconCCM (the default).
3) Only DefRemoteCCM, DefErrorCCM, and DefXconCCM.
4) Only DefErrorCCM and DefXconCCM.
5) Only DefXconCCM.
6) No defects are to be reported.

l) (writable) The time that defects must be present before a Fault Alarm is issued (20.35.3) (default 2.5 s).

m) (writable) The time that defects must be absent before resetting a Fault Alarm (20.35.4) (default 10 s).

n) An enumerated value indicating the highest priority defect that has been present since the MEP Fault Notification Generator state machine was last in the FNG_RESET state (20.35.9):

1) **DefNone**: No defect has been present since the last FNG_RESET state.
2) **DefRDICCM**: The last CCM received by this MEP from some remote MEP contained the RDI bit, so variable item o) in 12.14.7.1.3 is set.
3) **DefMACstatus**: The last CCM received by this MEP from some remote MEP indicated that the transmitting MEP's associated MAC is reporting an error status via the Port Status TLV (21.5.4) or Interface Status TLV (21.5.5), so variable item p) in 12.14.7.1.3 is set.
4) **DefRemoteCCM**: This MEP is not receiving CCMs from some other MEP in its configured list [item g) in 12.14.6.1.3], so variable item q) in 12.14.7.1.3 is set.
5) **DefErrorCCM**: This MEP is receiving invalid CCMs, so variable item r) in 12.14.7.1.3, is set.

6) **DefXconCCM**: This MEP is receiving CCMs that could be from some other MA, so variable item s) in 12.14.7.1.3 is set.

o) A Boolean flag (20.35.7) indicating that some other MEP in this MEP's MA is transmitting the RDI bit (can trigger DefRDICCM).

p) A Boolean flag (20.35.6) indicating that a Port Status TLV (21.5.4) or Interface Status TLV (21.5.5) is indicating an error condition (can trigger DefMACstatus).

q) A Boolean flag (20.35.5) indicating that CCMs are not being received from at least one of the configured remote MEPs (can trigger DefRemoteCCM).

r) A Boolean flag (20.21.3) indicating that erroneous CCMs are being received from some MEP in this MEP's MA (can trigger DefErrorCCM).

s) A Boolean flag (20.23.3) indicating that CCMs are being received from a MEP that could be in some other MA (can trigger DefXconCCM).

t) The last-received CCM (20.21.2) that triggered a DefErrorCCM fault (20.21.3).

u) The last-received CCM (20.23.2) that triggered a DefXconCCM fault (20.23.3).

v) (optional) The total number of out-of-sequence CCMs received (20.16.12).

w) The total number of CCMs transmitted (20.10.2).

x) The next Loopback Transaction Identifier to be sent in an LBM (20.30.2).

y) The total number of valid, in-order LBRs received (20.33.1).

z) The total number of valid, out-of-order LBRs received (20.33.1).

aa) (optional) The total number of LBRs received whose mac_service_data_unit did not match (except for the OpCode) that of the corresponding LBM (20.2.3).

ab) The next LTM Transaction Identifier to be sent in an LTM (20.41.1).

ac) The total number of unexpected LTRs received (20.44.1).

ad) The total number of LBRs transmitted (20.28.2).

ae) (writable) A list indicating which of the remote MEPs in the same MA are active. The Remote MEP state machines (20.20) are instantiated only for the active remote MEPs. By default, all configured remote MEPs in the same MA are active.

af) (writable) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), a Boolean flag indicating that the capability to report the presence of traffic is enabled. The default value is FALSE.

ag) (writable) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), a Boolean flag indicating that the mismatch defect is allowed to generate a Fault Alarm. The default value is FALSE.

ah) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), a Boolean flag indicating the presence of a traffic field mismatch defect (20.25.2) (can trigger DefMmCCM).

ai) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), a Boolean flag indicating the presence of a local mismatch defect (20.25.5) (can trigger DefMmCCM).

aj) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), an enumerated value indicating if the mismatch defect that has been present since the MEP Mismatch Fault Notification Generator state machine (20.40) was last in the MFNG_RESET state, either:

1) **DefNone**: No defect has been present since the last MFNG_RESET state; or
2) **DefMmCCM**: This MEP is receiving CCMs that have different value in their Traffic field than the CCMs transmitted by this MEP or is transmitting CCMs with both the RDI and the Traffic field bit set to 1 and the disableLocdefect (20.25.4) variable is cleared, so variable item ah) in 12.14.7.1.3 is set.

ak) Only applicable for PBB-TE MEPs supporting the Traffic field (21.6.1.4), a value indicating the current state of the MEP Mismatch Fault Notification Generator state machine (20.40).

al) (writable) Only applicable for ECMP path MEPs, a list of flow hash values to be used in a path testing cycle (20.10.5).

12.14.7.2 Write Maintenance association Endpoint managed object

12.14.7.2.1 Purpose

To alter a value in a specific managed object within a specific Maintenance association Endpoint managed object.

12.14.7.2.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).
b) A reference to one of the writable managed objects in 12.14.7.1.3 is to be altered.
c) A new value for the managed object.

12.14.7.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent MEP
    2) Operation rejected due to the selected managed object being Read-Only
    3) Operation rejected due to invalid value for the selected managed object
    4) Operation accepted

12.14.7.3 Transmit Loopback Messages

12.14.7.3.1 Purpose

To signal to the MEP to transmit some number of LBMs.

NOTE—The Maintenance association Endpoint managed object (12.14.7) can be examined to determine whether the corresponding LBRs have been received by the MEP.

12.14.7.3.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).
b) An indication of the target MAC address for LBMs transmitted by the MEP (20.31.1):
    1) The MEPID of a MEP in that MA or
    2) An Individual destination MAC address or
    3) For PBB-TE and SPBM VID MEPs, an individual MAC address to be used as the MIP MAC address in a PBB-TE MIP TLV.
c) The number of LBMs to be transmitted (default 1).
d) An arbitrary amount of data to be included in a Data TLV, along with an indication whether the Data TLV is to be included (20.31.1) (default no Data TLV).
e) The priority and drop_eligible parameters to be used in the transmitted LBMs [default is CCM priority item h) in 12.14.7.1.3, drop_eligible FALSE].
f) In the case of a PBB-TE MEP, the Reverse VID to be used in the associated PBB-TE MIP TLV 21.7.5. The parameter is not required in the case of PBB-TE MEPs associated with point-to-point TESIs or if the b3) entry is a MAC address corresponding to an entry in the ESP-DA field of any of the MA's ESPs.
g) In the case of an SPBM VID MEP, an individual or group MAC address to be used as the destination_address for the LBM primitive. If no value is provided the group MAC address for the SPBM default I-SID (Table 9-3, Figure 27-3) is used.
h) In the case of ECMP with flow filtering, a flow hash value if the destination address is an individual address.

12.14.7.3.3 Outputs

a) An indication of whether the command was accepted by the MEP:
   1) Operation rejected due to nonexistent MEP;
   2) Operation rejected due to invalid number of LBMs to be transmitted;
   3) Operation rejected due to too much data to be transmitted;
   4) Operation rejected due to invalid priority or drop_eligible parameters to be transmitted;
   5) Operation rejected due to invalid ESP-VID;
   6) The LBM(s) will be (or have been) sent; or
   7) The LBM(s) will not be sent (e.g., because the Bridge is busy with another LBM transmit operation).

b) The Loopback Transaction Identifier (20.30.2) of the first LBM (to be) sent. The value returned is undefined if the Transmit Loopback Messages command was not accepted.

12.14.7.4 Transmit Linktrace Message

12.14.7.4.1 Purpose

To signal to the MEP to transmit an LTM and to create an LTM entry in the MEP's Linktrace Database.

NOTE—The Maintenance association Endpoint managed object (12.14.7) can be examined to determine whether the corresponding LTRs have been received by the MEP.

12.14.7.4.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).

b) The Flags field for LTMs transmitted by the MEP (20.42.1).

c) An indication of the Target MAC Address field to be transmitted, either:
   1) The MEPID of another MEP in the same MA or
   2) An individual MAC address.

d) An initial value for the LTM TTL field (21.8.4). Default value, if not specified, is 64.

e) In the case of a PBB-TE MEP, the Reverse VID to be used in the associated PBB-TE MIP TLV (21.7.5). The parameter is not required in the case of PBB-TE MEPs associated with point-to-point TESIs.

f) In the case of an SPBM VID MEP, an individual or group MAC address to be used as the destination_address for the LTM primitive. If no value is provided the group MAC address for the SPBM default I-SID (Table 9-3, Figure 27-3) is used.

g) In the case of ECMP with flow filtering, a flow hash value if the destination address is an Individual address.

12.14.7.4.3 Outputs

a) An indication of whether the command was accepted by the MEP:
   1) Operation rejected due to nonexistent MEP;
   2) Operation rejected due to invalid Flags field to be transmitted;
   3) Operation rejected due to invalid Target MAC Address to be transmitted;
   4) Operation rejected due to invalid LTM TTL field to be transmitted;
   5) Operation rejected due to invalid ESP-VID;
   6) The command was accepted and the LTM has (or will be) transmitted; or
   7) The command was rejected and no LTM will be sent (e.g., because the Bridge is busy with another LTM transmit operation).

b) The LTM Transaction Identifier (20.41.1) of the LTM sent. The value returned is undefined if the Transmit Linktrace Message command was not accepted.

c) The LTM Egress Identifier TLV value transmitted in the LTM. The value returned is undefined if the Transmit Linktrace Message command was not accepted.

12.14.7.5 Read Linktrace Reply

12.14.7.5.1 Purpose

To obtain from the MEP's Linktrace database (20.41.2) the LTM entry for a previously transmitted LTM with a specific LTM Transaction Identifier. An LTM entry consists of a list of LTR entries, each corresponding to a Linktrace Reply (LTR) PDU received in response to that LTM. The LTM Transaction Identifier returned by successful Transmit Linktrace Message command [item b) in 12.14.7.5.2] is used in the Read Linktrace Reply command [item b) in 12.14.7.5.2] to select the LTM entry.

See J.5 for a discussion of how to interpret the output from the Read Linktrace Reply command.

12.14.7.5.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).
b) The LTM Transaction Identifier returned from a previous Transmit Linktrace Message command, indicating the LTM entry to which the LTR entries will be attached.
c) An index to distinguish among multiple LTRs with the same LTR Transaction Identifier field value.

12.14.7.5.3 Outputs

A list of LTR entries returned corresponding to the selected LTM Transaction Identifier (20.41.2). Each LTR entry in the list returns:

a) An indication of whether the command was accepted by the MEP:
    1) Operation rejected due to nonexistent MEP;
    2) Operation rejected due to LTM Transaction Identifier not found;
    3) Operation rejected due to LTR entry has been discarded because too many LTRs have been returned corresponding to that LTM Transaction Identifier;
    4) Operation rejected due to LTR entry with that index has not yet been returned; or
    5) Operation accepted.
b) The integer Reply TTL field value returned in the LTR (20.41.2.2).
c) A Boolean value stating whether an LTM was forwarded by the responding MP, as returned in the FwdYes flag of the Flags field (20.41.2.1).
d) A Boolean value stating whether the forwarded LTM reached a MEP enclosing its MA, as returned in the TerminalMEP flag of the Flags field (20.41.2.1).
e) An octet string holding the Last Egress Identifier field returned in the LTR Egress Identifier TLV of the LTR (20.41.2.3).
f) An octet string holding the Next Egress Identifier field returned in the LTR Egress Identifier TLV of the LTR (20.41.2.4).
g) An enumerated value indicating the value returned in the Relay Action field (20.41.2.5): RlyHit, RlyFDB, or RlyMPDB.
h) (if returned in the LTR) An enumerated value indicating the format of the Chassis ID (21.5.3.2).
i) (if returned in the LTR) The Chassis ID (21.5.3.3).
j) (if returned in the LTR) The Management Address information of the Bridge transmitting the LTR (21.5.3.7).
k) (if returned in the LTR) An enumerated value indicating the value returned in the Ingress Action field (20.41.2.6) of the LTR: IngOK, IngDown, IngBlocked, or IngVID.
l) (if returned in the LTR) The MAC address returned in the Ingress MAC Address field (20.41.2.7).

m) (if returned in the LTR) An enumerated value indicating the format of the Ingress Port ID field (20.41.2.8).
n) (if returned in the LTR) The Ingress Port ID (20.41.2.9).
o) (if returned in the LTR) An enumerated value indicating the value returned in the Egress Action field (20.41.2.10) of the LTR: EgrOK, EgrDown, EgrBlocked, or EgrVID.
p) (if returned in the LTR) The MAC address returned in the Egress MAC Address field (20.41.2.11).
q) (if returned in the LTR) An enumerated value indicating the format of the Egress Port ID (20.41.2.12).
r) (if returned in the LTR) The Egress Port ID (20.41.2.13).
s) (if returned in the LTR) The OUI or CID and contents of any Organization-Specific TLVs (21.5.2) returned in the LTR.

12.14.7.6 Read MEP Database

12.14.7.6.1 Purpose

To obtain from the MEP the contents of one element in the MEP CCM Database.

12.14.7.6.2 Inputs

a) A reference to a particular Maintenance association Endpoint managed object (12.14.7).
b) The MEPID of a remote MEP whose information from the selected database is to be returned.

12.14.7.6.3 Outputs

a) An indication of whether the command was accepted by the MEP:
    1) Operation rejected due to nonexistent MEP;
    2) Operation rejected due remote MEPID not configured in MA; or
    3) Operation accepted.
b) An enumerated value indicating the operational state of the Remote MEP state machine (20.20) for this remote MEP:
    1) RMEP_IDLE;
    2) RMEP_START;
    3) RMEP_FAILED; or
    4) RMEP_OK.
c) The time (SysUpTime, IETF RFC 3418) at which the Remote MEP state machine last entered either the RMEP_FAILED or RMEP_OK state, or 0 if it has not yet entered either of those states.
d) The MAC address of the remote MEP (the source_address of the last received CCM) or 0 if no CCM has been received (20.19.7).
e) A Boolean value indicating the state of the RDI bit in the last received CCM (TRUE for RDI = 1), or FALSE, if none has been received (20.19.2). In the case of an ECMP path MEP, an array of Boolean values indicating the value of rMEPlastRDI[i] for i=0..(Npaths – 1) indicating the RDI values in the last CCMs received in each path test cycle period. These values are true for any RDI = 1 or false if all RDI = 0 or if no CCM has ever been received (20.19.2).
f) (optional) The enumerated value from the Port Status TLV (20.19.3) from the last CCM received from the remote MEP, or the default value:
    1) **psNoPortStateTLV:** Indicates either that no CCM has been received, or that no Port Status TLV was present in the last CCM received.
g) (optional) The enumerated value from the Interface Status TLV (20.19.4) from the last CCM received from the remote MEP, or the default value:

1) **isNoInterfaceStatusTLV:** Indicates either that no CCM has been received or that no Interface Status TLV was present in the last CCM received.

h) (optional) The Sender ID TLV (20.19.5) from the last CCM received from the remote MEP or the default value:

1) **isNoSenderIdTLV:** Indicates either that no CCM has been received, or that no Sender ID TLV was present in the last CCM received.

12.14.7.7 Transmit MEP Fault Alarm

12.14.7.7.1 Purpose

To alert the Manager to the existence of a fault in a monitored MA by issuing a Fault Alarm. Transmit MEP Fault Alarm is not a command; it is an unsolicited notification from the xmitFaultAlarm() procedure, issued upon detection of the Fault Alarm condition by the MEP Fault Notification Generator state machine (20.37), or by the MEP Mismatch Fault Notification Generator state machine (20.40). The Fault Alarm is sent to the address specified in item j) in 12.14.7.1.3.

12.14.7.7.2 Outputs

a) An indication of which Bridge is reporting the Fault Alarm.

b) A reference, in a suitable format for the method of delivering the Fault Alarm, to the reporting MEP.

c) An enumerated value, equal to the contents of the variable highestDefect (20.35.9), and to the corresponding MEP managed object [item n) in 12.14.7.1.3] or indicating the presence of a mismatch defect [item aj) in 12.14.7.1.3].

12.15 Backbone Core Bridge (BCB) management

Each BCB is a conformant S-VLAN Bridge (5.10.1) that is managed by the managed objects summarized in 12.2 and specified in detail in 12.4 through 12.14.

12.16 Backbone Edge Bridge (BEB) management

The conformance requirements for BEBs are specified in 5.12. Each of the I-components and (or) the B-component of a BEB are managed using the managed objects defined in 12.2, while this subclause adds managed objects used in conjunction with those of 12.2 to manage the overall configuration and the VIPs, PIPs, and CBPs of a BEB. This subclause specifies the additional managed objects specific to the operation of BEBs, which:

a) Support a BEB configuration managed object identifying all the BEB components (12.16.1).

b) Identify BEB port types (12.16.2).

c) Provide additional managed objects for management of the VIPs, PIPs, and CBPs (12.16.3, 12.16.4, 12.16.5).

Only a single view of the BEB managed objects exists. This view may only contain the objects needed for the type of BEB under management. If the BEB contains only a single I-component then the view will have only the BEB configuration, BEB, VIP configuration, and PIP configuration managed objects. If the BEB has only a B-component, then the view will have only the BEB configuration, BEB, and CBP configuration managed objects.

An instance of a managed object associated with a BEB is referenced by a unique identifier. Rules associated with the selection of this identifier are specified within this subclause. Each BEB has a single BEB configuration managed object, which is described in this subclause and illustrated in Figure 12-2. This

managed object is accessed at only one of the components within a given BEB, the B-component if that is present, and the single I-component otherwise, and is referenced by that component's MAC address.

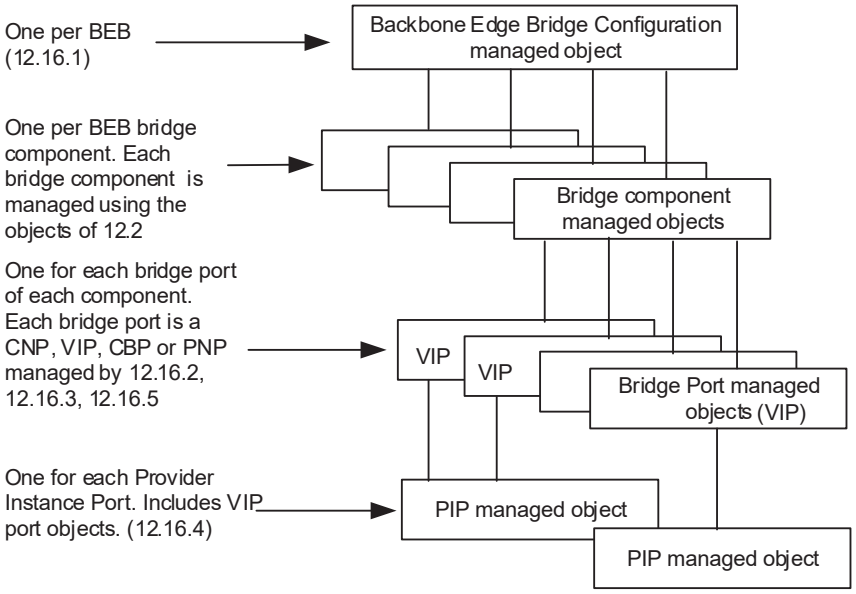


Figure 12-2—Relationship among BEB managed objects

Each VLAN Bridge component relays frames between Bridge Ports. In a BEB, these Bridge Ports can provide external connectivity directly, or can connect to other Bridge components through internal LANs. Each component contained within a BEB is associated with the BEB configuration managed object representing that BEB. The component is uniquely identified within the PBBN by the combination of a componentID unique within the BEB and by the MAC address of the BEB within that the component is contained. Each component may also be identified by the MAC address of the component that is unique within the PBBN. Within a BEB, a B-component uses two types of Bridge Ports—PNPs and CBPs—and an I-component uses two types of Bridge Ports—VIPs and CNPs. Each Bridge Port is represented by a Bridge Port managed object (12.4.2), a Provider Bridge Port Type managed object (12.13.1), and a BEB port configuration managed object (12.16.2). Each such managed object is uniquely identified, within the BEB, by the combination of the ComponentID and Port Number (12.3) of the associated Bridge Port.

Each VIP associated with an I-component is mapped to a PIP associated with that I-component. In general, multiple VIPs are associated with a single PIP. PIPs are not Bridge Ports, though they are ports on BEBs, as they are not used directly by the MAC Relay Entity (see Clause 8) of a Bridge component. Each VIP is supported by one and only one PIP. Each PIP is therefore identified uniquely by the ComponentID and Port Number of any of the VIPs that it supports and by convention is referenced by the smallest Port Number supported by the PIP. Each PIP is managed using the PIP configuration managed object (12.16.4), and each VIP is managed using the VIP configuration managed object of (12.16.3).

PIPs and CBPs of a BEB may be internal or external. Each externally accessible port on a BEB is designated as a PNP, CBP, PIP, or CNP.

The following managed objects define the semantics of the management operations specific to BEBs:

d) The BEB configuration managed object (12.16.1)
e) The BEB/PB/VLAN Bridge Port configuration managed object (12.16.2)
f) The VIP configuration managed object (12.16.3)
g) The PIP configuration managed object (12.16.4)
h) The CBP configuration managed object (12.16.5)

NOTE—All objects specified in 12.16 are persistent over power-up/down and system reboot unless otherwise specified.

12.16.1 BEB configuration managed object

The BEB configuration managed object identifies a BEB and all the managed objects that manage the BEB. The management operations that can be performed on the BEB configuration managed object are as follows:

a) Read BEB configuration (12.16.1.1)
b) Set BEB configuration (12.16.1.2)
c) Create BEB component (12.16.1.3)
d) Delete BEB component (12.16.1.4)
e) Create BEB Bridge Port (12.16.1.5)
f) Create BEB PIP (12.16.1.6)
g) Delete BEB Bridge Port (12.16.1.7)
h) Delete BEB PIP (12.16.1.8)

Items marked "(MIRP only)" shall be supported if the B-component supports the Multiple I-SID Registration Protocol (MIRP) (Clause 39).

12.16.1.1 Read BEB configuration

12.16.1.1.1 Purpose

All BEBs shall implement the read BEB configuration function to obtain information regarding the type of components and ports within a BEB. Items marked "(MIRP only)" shall be supported if the B-component supports the Multiple I-SID Registration Protocol (MIRP) (Clause 39).

12.16.1.1.2 Inputs

None.

12.16.1.1.3 Outputs

a) BEB address—the MAC address for the BEB used to access the BEB configuration managed object (8.13.8). Each BEB has a single BEB address even if the BEB has many components.
b) BEB name—a text string of up to 32 characters, of locally determined significance.
c) Number of I-components—in the BEB, which may range from 0 to many.
d) I-component addresses—a list specifying the following for each I-component or a NULL list value for no I-components:
    1) ComponentID—the number of the I-component.
    2) A Bridge address that is the MAC address for the I-Component (8.13.8).
e) Number of B-components—in the BEB, which may be 0 or 1.
f) B-component address—a list specifying the following for the B-component or a NULL list value for no B-component:
    1) ComponentID—the number of the B-component.
    2) A Bridge address that is the MAC address for the B-component (8.13.8).

g) Number of BEB ports (MAC Entities).

h) Port addresses—a list specifying the following for each port:
   1) ComponentID—the number identifying the Bridge component associated with this port.
   2) An interface—either that component's Port Number for the Bridge Port, or in the case of a PIP, the PIP Index.
   3) Port address—the specific MAC address associated with the port (8.13.2).
   4) External port—a Boolean indicating that the port is an external port.

i) (MIRP only) A Boolean value specifying whether MIRP is (TRUE) or is not (FALSE) enabled in this B-component (Clause 39).

j) (MIRP only) The MIRP B-VID to which MIRPDUs transmitted from a PNP are to be assigned if item k) contains the value cbpMirpGroup (1). The value 0 (the default value) indicates that the CBP PVID is to be used (39.2.1.6).

k) (MIRP only) An enumerated value specifying what destination_address and vlan_identifier are to be used when the MIRP Participant transmits an MIRPDU from a PNP:
   1) cbpMirpGroup: Use the Nearest Customer Bridge group address from Table 8-1 with the MIRP B-VID (this is the default value) [item a) in 39.2.1.6];
   2) cbpMirpVlan: Use the Nearest Customer Bridge group address from Table 8-1 with the B-VID field from the Backbone Service Instance table [item b) in 39.2.1.6]; or
   3) cbpMirpTable: Use the Default Backbone Destination and B-VID fields from the Backbone Service Instance table [item c) in 39.2.1.6].

l) (MIRP only) A Boolean value specifying the administrative status requested by management for attaching a MIRP Participant to a PNP or management Port. If TRUE, the BEB is to attach a MIRP Participant to exactly one PNP or management Port, and if FALSE, no MIRP Participant is to be present on any PNP or management Port. Default value is TRUE (39.1.2).

m) (MIRP only) The read-only Bridge Port Number (or 0, if none) of the PNP to which the MIRP Participant is attached (39.1.2).

12.16.1.2 Set BEB configuration

12.16.1.2.1 Purpose

All BEBs shall implement the set BEB configuration function to set the BEB Name. Items marked "(MIRP only)" shall be supported if the B-component supports the Multiple I-SID Registration Protocol (MIRP) (Clause 39). All items are persistent over power up or reboot.

12.16.1.2.2 Inputs

a) BEB Name—a text string of up to 32 characters, of locally determined significance.

b) (MIRP only) A Boolean value specifying whether MIRP is (TRUE) or is not (FALSE) enabled in this B-component (Clause 39).

c) (MIRP only) The MIRP B-VID to which received MIRPDUs are to be assigned if item d) contains the value cbpMirpGroup (1). The value 0 (the default) indicates that the CBP PVID is to be used (39.2.1.6).

d) (MIRP only) An enumerated value specifying what destination_address and vlan_identifier are to be used when the MIRP Participant transmits an MIRPDU towards the MAC relay entity, either cbpMirpGroup (1), cbpMirpVlan (2), or cbpMirpTable (3) (39.2.1.6).

e) (MIRP only) A Boolean value specifying the administrative status requested by management for attaching a MIRP Participant to a PNP or management Port. If TRUE, the BEB is to attach a MIRP Participant to exactly one PNP or management Port, and if FALSE, no MIRP Participant is to be present on any PNP or management Port (39.1.2).

12.16.1.2.3 Outputs

None.

12.16.1.3 Create BEB component (optional)

12.16.1.3.1 Purpose

A BEB may implement the create BEB component function to allow the dynamic creation of new components. Components created by this command are persistent over power-up or reboot.

12.16.1.3.2 Inputs

a) ComponentType. This takes one of the following values:
   1) I-Comp
   2) B-Comp

12.16.1.3.3 Outputs

None.

12.16.1.4 Delete BEB component (optional)

12.16.1.4.1 Purpose

A BEB may implement the delete BEB component function to allow deletion of components. Component deletion using this command is persistent over power-up or reboot.

12.16.1.4.2 Inputs

a) ComponentID—indicates the component being deleted.

12.16.1.4.3 Outputs

None.

12.16.1.5 Create BEB Bridge Port (optional)

12.16.1.5.1 Purpose

A BEB may implement the create BEB Bridge Port function to allow dynamic creation of Bridge Ports. Bridge Ports created by this command are persistent over power-up or reboot.

12.16.1.5.2 Inputs

a) Port Index—indicates the port where the new Bridge Port will be created.
b) ComponentID—indicates the component where the new Bridge Port will be created.
c) Port type. This takes one of the following values:
   1) CNP
   2) PNP
   3) CBP
   4) VIP

12.16.1.5.3 Outputs

None.

12.16.1.6 Create BEB PIP (optional)

12.16.1.6.1 Purpose

A BEB may implement the create BEB PIP function to allow dynamic creation of PIPs. PIPs created by this command are persistent over power-up or reboot.

12.16.1.6.2 Inputs

a) Port Index—indicates the port where the new PIP will be created.
b) ComponentID—indicates the component where the new PIP will be created.

12.16.1.6.3 Outputs

None.

12.16.1.7 Delete BEB Bridge Port (optional)

12.16.1.7.1 Purpose

A BEB may implement the delete BEB Bridge Port function to allow deletion of Bridge Ports. Bridge Port deletion using this command is persistent over power-up or reboot.

12.16.1.7.2 Inputs

a) ComponentID—the component for the Bridge Port.
b) Port Number—the Port Number for the Bridge Port.

12.16.1.7.3 Outputs

None.

12.16.1.8 Delete BEB PIP (optional)

12.16.1.8.1 Purpose

A BEB may implement the delete BEB PIP function to allow deletion of PIPs. PIP deletion using this command is persistent over power-up or reboot.

12.16.1.8.2 Inputs

a) PIP Index—identifies the PIP within the BEB.

12.16.1.8.3 Outputs

None.

12.16.2 BEB/PB/VLAN Bridge Port configuration managed object

The management operation that can be performed on the BEB/PB/VLAN Bridge Port configuration managed object is as follows:

a) Read BEB/PB/VLAN Bridge Port configuration (12.16.2.1)

12.16.2.1 Read BEB/PB/VLAN Bridge Port configuration

12.16.2.1.1 Purpose

All BEBs shall implement the read BEB/PB/VLAN Bridge Port configuration function to obtain information regarding the port type of a Bridge Port on the BEB.

12.16.2.1.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.

12.16.2.1.3 Outputs

a) Port Type. This takes one of the following values:
    1) C-VLAN Port
    2) PNP (identical to the PNP Bridge Port type specified by 12.13.1)
    3) CNP (identical to the CNP Bridge Port type specified by 12.13.1)
    4) CEP (identical to the CEP Bridge Port type specified by 12.13.1)
    5) CBP (5.12, 6.11, 12.13.1 will indicate PNP)
    6) VIP (5.12, 6.10, 12.13.1 will indicate PNP)

NOTE—Support for C-VLAN ports requires equipment with VLAN Bridge (5.9) functions in addition to BEB (5.12) functions. Support for CEP ports requires equipment with Provider Bridge (5.10) functions in addition to BEB functions.

12.16.3 VIP configuration managed object

The VIP configuration managed object applies to each VIP (6.10) on a BEB whether its associated PIP is externally or internally accessible.

It includes:

a) The VIP configuration parameters, which provide the subset of the Bridge VLAN Configuration managed object (12.10.1) that is relevant for the configuration of the backbone service instance.

The management operations that can be performed are as follows:

b) Read VIP configuration (12.16.3.1)
c) Set VIP configuration (12.16.3.2)

12.16.3.1 Read VIP configuration

12.16.3.1.1 Purpose

All BEBs with I-components shall implement the read VIP configuration function to allow reading the current configuration of the VIPs (6.10) in an I-component of a BEB. Each VIP is configured by 12.8, 12.10, 12.16.3.2. The adminPointToPointMAC parameter is configured by 12.8.2.3.2 while the PVID and Acceptable Frame Types parameters are supplied by the Bridge Port configuration of 12.10.1.2 and 12.10.1.3.

12.16.3.1.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.

12.16.3.1.3 Outputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) PIP Name—a text string of up to 32 characters that identifies the PIP within a BEB with which this VIP is associated.
d) VIP-ISID—the I-SID associated with this VIP (6.10).
e) Default Backbone Destination—an EUI-48 DA (6.10.2).
f) enableConnectionIdentifier—A Boolean to indicate if the connection_identifier parameter is allowed to learn associations between a B-MAC address and a C-MAC address (6.10).

12.16.3.2 Set VIP configuration

12.16.3.2.1 Purpose

All BEBs with I-components shall implement the set VIP configuration function to allow setting the configuration of the internal VIP in the I-component of a BEB.

12.16.3.2.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) VIP-ISID—the I-SID associated with this VIP (6.10).
d) enableConnectionIdentifier—A Boolean that determines if the connection_identifier parameter is allowed to learn associations between a B-MAC address and a C-MAC address (6.10). The default value is TRUE. This parameter should be configured to FALSE at the root node of a point-to-multipoint TESI.

12.16.3.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Bridge Port identified by the ComponentID and Port Number is not a VIP.
    2) Operation accepted.

12.16.4 PIP configuration managed object

The PIP Configuration managed object applies to each PIP (6.10) on a BEB.

It includes the following:

a) The VIP mapping, which provides the set of VIPs multiplexed on this PIP
b) The PIP MAC address, which is used as the B-SA for all encapsulated frames

The management operations that can be performed are as follows:

c) Read PIP Configuration (12.16.4.1)
d) Optionally, Set PIP Configuration (12.16.4.2)
e) Read VIP to PIP mapping (12.16.4.3)
f) Optionally, Set VIP to PIP mapping (12.16.4.4)

g) Read PIP Priority Code Point Selection (12.16.4.5)
h) Set PIP Priority Code Point Selection (12.16.4.6)
i) Read PIP Priority Code Point Decoding Table (12.16.4.7)
j) Optionally, Set PIP Priority Code Point Decoding Table (12.16.4.8)
k) Read PIP Priority Code Point Encoding Table (12.16.4.9)
l) Optionally, Set PIP Priority Code Point Encoding Table (12.16.4.10)
m) Read PIP Use_DEI parameter (12.16.4.11)
n) Optionally, Set PIP Use_DEI parameter (12.16.4.12)
o) Read PIP Require Drop Encoding parameter (12.16.4.13)
p) Optionally, Set PIP Require Drop Encoding parameter (12.16.4.14)

12.16.4.1 Read PIP configuration

12.16.4.1.1 Purpose

All BEBs with I-components shall implement the read PIP configuration function to allow reading the current configuration of the PIP in the I-component of a BEB.

12.16.4.1.2 Inputs

a) PIP Index—an identifier for the PIP within this BEB.

12.16.4.1.3 Outputs

a) PIP B-MAC address—identifies the PIP (6.10.2).
b) PIP Name—a text string of up to 32 characters used to identify a PIP within a BEB.
c) ComponentID—the number identifying the I-component with this PIP.
d) VIP map—a bit array of 4094 bits indicating all the VIPs associated with this port.

12.16.4.2 Set PIP configuration (optional)

12.16.4.2.1 Purpose

All BEBs with I-components may implement the set PIP configuration function to set the current configuration of the PIP in the I-component of a BEB.

12.16.4.2.2 Inputs

a) PIP Index—an identifier for the PIP within this BEB.
b) PIP B-MAC address—the B-MAC address used by this PIP in the B-SA field of transmitted frames.
c) PIP Name—a text string of up to 32 characters used to identify the PIP within a BEB.
d) VIP map—a bit array of 4094 bits indicating all the VIPs associated with this PIP.

12.16.4.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the PIP Index is invalid
    2) Operation rejected because the VIP map identifies a port that is not a VIP
    3) Operation accepted

12.16.4.3 Read VIP to PIP mapping

12.16.4.3.1 Purpose

All BEBs with I-components shall implement the read VIP to PIP mapping function to allow reading the VIP to PIP map information from the PIP configuration managed object.

12.16.4.3.2 Inputs

a) ComponentID—the number identifying a Bridge component with a VIP.
b) Port Number—that component's Port Number for this VIP.

12.16.4.3.3 Outputs

a) ComponentID—the number identifying a Bridge component with a VIP.
b) Port Number—that component’s Port Number for this VIP.
c) PIP Index—identifies the PIP supporting this VIP.
d) PIP B-MAC address—the B-MAC address used by this PIP supporting this VIP (6.10.2).
e) PIP Name—a text string of up to 32 characters identifying the PIP supporting this VIP.

12.16.4.4 Set VIP to PIP mapping (optional)

12.16.4.4.1 Purpose

All BEBs with I-components may implement the set VIP to PIP mapping function to allow binding individual VIPs to PIPs. The set VIP to PIP mapping function allows setting map entries for individual VIPs while the set PIP configuration function sets the entire VIP to PIP map.

12.16.4.4.2 Inputs

a) ComponentID—the number identifying a Bridge component with a VIP.
b) Port Number—that component’s Port Number for this VIP.
c) PIP Index—an identifier for this PIP within this component of the BEB.

12.16.4.4.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the ComponentID and Port Number do not identify a VIP.
    2) Operation rejected because the PIP Index does not identify a PIP within the specified component.
    3) Operation accepted.

12.16.4.5 Read PIP Priority Code Point Selection

12.16.4.5.1 Purpose

To read which row of the Priority Code Point Encoding Table and Priority Code Point Decoding Table (6.10.3) is currently selected for use on this PIP.

12.16.4.5.2 Inputs

a) PIP Index—an identifier for this PIP within this component of the BEB.

12.16.4.5.3 Outputs

a) Priority Code Point Selection. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.16.4.6 Set PIP Priority Code Point Selection

12.16.4.6.1 Purpose

To set which row of the Priority Code Point Encoding Table and Priority Code Point Decoding Table (6.10.3) will be selected for use on this PIP.

12.16.4.6.2 Inputs

a) PIP Index—an identifier for this PIP within this component of the BEB.
b) Priority Code Point Selection. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.16.4.6.3 Outputs

None.

12.16.4.7 Read PIP Priority Code Point Decoding Table

12.16.4.7.1 Purpose

To read the current contents of a row in the Priority Code Point Decoding Table (6.10.3) for a PIP.

12.16.4.7.2 Inputs

a) PIP Index—an identifier for this PIP.
b) Priority Code Point Row. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.16.4.7.3 Outputs

a) Priority value for Priority Code Point 0: Integer in range 0–7.
b) Drop_eligible value for Priority Code Point 0: Boolean.
c) Priority value for Priority Code Point 1: Integer in range 0–7.
d) Drop_eligible value for Priority Code Point 1: Boolean.
e) Priority value for Priority Code Point 2: Integer in range 0–7.
f) Drop_eligible value for Priority Code Point 2: Boolean.

g) Priority value for Priority Code Point 3: Integer in range 0–7.
h) Drop_eligible value for Priority Code Point 3: Boolean.
i) Priority value for Priority Code Point 4: Integer in range 0–7.
j) Drop_eligible value for Priority Code Point 4: Boolean.
k) Priority value for Priority Code Point 5: Integer in range 0–7.
l) Drop_eligible value for Priority Code Point 5: Boolean.
m) Priority value for Priority Code Point 6: Integer in range 0–7.
n) Drop_eligible value for Priority Code Point 6: Boolean.
o) Priority value for Priority Code Point 7: Integer in range 0–7.
p) Drop_eligible value for Priority Code Point 7: Boolean.

12.16.4.8 Set PIP Priority Code Point Decoding Table (optional)

12.16.4.8.1 Purpose

To modify the contents of a row in the Priority Code Point Decoding Table (6.10.3) for a PIP.

12.16.4.8.2 Inputs

a) PIP Index—an identifier for this PIP.
b) b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D
c) Priority value for Priority Code Point 0: Integer in range 0–7.
d) Drop_eligible value for Priority Code Point 0: Boolean.
e) Priority value for Priority Code Point 1: Integer in range 0–7.
f) Drop_eligible value for Priority Code Point 1: Boolean.
g) Priority value for Priority Code Point 2: Integer in range 0–7.
h) Drop_eligible value for Priority Code Point 2: Boolean.
i) Priority value for Priority Code Point 3: Integer in range 0–7.
j) Drop_eligible value for Priority Code Point 3: Boolean.
k) Priority value for Priority Code Point 4: Integer in range 0–7.
l) Drop_eligible value for Priority Code Point 4: Boolean.
m) Priority value for Priority Code Point 5: Integer in range 0–7.
n) Drop_eligible value for Priority Code Point 5: Boolean.
o) Priority value for Priority Code Point 6: Integer in range 0–7.
p) Drop_eligible value for Priority Code Point 6: Boolean.
q) Priority value for Priority Code Point 7: Integer in range 0–7.
r) Drop_eligible value for Priority Code Point 7: Boolean.

12.16.4.8.3 Outputs

None.

12.16.4.9 Read PIP Priority Code Point Encoding Table

12.16.4.9.1 Purpose

To read the current contents of a row in the Priority Code Point Encoding Table (6.10.3) for a Port.

12.16.4.9.2 Inputs

a) PIP Index—an identifier for this PIP.
b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D

12.16.4.9.3 Outputs

a) Priority Code Point value for priority 0 with drop_eligible False: Integer in range 0–7.
b) Priority Code Point value for priority 0 with drop_eligible True: Integer in range 0–7.
c) Priority Code Point value for priority 1 with drop_eligible False: Integer in range 0–7.
d) Priority Code Point value for priority 1 with drop_eligible True: Integer in range 0–7.
e) Priority Code Point value for priority 2 with drop_eligible False: Integer in range 0–7.
f) Priority Code Point value for priority 2 with drop_eligible True: Integer in range 0–7.
g) Priority Code Point value for priority 3 with drop_eligible False: Integer in range 0–7.
h) Priority Code Point value for priority 3 with drop_eligible True: Integer in range 0–7.
i) Priority Code Point value for priority 4 with drop_eligible False: Integer in range 0–7.
j) Priority Code Point value for priority 4 with drop_eligible True: Integer in range 0–7.
k) Priority Code Point value for priority 5 with drop_eligible False: Integer in range 0–7.
l) Priority Code Point value for priority 5 with drop_eligible True: Integer in range 0–7.
m) Priority Code Point value for priority 6 with drop_eligible False: Integer in range 0–7.
n) Priority Code Point value for priority 6 with drop_eligible True: Integer in range 0–7.
o) Priority Code Point value for priority 7 with drop_eligible False: Integer in range 0–7.
p) Priority Code Point value for priority 7 with drop_eligible True: Integer in range 0–7.

12.16.4.10 Set PIP Priority Code Point Encoding Table (optional)

12.16.4.10.1 Purpose

To modify the contents of a row in the Priority Code Point Encoding Table (6.10.3) for a PIP.

12.16.4.10.2 Inputs

a) PIP Index—an identifier for this PIP.
b) b) Priority Code Point Row. This takes one of the following values:
    1) 8P0D
    2) 7P1D
    3) 6P2D
    4) 5P3D
c) Priority Code Point value for priority 0 with drop_eligible False: Integer in range 0–7.
d) Priority Code Point value for priority 0 with drop_eligible True: Integer in range 0–7.
e) Priority Code Point value for priority 1 with drop_eligible False: Integer in range 0–7.
f) Priority Code Point value for priority 1 with drop_eligible True: Integer in range 0–7.
g) Priority Code Point value for priority 2 with drop_eligible False: Integer in range 0–7.
h) Priority Code Point value for priority 2 with drop_eligible True: Integer in range 0–7.
i) Priority Code Point value for priority 3 with drop_eligible False: Integer in range 0–7.
j) Priority Code Point value for priority 3 with drop_eligible True: Integer in range 0–7.
k) Priority Code Point value for priority 4 with drop_eligible False: Integer in range 0–7.
l) Priority Code Point value for priority 4 with drop_eligible True: Integer in range 0–7.
m) Priority Code Point value for priority 5 with drop_eligible False: Integer in range 0–7.
n) Priority Code Point value for priority 5 with drop_eligible True: Integer in range 0–7.

o) Priority Code Point value for priority 6 with drop_eligible False: Integer in range 0–7.
p) Priority Code Point value for priority 6 with drop_eligible True: Integer in range 0–7.
q) Priority Code Point value for priority 7 with drop_eligible False: Integer in range 0–7.
r) Priority Code Point value for priority 7 with drop_eligible True: Integer in range 0–7.

12.16.4.10.3 Outputs

None.

12.16.4.11 Read PIP Use_DEI parameter

12.16.4.11.1 Purpose

To read the current state of the Use_DEI parameter (6.10.3) for the PIP.

12.16.4.11.2 Inputs

a) PIP Index—an identifier for this PIP.

12.16.4.11.3 Outputs

a) Use_DEI parameter: Boolean.

12.16.4.12 Set PIP Use_DEI parameter (optional)

12.16.4.12.1 Purpose

To set the current state of the Use_DEI parameter (6.10.3) for the PIP.

12.16.4.12.2 Inputs

a) PIP Index: an identifier for this PIP.
b) Use_DEI parameter: Boolean.

12.16.4.12.3 Outputs

None.

12.16.4.13 Read PIP Require Drop Encoding parameter

12.16.4.13.1 Purpose

To read the current state of the Require Drop Encoding parameter (8.6.6) for the PIP.

12.16.4.13.2 Inputs

a) PIP Index—an identifier for this PIP.

12.16.4.13.3 Outputs

a) Require Drop Encoding parameter—Boolean.

12.16.4.14 Set PIP Require Drop Encoding parameter (optional)

12.16.4.14.1 Purpose

To set the current state of the Require Drop Encoding parameter (8.6.6) for the PIP.

12.16.4.14.2 Inputs

a) PIP Index—an identifier for this PIP.
b) Require Drop Encoding parameter—Boolean.

12.16.4.14.3 Outputs

None.

12.16.5 CBP Configuration managed object

The CBP Configuration managed object includes the following:

a) A Backbone Service Instance table (6.11)
b) A Flow Filtering Control Table (44.2.2)

Item b) is applicable only on BEBs supporting ECMP with flow filtering.

The management operations that can be performed are as follows:

c) Read Backbone Service Instance table entry (12.16.5.1)
d) Set Backbone Service Instance table entry (12.16.5.2)
e) TESI assignment managed object (12.16.5.3)
f) Read Flow Filtering Control Table entry (12.16.5.4)
g) Set Flow Filtering Control Table entry (12.16.5.5)

12.16.5.1 Read Backbone Service Instance table entry

12.16.5.1.1 Purpose

All BEBs shall implement the read Backbone Service Instance table entry function to allow reading the Backbone Service Instance table entries in the CBP configuration managed object.

12.16.5.1.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) Backbone-SID—identifying the backbone service instance (6.11).

12.16.5.1.3 Outputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) Backbone-SID—the identifier used in the PBBN for the backbone service instance (6.11).
d) B-VID (optional)—12-bit VID (6.11).
e) Default Backbone Destination (optional)—EUI-48 DA (6.11).
f) Local-SID (optional)—24-bit I-SID value (6.11).

12.16.5.2 Set Backbone Service Instance table entry

12.16.5.2.1 Purpose

All BEBs shall implement the set Backbone Service Instance table entry function to allow configuration of the backbone service instances available on each CBP. This information is persistent over power-up or reboot.

12.16.5.2.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) Backbone-SID—24-bit I-SID value (6.11).
d) B-VID (optional)—12-bit VID (6.11).
e) Default Backbone Destination (optional)—EUI-48 DA (6.11).
f) Local-SID (optional)—24-bit I-SID value (6.11).

12.16.5.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the ComponentID and Port Number do not identify a valid CBP.
    2) Operation rejected because the B-VID is assigned to ECMP with flow filtering (12.25.4.1, Table 44-1) and the Bridge does not support flow filtering.
    3) Operation accepted.

12.16.5.3 TESI assignment managed object

12.16.5.3.1 Purpose

All CBPs providing TESIs shall implement the TESI assignment managed object to assign a particular TESI on this CBP.

12.16.5.3.2 Inputs

a) ComponentID—the number identifying the Bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) A series of ordered 3-tuples of the form <ESP-DA, ESP-SA, ESP-VID>.

12.16.5.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the ComponentID and Port Number do not identify a valid CBP.
    2) Operation rejected because a 3-tuple in the provided series has a VID value in its ESP-VID field that is not allocated to TE-MSTID.
    3) Operation rejected because no 3-tuple in the provided series has the CBP's MAC address in its ESP-SA field.
    4) Operation rejected because there are only two 3-tuples provided and the values in their ESP-DA and ESP-SA fields are not reversed.
    5) Operation rejected because there are more than two different values specified in the ESP-DA fields of the provided series of 3-tuples.
    6) Operation accepted.

12.16.5.4 Read Flow Filtering Control Table entry

12.16.5.4.1 Purpose

BEBs supporting ECMP with flow filtering shall implement the read Flow Filtering Control Table entry function to allow reading the Flow Filtering Control Table entries in the CBP configuration managed object.

12.16.5.4.2 Inputs

a) ComponentID—the number identifying the bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) VID—identifying a B-VID.

12.16.5.4.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the ComponentID and Port Number do not identify a valid CBP
    2) Operation rejected because the CBP does not support F-TAG processing
    3) Operation accepted
b) ComponentID—the number identifying the bridge component associated with this port.
c) Port Number—that component's Port Number for the Bridge Port.
d) VID—the identifier of a B-VLAN.
e) Flow Filtering—indicates whether flow filtering behavior is enabled on the port for the VID (enabled/disabled).
f) Flow Hash Generation—indicates whether flow hash generation is enabled on the port for the VID (enabled/disabled).
g) TTL Value—the initial TTL value for frames entering the flow filtering SPT Domain (1..63).

12.16.5.5 Set Flow Filtering Control Table entry

12.16.5.5.1 Purpose

BEBs supporting ECMP with flow filtering shall implement the set Flow Filtering Control Table entry function to allow configuration of the initial TTL value for frames entering an SPT Domain. This information is persistent over power-up or reboot.

12.16.5.5.2 Inputs

a) ComponentID—the number identifying the bridge component associated with this port.
b) Port Number—that component's Port Number for the Bridge Port.
c) VID—12-bit VID.
d) TTL Value—the initial TTL value for frames entering the SPT Domain, Integer in range 1–63. The default value is 8.

NOTE—The Flow Filtering and Flow Hash Generation fields in the Flow Filtering Control Table are controlled by ISIS-SPB (28.8) and therefore are not settable by management.

12.16.5.5.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the ComponentID and Port Number do not identify a valid CBP
    2) Operation rejected because the CBP does not support F-TAG processing
    3) Operation accepted

12.17 DDCFM entities

The following are the DDCFM managed objects in a Bridge:

a) DDCFM Stack managed object (12.17.1)
b) Reflection Responder managed object (12.17.2)
c) RFM Receiver managed object (12.17.3)
d) Decapsulator Responder managed object (12.17.4)
e) SFM Originator managed object (12.17.5)

12.17.1 DDCFM Stack managed object

There is one DDCFM Stack managed object per Bridge. It allows the network administrator to retrieve DDCFM entities configured on a particular Bridge Port or an aggregated port within a Bridge Port. The management operation that can be performed is as follows:

a) Read DDCFM Stack managed object (12.17.1.1)

12.17.1.1 Read DDCFM Stack managed object

12.17.1.1.1 Purpose

To retrieve DDCFM entities configured on a particular Bridge Port or an aggregated port within a Bridge Port.

12.17.1.1.2 Input

a) An interface, either a Bridge Port, or an aggregated port within a Bridge Port.

12.17.1.1.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because of invalid reference to an interface;
    2) Operation accepted, but there is no DDCFM entity configured on the specified interface; or
    3) Operation accepted, there are (is a) DDCFM entities (entity) configured on the specified interface, and
b) If there are DDCFM entities configured on the specified interface, the following attributes should be returned:
    1) An RR is configured, its associated maintenance domain, and the value indicating its direction; and/or
    2) An RFM Receiver is configured, its associated maintenance domain; and/or
    3) A DR is configured, its associated maintenance domain, and its associated MA; and/or
    4) An SFM Originator is configured, its associated maintenance domain, its associated MA, and the value indicating its direction.

12.17.2 Reflection Responder managed object

The management operations that can be performed on the Reflection Responder managed object are as follows:

a) Create Reflection Responder managed object (12.17.2.1)
b) Write Reflection Responder managed object’s attributes (12.17.2.2)
c) Read Reflection Responder managed object’s attributes (12.17.2.3)
d) Delete Reflection Responder managed object (12.17.2.4)

e) Activate Reflection Responder (12.17.2.5)
f) Deactivate Reflection Responder (12.17.2.6)

12.17.2.1 Create Reflection Responder managed object

12.17.2.1.1 Purpose

To create a Reflection Responder (RR). After the creation, all the writable attributes have their default values unless being configured differently by the Write Reflection Responder managed object operation (12.17.2.2). The RR is in the inactive state after the creation and remains so until activated by a subsequent Activate Reflection Responder operation (12.17.2.5).

12.17.2.1.2 Inputs

a) A reference to a particular Reflection Responder managed object, which includes the following:
   1) An interface (either a Bridge Port or an aggregated port within a Bridge Port) on which the RR is defined. The interface identifier could be MAC address or port identifier.
   2) A reference to a particular Maintenance Domain managed object (12.14.5).
   3) A value indicating the direction in which the RR faces, which can be either Down [Active SAP is further away from the Frame filtering entity (default)], or Up (Active SAP is closer to the Frame filtering entity).

12.17.2.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid interface reference or invalid Maintenance Domain level
   2) Operation accepted

12.17.2.2 Write Reflection Responder managed object's attributes

12.17.2.2.1 Purpose

To configure and alter the value of one or more writable attribute(s) of an Reflection Responder managed object. The attributes of an Reflection Responder managed object cannot be modified when the RR is active.

12.17.2.2.2 Inputs

a) Reference to a Reflection Responder managed object [item a) in 12.17.2.1.2].
b) Writable attributes are as follows:
   1) Reference to a Maintenance Association managed object (12.14.6) within the RR's Maintenance Domain. If set to 0, the MA associated with the filtered frame shall be used for the Reflected Frame Message (RFM) emitted by the RR.
   2) Reflection Filter definition(s), which is to specify what data frames are selected to be reflected. Multiple filters can be combined together by "&& (and)", "|| (or)", or "! (negation)" operations with precedence association being determined by "( )." DDCFM-capable Bridges shall support each of the following filter primitives. Implementers may support additional filters, such as length of data frame being equal, larger, or smaller than a particular value.
      — All.
      — VID== vid; This primitive uses SVID if the RR is defined on a S component, and CVID if the RR is defined on a C component. Untagged frame shall not be selected by this filter primitive.
      — DA == xx.xx.xx.xx.xx.xx.
      — SA == xx.xx.xx.xx.xx.xx.
      — The first 2 bytes of the EtherType field ==xx.

3) Sampling Interval (29.2.3.4).
4) Reflection Target Address, which is a MAC address to which the reflected frames are targeted. Only individual address is allowed for the Reflection Target Address. The default is the source_address of the selected data frame being used for Reflection Target Address.
5) Continue option, indicating whether the selected data frames are to be continued toward the destination_address specified in the data frame. The default is TRUE to allow data frames to be forwarded to their destinations.
6) Boolean variable indicating if the duration is in seconds or in number of data frames.
7) Duration in seconds for the RR to remain active after being activated. Minimum 1 and maximum is implementation dependent.
8) The number data frames for the RR to reflect after being activated. Once this frame count is reached, the RR shall be deactivated automatically. Default is 0, which means the duration is limited by RR's timer.
9) The priority and drop_eligible parameters to be used in the transmitted encapsulated frames (default value: the highest priority, i.e., that with the highest numerical value, allowed to pass through the Bridge Port for any of the VID. Default value for drop_eligible is FALSE).
10) FloodingEnabled Flag indicating whether flooding is allowed if Egress port cannot be identified for RFM by the FDB.
11) Truncation flag indicating if the received data frame should be truncated to keep the length of RFM encapsulated frame not exceeding the Maximum Service Data Unit Size (6.5.8). If the Truncation flag is not set and the RFM encapsulated frame exceeds the Maximum Service Data Unit Size, the filtered data frame is fragmented to two smaller frames and encapsulated in two separate RFMs.

12.17.2.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the referenced Reflection Responder managed object does not exist
   2) Operation rejected because of one or more invalid writable attribute(s)
   3) Operation rejected because the referenced RR is active
   4) Operation accepted

12.17.2.3 Read Reflection Responder managed object's attributes

12.17.2.3.1 Purpose

To retrieve values of attributes in a Reflection Responder managed object.

12.17.2.3.2 Input

a) Reference to a particular Reflection Responder managed object [item a) in 12.17.2.1.2].

12.17.2.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to the Reflection Responder managed object
   2) Operation rejected because there is no RR with the given reference
   3) Operation accepted
b) If the operation is accepted, the following attributes for the RR should be returned:
   1) Reference to the Reflection Responder managed object.
   2) Reference to a Maintenance Association managed object (12.14.6) for the RFMs generated by the RR (writable).
   3) Reflection Filter definition(s) (writable).
   4) Sampling Interval (writable).

5) The Reflection Target Address (writable).
6) Continue option (writable).
7) Duration for RR to stay active after being activated (writable).
8) DurationInTimeFlag (writable).
9) The priority and drop_eligible parameters to be used in the transmitted RFMs (writable).
10) FloodingFlag (writable).
11) Truncation flag (writable).
12) Activation status (TRUE or FALSE).
13) Remaining time or count left for the RR to be active.
14) nextRFMtransID (29.3.1.16) value.

12.17.2.4 Delete Reflection Responder managed object

12.17.2.4.1 Purpose

To delete a Reflection Responder managed object. If the corresponding RR is still active, the deletion will deactivate the RR and then delete the corresponding managed object.

12.17.2.4.2 Input

a) Reference to a Reflection Responder managed object [item a) in 12.17.2.1.2].

12.17.2.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to RR
   2) Operation rejected because the referenced RR managed does not exist
   3) Operation accepted

12.17.2.5 Activate Reflection Responder

12.17.2.5.1 Purpose

To activate an RR.

Depending on the filter conditions specified for each RR, some RRs can potentially reflect large amount of data frames into the network, which could cause excessive extra traffic injected into the network and impact network performance. For those RRs, it is recommended that no more than one instance of the Reflection Responder managed object be activated per MD for an RR associated with an MP and that no more than one instance of the Reflection Responder managed object be activated per VID for an RR not associated with an MP (e.g., for an RR created on a Bridge Port).

12.17.2.5.2 Inputs

a) Reference to a Reflection Responder managed object [item a) in 12.17.2.1.2].

12.17.2.5.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because invalid reference or the referenced RR does not exist
   2) Operation rejected because of the referenced RR already being activated
   3) Operation accepted

12.17.2.6 Deactivate Reflection Responder

12.17.2.6.1 Purpose

To deactivate an active RR before its duration expires.

12.17.2.6.2 Input

a) Reference to a Reflection Responder managed object [item a) in 12.17.2.1.2].

12.17.2.6.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because invalid reference or the referenced RR does not exist
   2) Operation rejected because of the referenced RR not being activated
   3) Operation accepted

12.17.3 RFM Receiver managed object

The management operations that can be performed on the RFM Receiver managed object are as follows:

a) Create RFM Receiver managed object (12.17.3.1)
b) Delete RFM Receiver managed object (12.17.3.2)

An RFM Receiver is active when the corresponding RFM Receiver managed object is created. Therefore, there is no “Activate and Deactivate” operations for the RFM Receiver managed object.

12.17.3.1 Create RFM Receiver managed object

12.17.3.1.1 Purpose

To create an RFM Receiver managed object. Once an RFM Receiver managed object is created, the corresponding RFM Receiver is able to receive RFMs.

12.17.3.1.2 Inputs

a) Reference to an RFM Receiver managed object, which could be either:
   1) Reference to an MP or
   2) An interface (either a Bridge Port or an aggregated port within a Bridge Port) on which RFM Receiver is created and a reference to the corresponding RR’s Maintenance Domain managed object.

12.17.3.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to the RFM Receiver managed object
   2) Operation rejected because the referenced RFM Receiver managed object already exists
   3) Operation accepted

12.17.3.2 Delete RFM Receiver managed object

12.17.3.2.1 Purpose

To delete an RFM Receiver managed object.

12.17.3.2.2 Input

a) Reference to an RFM Receiver managed object [item a) in 12.17.3.1.2].

12.17.3.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to the RFM Receiver managed object
   2) Operation rejected because the referenced RFM Receiver managed object does not exist
   3) Operation accepted

12.17.4 Decapsulator Responder managed object

The management operations that can be performed on the Decapsulator Responder managed object are as follows:

a) Create Decapsulator Responder managed object (12.17.4.1)
b) Read Decapsulator Responder managed object (12.17.4.2)
c) Write Decapsulator Responder managed object's attributes (12.17.4.3)
d) Delete Decapsulator Responder managed object (12.17.4.4)
e) Activate Decapsulator Responder (12.17.4.5)
f) Deactivate Decapsulator Responder (12.17.4.6)

12.17.4.1 Create Decapsulator Responder managed object

12.17.4.1.1 Purpose

To create a Decapsulator Responder managed object and corresponding Decapsulator Responder (DR).

12.17.4.1.2 Inputs

a) Reference to a DR, which could be either:
   1) Reference to an MP or
   2) A triple consisting of an interface (either a Bridge Port or an aggregated port within a Bridge Port), a reference to a Maintenance Domain managed object, and a reference to a Maintenance Association managed object.

12.17.4.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to a Decapsulator Responder managed object.
   2) Operation rejected because the referenced Decapsulator Responder managed object already exists.
   3) Operation accepted.

12.17.4.2 Read Decapsulator Responder managed object

12.17.4.2.1 Purpose

To retrieve the attributes of a Decapsulator Responder managed object.

12.17.4.2.2 Input

a) Reference to a Decapsulator Responder managed object [item a) in 12.17.4.1.2].

12.17.4.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to a Decapsulator Responder managed object.
   2) Operation rejected because the referenced Decapsulator Responder managed object does not exist.
   3) Operation accepted.
b) If the operation is accepted, the following attributes for the DR should be returned:
   1) Reference to the Decapsulator Responder managed object.
   2) MAC address of the SFM Originator (writable).
   3) The value of SourceAddressStayFlag (writable).
   4) The value of FloodingEnabled flag (writable).
   5) The specified duration in seconds, for DR to remain active once activated (writable).
   6) Activation status.
   7) Remaining time left for DR to be active.
   8) The total number of out-of-sequence SFMs received (29.3.8.7).

12.17.4.3 Write Decapsulator Responder managed object's attributes

12.17.4.3.1 Purpose

To alter the value of one or more attributes of a Decapsulator Responder managed object when the corresponding DR is not active.

12.17.4.3.2 Inputs

a) Reference to a Decapsulator Responder managed object [item a) in 12.17.4.1.2].
b) Reference to the attribute whose value is to be changed:
   1) Boolean flag, SourceAddressStayFlag, to enforce the DR not to replace the source_address field of the decapsulated frame with the DR's own MAC address. Default is FALSE.
   2) MAC address of the SFM Originator, which is optional.
   3) Boolean FloodingEnabled flag indicating if flooding is allowed (TRUE) or not (FALSE) if the Egress port cannot be identified by the FDB.
   4) Duration in seconds, for DR to remain active once activated.

12.17.4.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to a Decapsulator Responder managed object.
   2) Operation rejected because the referenced Decapsulator Responder managed object does not exist.
   3) Operation rejected because of invalid attribute reference or invalid value.
   4) Operation rejected because the referenced DR is active.
   5) Operation accepted.

12.17.4.4 Delete Decapsulator Responder managed object

12.17.4.4.1 Purpose

To delete a Decapsulator Responder managed object. If the DR is still active, the deletion will deactivate the DR first and then delete the corresponding managed object.

12.17.4.4.2 Input

a) Reference to a Decapsulator Responder managed object [item a) in 12.17.4.1.2].

12.17.4.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference to a Decapsulator Responder managed object.
   2) Operation rejected because the referenced Decapsulator Responder managed object does not exist.
   3) Operation accepted.

12.17.4.5 Activate Decapsulator Responder

12.17.4.5.1 Purpose

To activate a DR.

12.17.4.5.2 Input

a) Reference to the Decapsulator Responder managed object [item a) in 12.17.4.1.2].

12.17.4.5.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference.
   2) Operation rejected because the referenced Decapsulator Responder managed object does not exist.
   3) Operation rejected because the referenced DR has already been activated.
   4) Operation accepted.

12.17.4.6 Deactivate Decapsulator Responder

12.17.4.6.1 Purpose

To deactivate a DR.

12.17.4.6.2 Input

a) Reference to the Decapsulator Responder managed object [item a) in 12.17.4.1.2].

12.17.4.6.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference.
   2) Operation rejected because the referenced Decapsulator Responder managed object does not exist.
   3) Operation rejected because the referenced DR is not active.
   4) Operation accepted.

12.17.5 SFM Originator managed object

The management operations that can be performed on the SFM Originator managed object are as follows:

a) Create SFM Originator managed object (12.17.5.1)
b) Read SFM Originator managed object (12.17.5.2)
c) Delete SFM Originator managed object (12.17.5.3)

d) Write SFM Originator managed object's attributes (12.17.5.4)
e) Activate SFM Originator (12.17.5.5)
f) Deactivate SFM Originator (12.17.5.6)

12.17.5.1 Create SFM Originator managed object

12.17.5.1.1 Purpose

To create a SFM Originator managed object.

12.17.5.1.2 Inputs

a) Reference to a SFM Originator managed object, which could be either:
   1) Reference to an MP or
   2) An interface (either a Bridge Port, or an aggregated port within a Bridge Port), a reference to a Maintenance Domain managed object, a reference to a Maintenance Association managed object, and a value indicating the direction in which the SFM Originator faces on the interface.

12.17.5.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference
   2) Operation rejected because the referenced SFM Originator managed object already exists
   3) Operation accepted

12.17.5.2 Read SFM Originator managed object

12.17.5.2.1 Purpose

To retrieve attributes of SFM Originator managed object.

12.17.5.2.2 Inputs

a) Reference to a SFM Originator managed object [item a) in 12.17.5.1.2].

12.17.5.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference
   2) Operation rejected because the referenced SFM Originator managed object does not exist
   3) Operation accepted
b) If the operation is accepted, following attributes for the SFM Originator should be returned:
   1) MAC address of the SFM Originator
   2) MAC address of the corresponding DR (writable)
   3) Duration (writable)
   4) Activation status: TRUE/FALSE
   5) The remaining time left for the SFM Originator to remain active

12.17.5.3 Delete SFM Originator managed object

12.17.5.3.1 Purpose

To delete a SFM Originator managed object, and the corresponding SFM Originator.

12.17.5.3.2 Inputs

a) The reference to a SFM Originator managed object [item a) in 12.17.5.1.2].

12.17.5.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference
   2) Operation rejected because the referenced SFM Originator managed object does not exist
   3) Operation accepted

12.17.5.4 Write SFM Originator managed object's attribute

12.17.5.4.1 Purpose

To change an attribute of a SFM Originator managed object.

12.17.5.4.2 Inputs

a) Reference to a SFM Originator managed object [item a) in 12.17.5.1.2].
b) MAC address of the corresponding DR.
c) Duration in seconds, for SFM Originator to stay active once activated.

12.17.5.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference of SFM Originator managed object or the attributes.
   2) Operation rejected because the referenced SFM Originator managed object does not exist.
   3) Operation accepted.

12.17.5.5 Activate SFM Originator

12.17.5.5.1 Purpose

To activate a SFM Originator.

12.17.5.5.2 Input

a) Reference to the SFM Originator managed object [item a) in 12.17.5.1.2].

12.17.5.5.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference
   2) Operation rejected because the referenced SFM Originator managed object does not exist
   3) Operation rejected because the referenced SFM Originator has already been activated
   4) Operation accepted

12.17.5.6 Deactivate SFM Originator

12.17.5.6.1 Purpose

To deactivate a SFM Originator.

12.17.5.6.2 Input

a) Reference to a SFM Originator managed object [item a) in 12.17.5.1.2].

12.17.5.6.3 Output

a) Operation status. This takes one of the following values:
   1) Operation rejected because of invalid reference
   2) Operation rejected because the referenced SFM Originator managed object does not exist
   3) Operation rejected because the referenced SFM Originator is not active
   4) Operation accepted

12.18 PBB-TE Protection Switching managed objects

The PBB-TE Protection Switching managed objects model operations that create, modify, delete, or inquire about, the configuration and the operation of protection switching. The following are the PBB-TE Protection Switching managed objects in a B-component of an IB-BEB capable of supporting TESIs:

a) The TE protection group list managed object
b) The TE protection group managed object

12.18.1 TE protection group list managed object

There is one TE protection group list managed object per IB-BEB. It contains a list of the TE protection groups that have been configured on the IB-BEB.

The management operations that can be performed on the TE protection group list managed object are as follows:

a) Read TE protection group list
b) Create TE protection group managed object
c) Delete TE protection group managed object

12.18.1.1 Read TE protection group list

12.18.1.1.1 Purpose

To obtain information about all of the TE protection groups in an IB-BEB.

12.18.1.1.2 Inputs

None.

12.18.1.1.3 Outputs

A list, perhaps empty, of the TE protection group managed objects configured on the IB-BEB. For each item in the list, the Read TE protection group list command returns:

a) A reference to a particular Maintenance Association managed object (12.14.6) identifying a PBB-TE MA that corresponds to the group's working entity.
b) A reference to a particular Maintenance Association managed object (12.14.6) identifying a PBB-TE MA with the same endpoints as the one provided in item b) that corresponds to the group's protection entity.
c) A reference to all TE protection group managed objects (12.18.2) that share a working or protection entity with the TE protection group in the list.

12.18.1.2 Create TE protection group managed object

12.18.1.2.1 Purpose

To create a new TE protection group managed object in an IB-BEB and add it to the IB-BEB's TE protection group list managed object.

12.18.1.2.2 Inputs

a) A reference to a particular Maintenance Association managed object (12.14.6) identifying a PBB-TE MA that corresponds to the working entity.
b) A reference to a particular Maintenance Association managed object identifying a PBB-TE MA with the same endpoints as the one provided in item a) that will monitor the protection entity.

12.18.1.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent Maintenance Domain.
    2) Operation rejected due to nonexistent MAs.
    3) Operation rejected because the referred MAs do not correspond to PBB-TE services.
    4) Operation rejected because the two referred MAs do not have the same endpoints.
    5) Operation rejected because the two referred MAs do not belong to the same MD.
    6) Operation rejected due to duplicate MAs.
    7) Operation accepted. In addition, the list, perhaps empty, of the TE protection group managed objects (12.18.2) that share a working or protection entity with the created TE protection group is provided.

12.18.1.3 Delete TE protection group managed object

12.18.1.3.1 Purpose

To delete a specific TE protection group managed object from an IB-BEB and from the IB-BEB's TE protection group list managed object.

12.18.1.3.2 Inputs

a) A reference to a particular TE protection group managed object (12.18.2).

12.18.1.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent TE protection group
    2) Operation rejected because the TE protection group is enabled
    3) Operation accepted

12.18.2 TE protection group managed object

There can be any number of TE protection group managed objects per IB-BEB, one for each working and protection pair of TESIs with common endpoints.

The management operations that can be performed on the TE protection group managed object are as follows:

a) Read TE protection group managed object
b) Write TE protection group managed object
c) TE protection group administrative commands managed object

12.18.2.1 Read TE protection group managed object

12.18.2.1.1 Purpose

To obtain information from an IB-BEB about a specific TE protection group managed object.

12.18.2.1.2 Inputs

a) A reference to a particular TE protection group managed object.

12.18.2.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent TE protection group
   2) Operation accepted

b) (writable) A list of Backbone-SIDs, identifying the protected backbone service instances, or NULL indicating that no backbone service instances are assigned to the TE protection group and that the TE protection group is disabled.

c) An enumerated value indicating the operational state of the Service Mapping state machine (Figure 26-17) for each TE protection group:
   1) WORKING_PATH
   2) PROTECTION_PATH
   3) WTR
   4) PROT_ADMIN

d) An enumerated value indicating the status of active requests within the TE protection group:
   1) NoRequest: No administrative command is in effect.
   2) LoP: Set if LoP (26.10.3.3.4) is TRUE, indicating that an administrative command to prohibit the use of the protection entity is in effect.
   3) FS: Set if FS (26.10.3.3.5) is TRUE, indicating that an administrative command to perform forced switching to the protection path(s) is in effect.
   4) p.SFH: Set if SFH (26.10.3.3.3) is TRUE on the protection entity.
   5) w.SFH: Set if SFH is TRUE on the working entity.
   6) MStoProtection: Set if MStoProtection (26.10.3.3.6) is TRUE, indicating that an administrative command to perform manual switching to the protection path(s) is in effect.
   7) MStoWorking: Set if MStoWorking (26.10.3.3.7) is TRUE, indicating that an administrative command to perform manual switching to the working path is in effect.

e) (writable) (optional) The Wait-to-restore (WTR) period (26.10.3.3.8). In revertive operation it may be configured in steps of 1 min between 5 min and 12 min; the default value is 5 min. The value 0 indicates nonrevertive operation.

f) (writable) (optional) The Hold-Off period (26.10.3.3.9). The range of the Hold-Off period is 0 s to 10 s in steps of 100 ms; the default value is 0.

12.18.2.2 Write TE protection group managed object

12.18.2.2.1 Purpose

To alter a value of a specific TE protection group managed object.

12.18.2.2.2 Inputs

a) A reference to a particular TE protection group managed object.

b) A reference to one of the writable managed objects in 12.18.2.1.3 that is to be altered.

c) A new value for the managed object.

12.18.2.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent TE protection group
   2) Operation rejected due to the selected managed object being Read-Only
   3) Operation rejected due to lack of authority to set this variable
   4) Operation rejected due to invalid value for the selected managed object
   5) Operation accepted

12.18.2.3 TE protection group administrative commands managed object

12.18.2.3.1 Purpose

To set an administrative command on a TE protection group managed object.

12.18.2.3.2 Inputs

a) A reference to a particular TE protection group managed object.
b) An enumerated value indicating the exercised administrative command:
   1) Clear: An indication to clear all other administrative commands.
   2) Lockout of Protection: An administrative command to prohibit the use of the protection entity.
   3) Forced Switch: An administrative command to perform forced switching to the protection path(s).
   4) Manual Switch To Protection: An administrative command to perform manual switching to the protection path(s) if it is operational.
   5) Manual Switch To Working: An administrative command to perform manual switching to the working path if it is operational.

12.18.2.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent TE protection group
   2) Operation rejected due to lack of authority to set this variable
   3) Operation rejected due to an active higher priority request
   4) Operation accepted

12.19 TPMR managed objects

The managed resources of a TPMR, accessed via the TPMR management entity, are those of the processes and entities defined in this clause, and listed as follows:

a) The TPMR management entity (12.19.1)
b) The individual MAC and PHY entities associated with each TPMR Port
c) The Forwarding Process of the MAC Relay Entity (8.6, 12.19.3)
d) The MAC Status Propagation Entity (MSPE) (23.3, 12.19.4)

The management of each of these resources is described in terms of managed objects and operations in the following subclauses.

12.19.1 TPMR management entity

This managed resource comprises the following objects:

a) The TPMR Configuration (12.19.1.1)
b) The Port Configuration for each Port (12.19.1.2)

12.19.1.1 TPMR configuration

The TPMR configuration object models the operations that modify, or inquire about, the configuration of the TPMR's resources. There is a single TPMR configuration object per TPMR.

The management operations that can be performed on the TPMR configuration are as follows:

a) Read TPMR (12.19.1.1.1)
b) Set TPMR Name (12.19.1.1.2)

12.19.1.1.1 Read TPMR

12.19.1.1.1.1 Purpose

To obtain general information regarding the TPMR.

12.19.1.1.1.2 Inputs

None.

12.19.1.1.1.3 Outputs

a) TPMR Name—a text string of up to 32 characters, of locally determined significance.
b) TPMR MAC addresses—the MAC addresses of the two externally accessible TPMR Ports. The following information is returned for each Port:
    1) The Port number.
    2) The MAC address of the Port.
    3) A Boolean value, which is TRUE if the MAC address is the management address for the TPMR, and is otherwise FALSE.

NOTE 1—The TPMR management entity may make use of one or both Ports of a TPMR to transmit and receive management frames. However, the MAC address used by the TPMR management entity as the source MAC address in transmitted management frames (the management MAC address) is the individual MAC address associated with one of the Ports of the TPMR (a management Port, see 8.3, 8.5).

NOTE 2—As the transmission and reception rules for a TPMR (8.5.2) mean that frames forwarded by a TPMR are not received by higher layer entities on the forwarding Port, by receiving management frames on either Port the TPMR management entity can determine which LAN incoming management frames were transmitted on, as incoming frames are only presented to higher layer entities attached to the reception Port.

c) Uptime—count in seconds of the time elapsed since the TPMR was last reset or initialized.

12.19.1.1.2 Set TPMR Name

12.19.1.1.2.1 Purpose

To associate a text string, readable by the Read TPMR operation, with a TPMR.

12.19.1.1.2.2 Inputs

a) TPMR Name—a text string of up to 32 characters.

12.19.1.1.2.3 Outputs

None.

12.19.1.2 Port configuration

The Port Configuration object models the operations that modify, or inquire about, the configuration of the Ports of a TPMR. By definition there are two Ports per TPMR (one for each MAC interface), and each is identified by a permanently allocated Port number.

The management operations that can be performed on the Port Configuration are as follows:

a) Read Port (12.19.1.2.1)
b) Set Port Name (12.19.1.2.2)

12.19.1.2.1 Read Port

12.19.1.2.1.1 Purpose

To obtain general information regarding a specific TPMR Port.

12.19.1.2.1.2 Inputs

a) Port Number—the number of the Port. This parameter can take the integer values 1 and 2 only.

12.19.1.2.1.3 Outputs

a) Port Name—a text string of up to 32 characters, of locally determined significance.
b) Port Type—the MAC Entity type of the Port (IEEE Std 802.3; ISO/IEC 8802-11; ISO 9314; other).
c) Management address forwarding status. This takes the value TRUE if forwarding is enabled for the management address on the Port or FALSE if forwarding is disabled for the management address on the Port (see 5.15).

12.19.1.2.2 Set Port Name

12.19.1.2.2.1 Purpose

To associate a text string, readable by the Read Port operation, with a TPMR Port.

12.19.1.2.2.2 Inputs

a) Port Number—the number of the Port. This parameter can take the integer values 1 and 2 only.
b) Port Name—a text string of up to 32 characters.

12.19.1.2.2.3 Outputs

None.

12.19.2 MAC and PHY entities

The management operations and facilities provided by the MAC and PHY entities are those specified in the layer management standards of the individual MACs and PHYs. A MAC entity, and its underlying PHY entity, is associated with each TPMR Port.

12.19.3 Forwarding Process

The Forwarding Process contains information relating to the forwarding of frames. Counters are maintained that provide information on the number of frames forwarded, filtered, and dropped due to error.

This managed resource comprises the following objects:

a) The Port Counters (12.19.3.1)
b) Optionally, the Priority Handling objects for each Port (12.19.3.2)
c) Optionally, The Traffic Class Table for each Port (12.6.3)

12.19.3.1 The Port Counters

The Port Counters object models the operations that can be performed on the Port counters of the Forwarding Process resource. There is one instance of the Port Counters object for each MAC Entity per TPMR (i.e., two instances total).

The management operation that can be performed on the Port Counters is as follows:

a) Read Forwarding Port Counters (12.19.3.1.1)

12.19.3.1.1 Read forwarding port counters

12.19.3.1.1.1 Purpose

To read the forwarding counters associated with a specific TPMR Port.

12.19.3.1.1.2 Inputs

a) Port Number—the number of the Port. This parameter can take the integer values 1 and 2 only.

12.19.3.1.1.3 Outputs

a) Frames Received—count of all valid frames received on this Port (including BPDUs, frames addressed to the TPMR as an end station, and frames that were submitted to the Forwarding Process, 8.6).
b) Octets Received—count of the total number of octets in all valid frames received on this Port (including BPDUs, frames addressed to the TPMR as an end station, and frames that were submitted to the Forwarding Process).
c) Frames Discarded by Forwarding Process—count of all frames that were received on this Port but were discarded by the Forwarding Process for any reason.
d) Frames Forwarded to Transmission Port—count of all frames that were received on this Port and were forwarded to the transmission Port (8.6.8).
e) Frames Discarded due to Queue Full—count of all frames received on this Port that were to be transmitted through the transmission Port but were discarded due to lack of available queue space (8.6.6, 8.6.7).
f) Frames Discarded Lifetime Exceeded—count of all frames received on this Port that were to be transmitted through the transmission Port but were discarded due to their frame lifetime having been exceeded (8.6.7).

g) Frames Discarded on Error—count of all frames received on this Port that were to be transmitted through the transmission Port but could not be transmitted (e.g., frame would be too large, 6.5.8).
h) Frame Discard on Error Details—a list of 16 elements, each containing the source address of a frame and the reason why the frame was discarded (e.g., frame too large). The list is maintained as a circular buffer. The reason for discard on error, at present, is as follows:
    1) Transmissible SDU size exceeded

12.19.3.2 Priority handling

The Priority Handling object models the operations that can be performed on, or inquire about, the Default Priority parameter, the Priority Regeneration Table parameter, the Outbound Access Priority Table parameter, the Priority Code Point parameters, and the Service Access Priority parameters for each Port. The operations that can be performed on this object are as follows:

a) Read Port Default Priority (12.6.2.1)
b) Set Port Default Priority (12.6.2.2)
c) Read Port Priority Regeneration Table (12.6.2.3)
d) Set Port Priority Regeneration Table (12.6.2.4)
e) Read Port Priority Code Point Selection (12.6.2.5)
f) Set Port Priority Code Point Selection (12.6.2.6)
g) Optionally, Read Port Priority Code Point Decoding Table (12.6.2.7)
h) Read Use_DEI parameter (12.6.2.11)
i) Optionally, Set Use_DEI parameter (12.6.2.12)

12.19.3.2.1 Read Port Default Priority

12.19.3.2.1.1 Purpose

To read the current state of the Default Priority parameter (IEEE Std 802.1ACI) for a specific TPMR Port.

12.19.3.2.1.2 Inputs

a) Port number.

12.19.3.2.1.3 Outputs

a) Default Priority value—Integer in range 0–7.

12.19.3.2.2 Set Port Default Priority

12.19.3.2.2.1 Purpose

To set the current state of the Default Priority parameter (IEEE Std 802.1AC) for a specific TPMR Port.

12.19.3.2.2.2 Inputs

a) Port number.
b) Default Priority value—Integer in range 0–7.

12.19.3.2.2.3 Outputs

None.

12.19.3.2.3 Read Port Priority Regeneration Table

12.19.3.2.3.1 Purpose

To read the current state of the Priority Regeneration Table parameter (6.9.4) for a specific TPMR Port.

12.19.3.2.3.2 Inputs

a) Port number.

12.19.3.2.3.3 Outputs

a) Regenerated Priority value for Received Priority 0—Integer in range 0–7.
b) Regenerated Priority value for Received Priority 1—Integer in range 0–7.
c) Regenerated Priority value for Received Priority 2—Integer in range 0–7.
d) Regenerated Priority value for Received Priority 3—Integer in range 0–7.
e) Regenerated Priority value for Received Priority 4—Integer in range 0–7.
f) Regenerated Priority value for Received Priority 5—Integer in range 0–7.
g) Regenerated Priority value for Received Priority 6—Integer in range 0–7.
h) Regenerated Priority value for Received Priority 7—Integer in range 0–7.

12.19.3.2.4 Set Port Priority Regeneration Table

12.19.3.2.4.1 Purpose

To set the current state of the Priority Regeneration Table parameter (6.9.4) for a specific TPMR Port.

12.19.3.2.4.2 Inputs

a) Port number;
b) Regenerated Priority value for Received Priority 0—Integer in range 0–7.
c) Regenerated Priority value for Received Priority 1—Integer in range 0–7.
d) Regenerated Priority value for Received Priority 2—Integer in range 0–7.
e) Regenerated Priority value for Received Priority 3—Integer in range 0–7.
f) Regenerated Priority value for Received Priority 4—Integer in range 0–7.
g) Regenerated Priority value for Received Priority 5—Integer in range 0–7.
h) Regenerated Priority value for Received Priority 6—Integer in range 0–7.
i) Regenerated Priority value for Received Priority 7—Integer in range 0–7.

12.19.3.2.4.3 Outputs

None.

12.19.3.2.5 Read Port Priority Code Point Selection

12.19.3.2.5.1 Purpose

To read which row of the Priority Code Point Decoding Table (6.9.3) is currently selected for use on this Port.

12.19.3.2.5.2 Inputs

a) Port Number: the number of the TPMR Port.

12.19.3.2.5.3 Outputs

a) Priority Code Point Selection. This takes one of the following values:
    1) 8P0D

2) 7P1D
3) 6P2D
4) 5P3D

12.19.3.2.6 Set Port Priority Code Point Selection

12.19.3.2.6.1 Purpose

To set which row of the Priority Code Point Decoding Table (6.9.3) will be selected for use on this Port.

12.19.3.2.6.2 Inputs

a) Port Number: the number of the TPMR Port.
b) Priority Code Point Selection. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.19.3.2.6.3 Outputs

None.

12.19.3.2.7 Read Priority Code Point Decoding Table

12.19.3.2.7.1 Purpose

To read the current contents of a row in the Priority Code Point Decoding Table (6.9.3) for a Port.

12.19.3.2.7.2 Inputs

a) Port Number: the number of the Bridge Port.
b) Priority Code Point Row. This takes one of the following values:
   1) 8P0D
   2) 7P1D
   3) 6P2D
   4) 5P3D

12.19.3.2.7.3 Outputs

a) Priority value for Priority Code Point 0: Integer in range 0–7.
b) Drop_eligible value for Priority Code Point 0: Boolean.
c) Priority value for Priority Code Point 1: Integer in range 0–7.
d) Drop_eligible value for Priority Code Point 1: Boolean.
e) Priority value for Priority Code Point 2: Integer in range 0–7.
f) Drop_eligible value for Priority Code Point 2: Boolean.
g) Priority value for Priority Code Point 3: Integer in range 0–7.
h) Drop_eligible value for Priority Code Point 3: Boolean.
i) Priority value for Priority Code Point 4: Integer in range 0–7.
j) Drop_eligible value for Priority Code Point 4: Boolean.
k) Priority value for Priority Code Point 5: Integer in range 0–7.
l) Drop_eligible value for Priority Code Point 5: Boolean.
m) Priority value for Priority Code Point 6: Integer in range 0–7.
n) Drop_eligible value for Priority Code Point 6: Boolean.
o) Priority value for Priority Code Point 7: Integer in range 0–7.
p) Drop_eligible value for Priority Code Point 7: Boolean.

12.19.3.2.8 Read Use_DEI Parameter

12.19.3.2.8.1 Purpose

To read the current state of the Use_DEI parameter (6.9.3) for the Port.

12.19.3.2.8.2 Inputs

a) Port Number: the number of the TPMR Port.

12.19.3.2.8.3 Outputs

a) Use_DEI parameter: Boolean.

12.19.3.2.9 Set Use_DEI Parameter

12.19.3.2.9.1 Purpose

To set the current state of the Use_DEI parameter (6.9.3) for the Port.

12.19.3.2.9.2 Inputs

a) Port Number: the number of the TPMR Port.
b) Use_DEI parameter: Boolean.

12.19.3.2.9.3 Outputs

None.

12.19.3.3 Traffic Class Table

The Traffic Class Table object models the operations that can be performed on, or inquire about, the current contents of the Traffic Class Table (8.6.6) for a given Port. The operations that can be performed on this object are Read Port Traffic Class Table and Set Port Traffic Class Table.

12.19.3.3.1 Read Port Traffic Class Table

12.19.3.3.1.1 Purpose

To read the contents of the Traffic Class Table (8.6.6) for a given Port.

12.19.3.3.1.2 Inputs

a) Port Number.

12.19.3.3.1.3 Outputs

a) The number of traffic classes, in the range 1 through 8, supported on the Port.
b) For each value of traffic class supported on the Port, the value of the traffic class in the range 0 through 7, and the set of priority values assigned to that traffic class.

12.19.3.3.2 Set Port Traffic Class Table

12.19.3.3.2.1 Purpose

To set the contents of the Traffic Class Table (8.6.6) for a given Port.

12.19.3.3.2.2 Inputs

a) Port number.
b) For each value of traffic class supported on the Port, the value of the traffic class in the range 0 through 7, and the set of priority values assigned to that traffic class.

NOTE—If a traffic class value greater than the largest traffic class available on the Port is specified, then the value applied to the traffic class Table is the largest available traffic class.

12.19.3.3.2.3 Outputs

None.

12.19.4 MAC Status Propagation Entity (MSPE)

This managed resource comprises the following object:

a) The MAC status propagation configuration for each Port of the TPMR (12.19.4.1)

12.19.4.1 MAC status propagation (MSP)

The MAC status propagation object models the operations that modify, or inquire about, the configuration and statistics of the MSPE for a particular Port of the TPMR.

The management operations that can be performed on the MAC status propagation configuration are as follows:

a) Read MSP performance parameters (12.19.4.1.1)
b) Set MSP performance parameters (12.19.4.1.2)
c) Read MSP statistics (12.19.4.1.3)

12.19.4.1.1 Read MSP performance parameters

12.19.4.1.1.1 Purpose

To solicit information regarding the current configuration of the MSP performance parameters with respect to a particular Port of the TPMR.

12.19.4.1.1.2 Inputs

a) Port number. The number of the Port of the TPMR. This can take the values 1 or 2 only.

12.19.4.1.1.3 Outputs

a) LinkNotify. The current value (Boolean) of LinkNotify (23.5.1) being used by the MSP state machines.
b) LinkNotifyWait. The current value, in centiseconds, of LinkNotifyWait (23.5.2) being used by the MSP state machines.
c) LinkNotifyRetry. The current value, in centiseconds, of LinkNotifyRetry (23.5.3) being used by the MSP state machines.
d) MACNotify. The current value (Boolean) of MACNotify (23.5.4) being used by the MSP state machines.
e) MACNotifyTime. The current value, in centiseconds, of MACNotifyTime (23.5.5) being used by the MSP state machines.
f) MACRecoverTime. The current value, in centiseconds, of MACRecoverTime (23.5.6) being used by the MSP state machines.

12.19.4.1.2 Set MSP performance parameters

12.19.4.1.2.1 Purpose

To change the MSP performance parameters to be used for a particular Port of the TPMR.

12.19.4.1.2.2 Inputs

a) Port number. The number of the Port of the TPMR. This can take the values 1 or 2 only.
b) LinkNotify. The desired value (Boolean) of LinkNotify (23.5.1) to be used by the MSP state machines.
c) LinkNotifyWait. The desired value, in centiseconds, of LinkNotifyWait (23.5.2) to be used by the MSP state machines.
d) LinkNotifyRetry. The desired value, in centiseconds, of LinkNotifyRetry (23.5.3) to be used by the MSP state machines.
e) MACNotify. The desired value (Boolean) of MACNotify (23.5.4) to be used by the MSP state machines.
f) MACNotifyTime. The desired value, in centiseconds, of MACNotifyTime (23.5.5) to be used by the MSP state machines.
g) MACRecoverTime. The desired value, in centiseconds, of MACRecoverTime (23.5.6) to be used by the MSP state machines.

12.19.4.1.2.3 Outputs

None.

12.19.4.1.3 Read MSP statistics

12.19.4.1.3.1 Purpose

To read the MSP statistics (23.12) for a particular Port of the TPMR.

12.19.4.1.3.2 Inputs

a) Port number. The number of the Port of the TPMR. This can take the values 1 or 2 only.

12.19.4.1.3.3 Outputs

a) acksTransmitted: The number of *acks* transmitted (23.6.15) by the Port's Transmit Process as a consequence of txAck being set.
b) addNotificationsTransmitted: The number of *adds* transmitted (23.6.16) by the Port's Transmit Process as a consequence of txAdd being set.
c) addConfirmationsTransmitted: The number of *add confirms* transmitted (23.6.17) by the Port's Transmit Process as a consequence of txAddConfirm being set.
d) lossNotificationsTransmitted: The number of *loss*es transmitted (23.6.18) by the Port's Transmit Process as a consequence of txLoss being set.
e) lossConfirmationsTransmitted: The number of *loss confirms* transmitted (23.6.19) by the Port's Transmit Process as a consequence of txLossConfirm being set.
f) acksReceived: The number of *acks* received (23.6.10) by the Port's Transmit Process.
g) addNotificationsReceived: The number of *adds* received (23.6.11) by the Port's Receive Process.
h) addConfirmationsReceived: The number of *add confirms* received (23.6.12) by the Port's Receive Process.
i) lossNotificationsReceived: The number of *loss*es received (23.6.13) by the Port's Receive Process.

j) lossConfirmationsReceived: The number of *loss confirms* received (23.6.14) by the Port's Receive Process.
k) addEvents: The number of transitions to STM:ADD directly from STM:DOWN or STM:LOSS (23.8).
l) lossEvents: The number of transitions to STM:LOSS directly from STM:UP or STM:ADD (23.8).
m) macStatusNotifications: The number of transitions to SNM:MAC_NOTIFICATION (23.9).

12.20 Management entities for FQTSS

The Bridge enhancements for support of FQTSS are defined in Clause 34.

This managed resource comprises the following objects:

a) The Bandwidth Availability Parameter Table (12.20.1)
b) The Transmission Selection Algorithm Table (12.20.2)
c) The Priority Regeneration Override Table (12.20.3)
d) The SR Class to Priority Mapping Table (12.20.4)

12.20.1 The Bandwidth Availability Parameter Table

There is one Bandwidth Availability Parameter Table per Port of a Bridge component. Each table row contains a set of parameters for each traffic class configured for use with time-sensitive streams, as detailed in Table 12-4. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of Ports and components.

Table 12-4—Bandwidth Availability Parameter Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
trafficClass[c]	unsigned integer [0..7]	R	BE	3.271, 8.6.8
deltaBandwidth	percentage	RW	BE	34.3
adminIdleSlope	unsigned integer	RW	BEC	34.3
operIdleSlope	unsigned integer	R	BE	34.3
classMeasurementInterval	unsigned integer	RW	be	34.3, 34.4, 34.6
lockClassBandwidth	Boolean	RW	be	34.3

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of FQTSS; E = Required for end station support of FQTSS; b = Optional for Bridge or Bridge component support of FQTSS; e = Optional for end station support of FQTSS; C = Required for Bridge or Bridge component support of Stream reservation remote management,
[c] The term "trafficClass" in this table is the same as the "traffic class" definition of this standard.

The classMeasurementInterval attribute provides management control of the classMeasurementInterval parameter specified in 34.3. The classMeasurementInterval attribute uses units of nanoseconds, converted to/from units of seconds for use in 34.3. If management of classMeasurementInterval is not supported, the default values (34.5) are used as the fixed Port configuration.

If management of lockClassBandwidth is not supported, the default value of false is used as the fixed Port configuration.

12.20.2 The Transmission Selection Algorithm Table

There is one Transmission Selection Algorithm Table per Port of a Bridge component. Each table row contains a set of parameters for each traffic class that the Port supports, as detailed in Table 12-5.

NOTE—To manage the mapping of traffic class to priority, refer to the Traffic Class Table managed object (12.6.3).

Table 12-5—Transmission Selection Algorithm Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
Traffic class	unsigned integer [0..7]	R	B	8.6.8
Transmission selection algorithm	enumerated (see Table 8-6)	RW	B	8.6.8, Table 8-6

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of FQTSS.

12.20.3 The Priority Regeneration Override Table

There is one Priority Regeneration Override Table per Port of a Bridge component. This is in addition to the Priority Handling managed object (12.6.2) that would also exist per Port of a Bridge component. Each table row contains a set of parameters for each received priority value that is associated with an SR class (3.262, 6.9.4), as detailed in Table 12-6.

Table 12-6—Priority Regeneration Override Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
Received priority	integer [0..7]	R	B	6.9.4
Regenerated priority	integer [0..7]	RW	B	6.9.4
SRPdomainBoundaryPort	boolean	R	B	35.1.4

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of FQTSS.

12.20.4 SR Class to Priority Mapping Table

There is one SR Class to Priority Mapping Table per Bridge component. Each table row corresponds to an SR class, as detailed in Table 12-7. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of Ports and components, using Priority to specify the row to create/delete.

Table 12-7—SR Class to Priority Mapping Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
Priority	unsigned integer [0..7]	R	b	6.9.3
SRclassID	unsigned integer [0..6]	RW	b	35.2.2.9.2

[a] R = Read only access; RW = Read/Write access.
[b] b = Optional for Bridge or Bridge component support of FQTSS.

The SRclassID attribute specifies the SR class ID from Table 35-6 of 35.2.2.9.2, mapped to the associated Priority (SRclassPriority of 35.2.2.9.3). The default values for this managed object use the default values specified in 34.5 (i.e., Priority 3 for SRclassID 6 and Priority 2 for SRclassID 5).

If this managed object is not supported, the default values specified in 34.5 are used as the fixed configuration.

NOTE 1—This managed object is not needed for an end station, since according to the requirements of 35.2.2.9.3, an end station uses the SR class to priority mapping that the neighboring Bridge provides in SRP's Domain attribute.

NOTE 2—To manage the mapping of traffic class to priority, refer to the Traffic Class Table managed object (12.6.3).

NOTE 3—The maximum number of rows supported for this table is provided in the maxSRclasses parameter of 12.22.1.

12.21 Congestion Notification managed objects

A number of the variables that implement congestion notification, including Congestion Points (CPs), Reaction Points (RPs), and Congestion Notification Domain (CND) defense, are manageable objects. There are a number of managed objects, each including a number of variables. The managed objects are as follows:

a) CN component managed object (12.21.1)
b) CN component priority managed object (12.21.2)
c) CN Port priority managed object (12.21.3)
d) Congestion Point managed object (12.21.4)
e) Reaction Point port priority managed object (12.21.5)
f) Reaction Point group managed object (12.21.6)

NOTE—If multiple managed objects are altered over a period of time, then between the time the first and last object has been altered, operation of the state machines could produce unexpected results. This standard assumes that any number of managed objects can be altered as an atomic operation, so that no inconsistent intermediate states can occur. See 17.7.13 for one mechanism to ensure consistency.

12.21.1 CN component managed object

A single instance of the CN component managed object shall be implemented by a Bridge component or end station that is congestion aware. It comprises all of the variables included in the CN component variables (32.2), as illustrated in Table 12-8. An end station may omit the managed objects noted "C" in the Conformance column of Table 12-8 if it does not support CPs, and may in any case omit the managed object marked "e."

12.21.2 CN component priority managed object

The CN component priority managed object contains the managed objects that control a single CNPV for all Ports in an end station or Bridge component. It comprises all of the variables included in the congestion notification per-CNPV variables (32.3), as illustrated in Table 12-9. In one common use case for congestion notification, every Port of a Bridge or end station has the same number of CPs, each configured for the same

Table 12-8—CN component managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
cngMasterEnable	Boolean	RW	BE	32.2.1
cngCnmTransmitPriority	unsigned integer [0..7]	R	BC	32.2.2
cngDiscardedFrames	counter	R	BC	32.2.3
cngErroredPortList	list	R	Be	32.2.4

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for a Bridge or Bridge component that is congestion aware; C = Required for an end station that implements one or more CPs; E = Required for an end station that is congestion aware; e = Optional for an end station that is congestion aware.

set of priority values. This managed object facilitates configuring that case. These objects can override, and can be overridden by, the CN Port priority managed objects (12.21.3) as described in 32.1.3.

A CN component priority managed object shall be implemented by a Bridge component or end station that is congestion aware for each priority value that can be a CNPV. An end station may omit the managed objects noted "C" in the Conformance column in Table 12-9 if it does not support CPs. The operations that can be performed on a congestion-aware system's CN component priority managed object are as follows:

a) Create CN component priority managed object (12.21.2.1)
b) Delete CN component priority managed object (12.21.2.2)

Table 12-9—CN component priority managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
cncpDefModeChoice	enum{cpcAdmin, cpcAuto}	RW	BE	32.3.1
cncpAlternatePriority	integer [0..7]	RW	BC	32.3.2
cncpAutoAltPri	integer [0..7]	R	BC	32.3.3
cncpAdminDefenseMode	enum{cptDisabled, cptInterior, cptInteriorReady, cptEdge}	RW	BE	32.3.4
cncpCreation	enum{cncpAutoEnable, cncpAutoDisable}	RW	BE	32.3.5
cncpLldpInstanceChoice	enum{cnlNone, cnlAdmin}	RW	BE	32.3.6
cncpLldpInstanceSelector	IEEE 802.1AB™ LLDP instance selector	RW	BE	32.3.7

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for a Bridge or Bridge component that is congestion aware; C = Required for an end station that implements one or more CPs; E = Required for an end station that is congestion aware.

12.21.2.1 Create CN component priority managed object

Creating a CN component priority managed object creates an instance of each of the congestion notification per-CNPV variables (32.3), and also creates the corresponding CN Port priority managed objects (12.21.3) and all their dependent managed objects and variables, on every Port in the Bridge component or end station, as illustrated in CN Port priority managed object. Depending on the value of cncpCreation (32.3.5), creating a CN component priority managed object can make the selected priority a CNPV throughout the Bridge component or end station.

12.21.2.2 Delete CN component priority managed object

Deleting a CN component priority managed object deletes all of the CN component variables (32.2), and also deletes the corresponding CN Port priority managed objects (12.21.3) and all their dependent managed objects and variables, on all Ports in the Bridge component or end station, thus making the priority not a CNPV throughout the Bridge component or end station.

12.21.3 CN Port priority managed object

There is one CN Port priority managed object per Port per priority in a congestion-aware end station or Bridge component. It comprises some of the variables included in the CND defense per-Port per-CNPV variables (32.4), as illustrated in Table 12-10. These objects can override, and can be overridden by, the CN component managed objects (12.21.1) and CN component priority managed objects (12.21.2) as described in 32.1.3.

Table 12-10—CN Port priority managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
cnpdDefModeChoice	enum{cpcAdmin, cpcAuto, cpcComp}	RW	BE	32.4.1
cnpdAdminDefenseMode	enum{cptDisabled, cptInterior, cptInteriorReady, cptEdge}	RW	BE	32.4.2
cnpdAutoDefenseMode	enum{cptDisabled, cptInterior, cptInteriorReady, cptEdge}	R	BE	32.4.3
cnpdLldpInstanceChoice	enum{cnlNone, cnlAdmin}	RW	BE	32.4.4
cnpdLldpInstanceSelector	IEEE 802.1AB LLDP instance selector	RW	BE	32.4.5
cnpdAlternatePriority	integer [0..7]	RW	BC	32.4.6

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for a Bridge or Bridge component that is congestion aware; C = Required for an end station that implements one or more CPs; E = Required for an end station that is congestion aware.

A CN Port priority managed object is created or deleted when the corresponding Port or CN component priority managed object is created or deleted, and its initial state on creation is determined by cncpCreation (32.3.5).

The CN Port priority managed object shall be implemented by a Bridge component or end station that is congestion aware. An end station may omit the managed objects noted "C" in the Conformance column in Table 12-10 if it does not support CPs.

12.21.4 Congestion Point managed object

There is one Congestion Point managed object for each CP in a Bridge component or end station. It comprises some of the variables included in the CP variables (32.8), as illustrated in Table 12-11.

Table 12-11—Congestion Point managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
cpMacAddress	MAC address	R	BC	32.8.1
cpId	octet string (size = 8)	R	BC	32.8.2
cpQSp	unsigned integer	R	BC	32.8.3
cpW	real number	RW	BC	32.8.6
cpSampleBase	unsigned integer	RW	BC	32.8.11
cpDiscardedFrames	counter	R	BC	32.8.12
cpTransmittedFrames	counter	R	BC	32.8.13
cpTransmittedCnms	counter	R	BC	32.8.14
cpMinHeaderOctets	unsigned integer	RW	BC	32.8.15

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for a Bridge or Bridge component that is congestion aware; C = Required for an end station that implements one or more CPs.

The Congestion Point managed object shall be implemented by a congestion-aware Bridge component. It shall be implemented by an end station that supports CPs.

NOTE—The Recommended priority to traffic class mappings in Table 8-5 can assign more than one CNPV to the same traffic class, the same queue, and hence the same CP. There can be only one CP controlling a given queue, and that CP has one set of controlling managed objects, not one set per CNPV. That set of managed objects can be accessed using any of the CNPV values assigned to the CP's queue. Thus, changing a managed object for one CNPV changes the managed object for all CNPVs assigned to the same queue.

12.21.5 Reaction Point port priority managed object

A congestion-aware end station shall implement one Reaction Point port priority managed object for each CNPV on each port. The Reaction Point port priority managed object controls the creation of RPs on the port and CNPV, as illustrated in Table 12-12.

Table 12-12—Reaction Point port priority managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
rpppMaxRps	unsigned integer	RW	E	32.10.1
rpppCreatedRps	counter	R	E	32.10.2
rpppRpCentiseconds	unsigned integer	R	E	32.10.3

[a] R = Read only access; RW = Read/Write access.
[b] E = Required for an end station that is congestion aware.

12.21.6 Reaction Point group managed object

There is one Reaction Point group managed object for each set of RP group variables (32.11), as illustrated in Table 12-13. The Reaction Point group managed object shall be implemented by an end station that is congestion aware.

Table 12-13—Reaction Point group managed object row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
rpgEnable	Boolean	RW	E	32.11.1
rpgTimeReset	unsigned integer	RW	E	32.11.2
rpgByteReset	unsigned integer	RW	E	32.11.3
rpgThreshold	unsigned integer	RW	E	32.11.4
rpgMaxRate	unsigned integer	RW	E	32.11.5
rpgAiRate	unsigned integer	RW	E	32.11.6
rpgHaiRate	unsigned integer	RW	E	32.11.7
rpgGd	real number	RW	E	32.11.8
rpgMinDecFac	real number	RW	E	32.11.9
rpgMinRate	unsigned integer	RW	E	32.11.10

[a] RW = Read/Write access.
[b] E = Required for an end station that is congestion aware.

12.22 Stream Reservation Protocol (SRP) entities

The Bridge enhancements for support of SRP are defined in Clause 35.

This managed resource comprises the following objects:

a) SRP Bridge Base Table (12.22.1)
b) SRP Bridge Port Table (12.22.2)
c) SRP Latency Parameter Table (12.22.3)
d) SRP Stream Table (12.22.4)

e) SRP Reservations Table (12.22.5)

12.22.1 SRP Bridge Base Table

There is a set of parameters that configure SRP operation for the entire device. Those parameters are shown in Table 12-14.

Table 12-14—SRP Bridge Base Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
msrpEnabledStatus	Boolean	RW	B	35.2.1.4(d)
talkerPruning	Boolean	RW	B	35.2.1.4(b)
msrpMaxFanInPorts	unsigned integer	RW	B	35.2.1.4(f)
msrpLatencyMaxFrameSize	unsigned integer	RW	B	35.2.1.4(g)
talkerVlanPruning	Boolean	RW	b	35.2.1.4 item l)
maxSRclasses	unsigned integer	R	b	35.2.1.4 item m)

[a] R = Read only access; RW = Read/Write access.
[b] B = required for Bridge or Bridge component support of SRP; E = required for end station support of SRP; b = Optional for Bridge or Bridge component support of SRP.

12.22.2 SRP Bridge Port Table

There is one SRP Configuration Parameter Table per Port of a Bridge component. Each table row contains a set of parameters for each MSRP entity per Port, as detailed in Table 12-15.

Table 12-15—SRP Bridge Port Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
msrpPortEnabledStatus	Boolean	RW	B	35.2.1.4(e)
MSRP Failed Registrations	counter	R	B	10.7.12.1
MSRP Last PDU Origin	MAC address	R	B	10.7.12.2
SR_PVID	unsigned integer[1..4094]	RW	B	Table 9-2 35.2.1.4(i)
talkerPruningPerPort	Boolean	RW	b	35.2.1.4 item k)

[a] R = Read only access; RW = Read/Write access.
[b] B = required for Bridge or Bridge component support of SRP; E = required for end station support of SRP; b = Optional for Bridge or Bridge component support of SRP.

12.22.3 SRP Latency Parameter Table

There is one SRP Latency Parameter Table per Port of a Bridge component. Each table row contains a set of parameters for each traffic class supported on a port, as detailed in Table 12-16. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of ports and components.

Table 12-16—SRP Latency Parameter Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
Traffic class	unsigned integer [0..7]	R	BE	34.3
portTcMaxLatency	unsigned integer	R	BE	35.2.1.4(a), 35.2.2.8.6

[a] R = Read only access; RW = Read/Write access.
[b] B = required for Bridge or Bridge component support of SRP; E = required for end station support of SRP.

12.22.4 SRP Stream Table

There is one SRP Stream Table per Bridge component. Each table contains a set of parameters for each StreamID that is registered on the Bridge, as detailed in Table 12-17. Rows in the table are created and removed dynamically as StreamIDs are registered and deregistered on the Bridge.

Table 12-17—SRP Stream Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamID	octet string(size(8))	RW	BE	35.2.2.8.2
Stream Destination Address	MAC address	R	BE	35.2.2.8.3(a)
Stream VID	unsigned integer [0..4094]	R	BE	35.2.2.8.3(b)
MaxFrameSize	unsigned integer [0..65 535]	R	BE	35.2.2.8.4(a)
MaxIntervalFrames	unsigned integer [0..65 535]	R	BE	35.2.2.8.4(b)
Data Frame Priority	unsigned integer [0..7]	R	BE	35.2.2.8.5(a)
Rank	unsigned integer [0..1]	R	BE	35.2.2.8.5(b)

[a] R = Read only access; RW = Read/Write access.
[b] B = required for Bridge or Bridge component support of SRP; E = required for end station support of SRP.

12.22.5 SRP Reservations Table

There is one SRP Reservations Table per reservation direction per port of a Bridge component. Each table contains a set of parameters for each Talker or Listener Reservation that is registered on a port of the Bridge, as detailed in Table 12-18. Rows in the table can be created or removed dynamically as Talker and Listener declarations are registered and deregistered on a port of the Bridge.

Table 12-18—SRP Reservations Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamID	octet string(size(8))	RW	BE	35.2.2.8.2
Direction	unsigned integer[0..1]	R	BE	35.2.1.2
Declaration Type	unsigned integer [0..4]	R	BE	35.2.1.3
Accumulated Latency	unsigned integer	R	BE	35.2.2.8.6
Failed system ID	BridgeId	R	BE	35.2.2.8.7(a)
Failure Code	unsigned integer [0..16]	R	BE	35.2.2.8.7(b)
Dropped Frames	counter	R	BE	35.2.5.1
Stream Age	unsigned integer	R	BE	35.2.1.4(c)

[a]R = Read only access; RW = Read/Write access.
[b]B = required for Bridge or Bridge component support of SRP; E = required for end station support of SRP.

12.22.6 SRP Stream Preload Table

There is one SRP Stream Preload Table per Bridge component. Each table contains a set of parameters for each StreamID that is preloaded on the Bridge as it initializes (i.e., powers up/reboots), as detailed in Table 12-17. The preloading of Table 12-17 on each Port of the Bridge is specified in 12.22.5. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of Ports and components.

Table 12-19—SRP Stream Preload Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamID	octet string(size(8))	RW	b	35.2.2.8.2
Stream Destination Address	MAC Address	RW	b	35.2.2.8.3 item a)
Stream VLAN ID	unsigned integer [0..4094]	RW	b	35.2.2.8.3 item b)
MaxFrameSize	unsigned integer [0..65535]	RW	b	35.2.2.8.4 item a)
MaxIntervalFrames	unsigned integer [0..65535]	RW	b	35.2.2.8.4 item b)
Data Frame Priority	unsigned integer [0..7]	RW	b	35.2.2.8.4 item a)
Rank	unsigned integer [0..1]	RW	b	35.2.2.8.5 item b)

[a] R = Read only access; RW = Read/Write access.
[b] b = Optional for Bridge or Bridge component support of SRP.

12.22.7 SRP Reservations Preload Table

There is one SRP Reservations Preload Table per reservation direction per Port of a Bridge component. Each table contains a set of parameters for each Talker or Listener registration that is preloaded on the Bridge as it initializes (i.e., powers up/reboots), as detailed in Table 12-18. Rows in the table can be created

or removed dynamically in implementations that support dynamic configuration of Ports and components.

Table 12-20—SRP Reservations Preload Table row elements

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamID	octet string(size(8))	RW	b	35.2.2.8.2
Direction	unsigned integer[0..1]	RW	b	35.2.1.2
Accumulated Latency	unsigned integer	RW	b	35.2.2.8.6

[a]R = Read only access; RW = Read/Write access.
[b]b = optional for Bridge or Bridge component support of SRP.

The SRP preload tables (Table 12-17 and Table 12-18) are used to initialize Streams within each Bridge as it powers up, to preload the Stream registrations that will later be provided by operation of SRP. When the Bridge initializes, the SRP preload tables shall be used for a two phase operation as follows:

In the first phase, the Bridge iterates Table 12-18 to find rows for which the Direction is Talker. For each Talker row, if the StreamID in Table 12-18 is also found in Table 12-17, the Bridge shall:

a) Invoke the MVRP ES_REGISTER_VLAN_MEMBER service primitive (11.2.3.2.1) on the Port. The attribute_type parameter carries the VID Vector Attribute Type (11.2.3.1.6). The attribute_value parameter carries the Stream VLAN ID for the associated StreamID in Table 12-17.
b) Invoke MSRP REGISTER_STREAM.request (35.2.3.1.1) on the Port. The attribute_type parameter carries the Talker Advertise Vector Attribute Type [item a) in 35.2.2.4]. The Declaration Type in the attribute_value parameter is Talker Advertise. The attribute_value parameter carries the following parameters from Table 12-17: StreamID, DataFrameParameters.destination_address from Stream Destination Address, DataFrameParameters.vlan_identifier from Stream VLAN ID, TSpec.MaxFrameSize, TSpec.MaxIntervalFrames, PriorityAndRank.Data Frame Priority, and PriorityAndRank.Rank. The attribute_value parameter carries the following per-Port parameters from Table 12-18: Accumulated Latency. The Failure Information in the attribute_value parameter is not applicable to Talker Advertise.

In the second phase, the Bridge iterates Table 12-18 to find rows for which the Direction is Listener. For each Listener row, if the StreamID was processed as a Talker during the first phase, then the Bridge shall:

c) Invoke MSRP REGISTER_ATTACH.request (35.2.3.1.5) on the Port. The attribute_type parameter carries the Listener Vector Attribute Type [item c) in 35.2.2.4]. The Declaration Type in the attribute_value parameter is Listener Ready. The attribute_value parameter carries StreamID from Table 12-18.
d) Invoke the MVRP ES_REGISTER_VLAN_MEMBER service primitive (11.2.3.2.1) on the Port. The attribute_type parameter carries the VID Vector Attribute Type (11.2.3.1.6). The attribute_value parameter carries the Stream VLAN ID for the associated StreamID in Table 12-17.
e) Update the Dynamic Reservation Entries (8.8.7) for the Port to Forwarding, using the Stream Destination Address for the associated StreamID in Table 12-17.

For traffic class N that is mapped to the Data Frame Priority of Table 12-17, increase the *operIdleSlope(N)* variable [item d) in 34.3] using the bandwidth requirements of the Stream (MaxFrameSize and MaxIntervalFrames of Table 12-17).

12.23 Priority-based Flow Control objects

The following Priority-based Flow Control objects exist for each port that support PFC:

a) **PFCLinkDelayAllowance:** the allowance made for round-trip propagation delay of the link in bits
b) **PFCRequests:** a count of the invoked PFC M_CONTROL.request primitives
c) **PFCIndications:** a count of the received PFC M_CONTROL.indication primitives

Table 12-21 shows the format and applicability of these objects.

Table 12-21—Priority-based Flow Control objects

Name	Data type	Operations supported[a]	Conformance[b]
PFCLinkDelayAllowance	unsigned integer	RW	BE
PFCRequests	unsigned integer	R	BE
PFCIndications	unsigned integer	R	BE

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of PFC; E = Required for end station support of PFC.

NOTE—The PFC Initiator (see 36.2.1) can use the PFCLinkDelayAllowance parameter as one of the factors to determine when to issue a PFC M_CONTROL.request in order to not discard frames. The parameter can be written to adjust to different link characteristics that affect the link delay (e.g., link length or link technology). See Annex N for an example of how to compute this parameter.

12.24 1:1 PBB-TE IPS managed objects

The IPS managed objects model operations that create, modify, delete, or inquire about the configuration and the operation of IPS (26.11). To this end, they describe objects related to an Infrastructure Protection Group (IPG) (26.11.2.1). The following are the IPS managed objects associated with a Segment Endpoint Bridge (SEB):

a) TE protection group list managed object (12.18.1)
b) IPG managed object (12.24.2)

12.24.1 IPG list managed object

There is one TE protection group list managed object per SEB. The IPG list managed object contains a list of the IPGs that have been configured on the SEB.

The management operations that can be performed on the TE protection group list managed object are as follows:

a) Read Maintenance Domain list (12.14.1.1)
b) Create Maintenance Domain managed object (12.14.1.2)
c) Delete Maintenance Association managed object (12.14.5.4)

12.24.1.1 Read IPG list

12.24.1.1.1 Purpose

To obtain information about the set of IPGs associated with a SEB.

12.24.1.1.2 Inputs

None.

12.24.1.1.3 Outputs

A list, perhaps empty, of the IPG managed objects configured on the SEB. For each item in the list, the Read Maintenance Domain list command returns the following:

a) A value identifying the IPG.
b) A reference to the particular Maintenance Association managed object (12.14.6) identifying the Infrastructure Segment MA that corresponds to the working entity of the IPG.
c) A reference to the particular Maintenance Association managed object identifying the Infrastructure Segment MA that corresponds to the protection entity of the IPG.
d) In the case of M:1 IPS, a prioritized list of references to Maintenance Association managed object, each of which identifies a candidate Protection Segment associated with the IPG.

12.24.1.2 Create IPG managed object

12.24.1.2.1 Purpose

To create a new IPG managed object in a SEB and add it to the TE protection group list managed object associated with the SEB.

12.24.1.2.2 Inputs

a) A reference to a particular Maintenance Association managed object identifying the Infrastructure Segment MA that corresponds to the working entity of the IPG.
b) In the case of 1:1 IPS, a reference to a particular Maintenance Association managed object identifying the Infrastructure Segment MA that corresponds to the protection entity of the IPG or, in the case of M:1 IPS, a prioritized list of references to Maintenance Association managed object, each of which identifies an Infrastructure Segment MA associated with an Infrastructure Segment that is a candidate Protection Segment for the IPG.

12.24.1.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to nonexistent MD.
    2) Operation rejected due to a nonexistent MA.
    3) Operation rejected because a referenced MA is not associated with an Infrastructure Segment.
    4) Operation rejected because the referenced MAs do not belong to the same MD.
    5) Operation rejected because two or more managed objects referenced are associated with the same MA.
    6) Operation rejected because neither Segment Monitoring Path Identifier (SMP-ID) associated with a SEG-ID identifying one of the referenced Infrastructure MAs contains in its SMP-SA field the MAC address of a PNP associated with the SEB.
    7) Operation accepted.

12.24.1.3 Delete IPG managed object

12.24.1.3.1 Purpose

To remove a specific IPG managed object from the TE protection group list managed object associated with the SEB and to delete that IPG managed object.

12.24.1.3.2 Inputs

a) A reference to a particular IPG managed object (12.24.2).

12.24.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent IPG
   2) Operation rejected because the IPG is enabled
   3) Operation accepted

12.24.2 IPG managed object

There can be any number of IPG managed objects per SEB.

The management operations that can be performed on the IPG managed object are as follows:

a) Read Maintenance Association managed object (12.14.6.1)
b) Write Maintenance Association managed object (12.14.6.2)
c) TE protection group administrative commands managed object (12.18.2.3)

12.24.2.1 Read IPG managed object

12.24.2.1.1 Purpose

To obtain information from a SEB regarding a specified IPG managed object.

12.24.2.1.2 Inputs

a) A reference to an IPG managed object.

12.24.2.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to nonexistent IPG
   2) Operation accepted
b) The MAID and Port Number associated with the Working Segment and an indication (TRUE or FALSE) about whether the Working Segment is operational.
c) The MAID and Port Number associated with the Protection Segment and an indication (TRUE or FALSE) about whether the Protection Segment is operational.
d) (optional) In the case of M:1 IPS, the list of MAIDs and Port Numbers associated with Candidate Protection Segments ordered from highest to lowest priority and an indication (TRUE or FALSE) about whether each candidate Protection Segment is operational.
e) (writable) A list of TE-SIDs, possibly NULL, identifying TESIs protected by the IPG. If not NULL, the IPG is considered to be enabled.
f) An enumerated value indicating the operational state of the Service Mapping state machine (Figure 26-22) for each IPG:
   1) WORKING_SEGMENT
   2) PROTECTION_SEGMENT
   3) WTR
   4) PROT_ADMIN
g) An enumerated value indicating the status of active requests within the IPG:
   1) **NoRequest:** No administrative command is in effect.
   2) **LoP:** Set if LoP (26.10.3.3.4) is TRUE, indicating that an administrative command to prohibit the use of the Protection Segment is in effect.

3) **FS:** Set if FS (26.10.3.3.5) is TRUE, indicating that an administrative command to perform forced switching to the Protection Segment is in effect.
4) **p.SFH:** Set if SFH (26.10.3.3.3) is TRUE on the Protection Segment.
5) **w.SFH:** Set if SFH is TRUE on the Working Segment.
6) **MStoProtection:** Set if MStoProtection (26.10.3.3.6) is TRUE, indicating that an administrative command to perform manual switching to the Protection Segment is in effect.
7) **MStoWorking:** Set if MStoWorking (26.10.3.3.7) is TRUE, indicating that an administrative command to perform manual switching to the Working Segment is in effect.

h) (writable) (optional) The wait-to-restore (WTR) period (26.10.3.3.8.) In revertive operation it may be configured in steps of 1 min between 5 and 12 min; the default value is 5 min. The value 0 indicates nonrevertive operation. The value 0 is not permitted when the IPG is associated with M:1 IPS.
i) (writable) (optional) The hold-off period (26.10.3.3.9). The range of the hold-off period is 0 to 10 s in steps of 100 ms; the default value is 0.
j) (optional) An enumerated value indicating the operational state of the Protection Segment Selection state machine (Figure 26-26) for each IPG:
   1) PS_ASSIGNED
   2) SEGMENT_OK
   3) SEGMENT_FAILED
   4) ASSIGN_NEW_PS
   5) REVERT_TO_BETTER_PS
k) (writable) (optional) The M:1 wait-to-restore (MWTR) period (26.11.5.4.7.). In revertive operation it may be configured in steps of 1 min between 5 and 12 min; the default value is 5 min. The value 0 indicates nonrevertive operation.

12.24.2.2 Write IPG managed object

12.24.2.2.1 Purpose

To update a writable item associated with a specified IPG managed object.

12.24.2.2.2 Inputs

a) A reference to an IPG managed object.
b) The identity of a writable item in 12.18.2.1.3 that is to be updated.
c) The updated value of the specified item.

12.24.2.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to specification of nonexistent IPG
   2) Operation rejected due to the selection of an item that is not writable
   3) Operation rejected due to lack of authority to set the value of this item
   4) Operation rejected due to the specification of an invalid value for the selected item
   5) Operation accepted

12.24.2.3 Apply administrative command to IPG managed object

12.24.2.3.1 Purpose

To apply a specified administrative command to an IPG managed object.

12.24.2.3.2 Inputs

a) A reference to an IPG managed object.
b) An enumerated value indicating the exercised administrative command:
   1) **Clear:** An indication to clear all other administrative commands.
   2) **Lockout of Protection:** An administrative command to prohibit the use of the Protection Segment.
   3) **Forced Switch:** An administrative command to perform forced switching to the Protection Segment.
   4) **Manual Switch To Protection:** An administrative command to perform manual switching to the Protection Segment if that Infrastructure Segment is operational.
   5) **Manual Switch To Working:** An administrative command to perform manual switching to the Working Segment if that Infrastructure Segment is operational.

12.24.2.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected due to specification of a nonexistent IPG.
   2) Operation rejected due to lack of authority to apply the specified command to the identified IPG managed object.
   3) Operation rejected due to an active higher priority request.
   4) Operation accepted.

12.25 Shortest Path Bridging managed objects

The Shortest Path Bridging managed objects model operations that create, modify, delete, or inquire about the configuration and the operation of an SPT Bridge and the region in which it is operating. These managed objects model only behaviors unique to SPB. Figure 12-3 illustrates the hierarchical relationships among the various SPB managed objects.

IS-IS provides a logical topology instance and within each instance the SPT Domain defines a set of managed objects. The following are the managed objects in an SPT Bridge:

a) The SPB System managed object (12.25.1)
b) The SPB MTID Static managed object (12.25.2) (see Multi-Topology Identifier (MTID) in Clause 3)
c) The SPB Topology Instance Dynamic managed object (12.25.3)
d) The SPB ECT Static Entry managed object (12.25.4)
e) The SPB ECT Dynamic Entry managed object (12.25.5)
f) The SPB Adjacency Static Entry managed object (12.25.6)
g) The SPB Adjacency Dynamic Entry managed object (12.25.7)
h) The SPBM BSI Static Entry managed object (12.25.8)
i) The SPB Topology Node Table managed object (12.25.9)
j) The SPB Topology ECT Table managed object (12.25.10)
k) The SPB Topology Edge Table managed object (12.25.11)
l) The SPBM Topology Service Table managed object (12.25.12)
m) The SPBV Topology Service Table managed object (12.25.13)
n) The ECMP ECT Static Entry managed object (12.25.14)
o) The PCR ECT Static Entry managed object (12.28.1)
p) The PCR Topology ECT Table managed object (12.28.2)

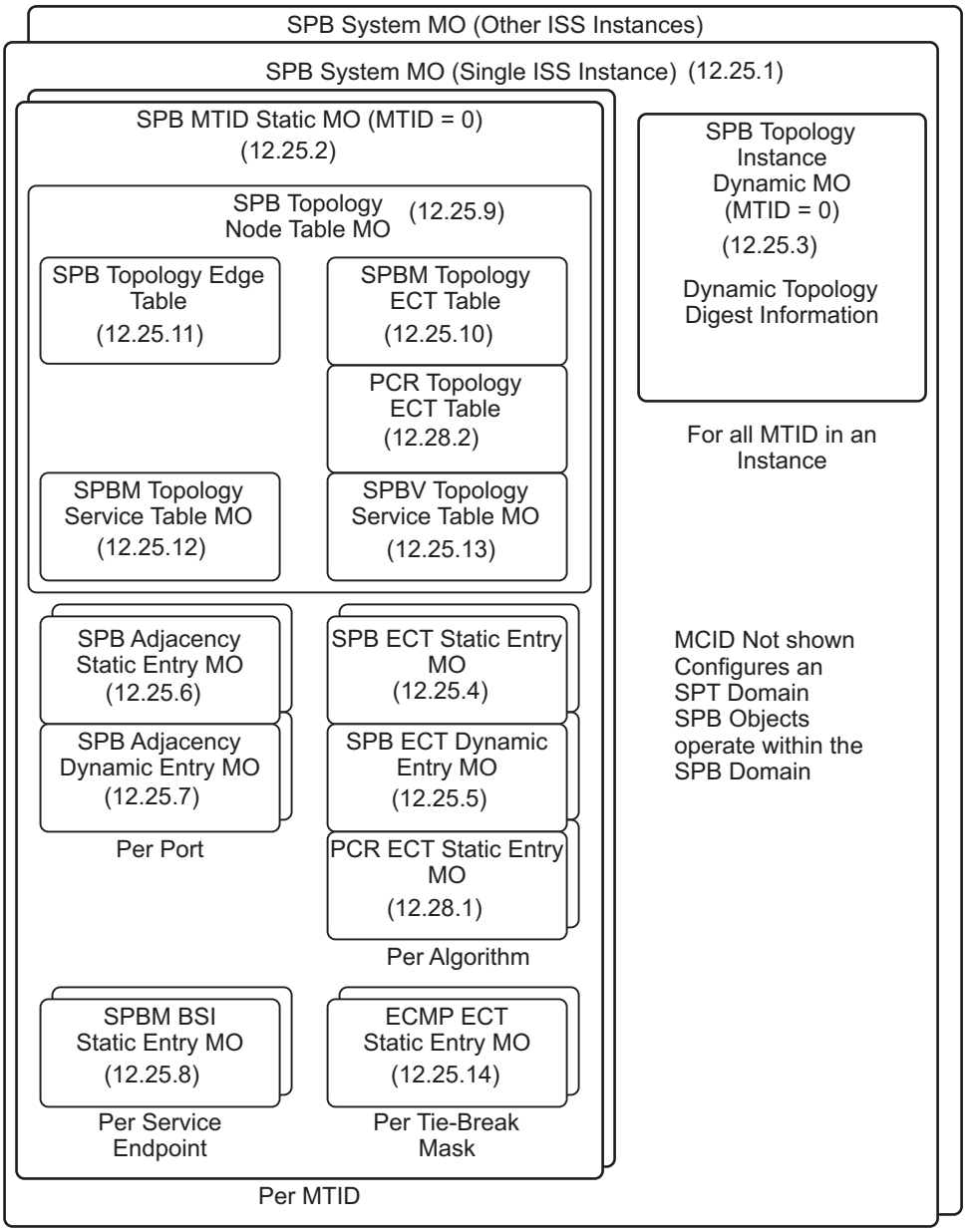


Figure 12-3—SPB managed objects (MOs)

12.25.1 The SPB System managed object

There is one SPB System managed object per ISIS-SPB area supported by an SPT Bridge. A single area only is supported in this version of the specification. It contains the fundamental SPB configuration parameters for the Bridge. It is persistent over reboot. The management operations that can be performed on the SPB System managed object are as follows:

a) Create SPB System managed object (12.25.1.1)
b) Write SPB System managed object (12.25.1.2)
c) Read SPB System managed object (12.25.1.3)
d) Delete SPB System managed object (12.25.1.4)

12.25.1.1 Create SPB System Managed object

12.25.1.1.1 Purpose

To create and configure the SPB System managed object on a Bridge.

12.25.1.1.2 Inputs

a) The part of the IS-IS Area Address that is domain specific (see Figure 4, ISO/IEC 10589:2002). This shall be set to zero in this version of this specification whenever SPB is the only protocol being supported by this IS-IS instance.
b) The MAC address to be used as the SPB System Identifier by all instances of ISIS-SPB on this Bridge. The System ID defaults to the Bridge Address if this input is not provided. The Bridge Address is the value returned by item a) of Discover Bridge (12.4.1.1.3) and Read Bridge (12.4.1.2.3).
c) The Group address used to address this ISIS-SPB instance (see Table 8-16). This address is configured to manage the transparency to ISIS-SPB of neighboring network elements, and also to specify the IS-IS Level at which this SPB instance is operating, which shall be Level 1 in this version of this specification.

12.25.1.1.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the specified IS-IS Area Address is already in use.
    2) Operation rejected because the provided Group address does not correspond to an allowed address (Table 8-16).
    3) Operation rejected because the specified SPB System Identifier value is not valid.
    4) Operation rejected due to the Bridge’s inability to support the requested IS-IS Level.
    5) Operation accepted.

12.25.1.2 Write SPB System managed object

12.25.1.2.1 Purpose

To configure an SPB System managed object on a Bridge.

12.25.1.2.2 Inputs

a) The part of the IS-IS Area Address that is domain specific (see Figure 4, ISO/IEC 10589:2002). This shall be zero in this version of this specification.
b) The SPB System Shortest Path Source Identifier (SPSourceID) (27.10).
c) If SPBV mode is used, whether the SPVIDs associated with this Bridge are assigned, or are to be auto-allocated. The use of SPBV mode is inferred from the assignment of at least one VID to the reserved MSTID value 0xFFD (27.4) in the FID to MSTID Allocation Managed Object (12.12.2.2).
d) If SPBM mode is used, whether the SPsourceID associated with this Bridge is assigned, or is to be auto-allocated. The use of SPBM mode is inferred from the assignment of at least one VID to the reserved MSTID value 0xFFC (27.4) in the FID to MSTID Allocation Managed Object (12.12.2.2).
e) The agreement digest Convention identifier (28.4.3), specifying the agreement rules being used. It can take the values 1 to 3 as specified in 28.4.3.

12.25.1.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected due to the Bridge’s inability to support the requested SPB capability
    2) Operation accepted

12.25.1.3 Read SPB System managed object

12.25.1.3.1 Purpose

To obtain information about SPB System managed object on a Bridge.

12.25.1.3.2 Inputs

a) The part of the IS-IS Area Address that is domain specific (see Figure 4, ISO/IEC 10589:2002).

12.25.1.3.3 Outputs

a) The part of the IS-IS Area Address that is domain specific (see Figure 4, ISO/IEC 10589:2002).
b) The SPB System Identifier used by all instances of ISIS-SPB on this Bridge.
c) The Group address used to address this ISIS-SPB instance (Table 8-16). This address also identifies the IS-IS Level at which this SPB instance is operating.
d) The SPB System Name used by all instances of ISIS-SPB. This takes the value configured by Set Bridge Name (12.4.1.3) and which can also be read as item b) of Read Bridge (12.4.1.2).
e) The Bridge Priority (13.26.2). The value used by SPB is set in the CIST Bridge Protocol Parameters (12.8.1.3).
f) The SPB System SPSourceID (27.10).
g) The SPBV Mode, identifying whether, if SPBV mode is used, the SPVIDs associated with this Bridge are assigned, or are to be auto-allocated.
h) The SPBM Mode, identifying whether, if SPBM mode is used, the SPsourceID associated with this Bridge is assigned, or is to be auto-allocated.
i) The agreement digest Convention identifier (28.4.3), specifying the agreement rules being used.

12.25.1.4 Delete SPB System managed object

12.25.1.4.1 Purpose

To delete the SPB System managed object on a Bridge, so disabling it as an SPT Bridge.

12.25.1.4.2 Inputs

a) The part of the IS-IS Area Address that is domain specific (see Figure 4, ISO/IEC 10589:2002).

12.25.1.5 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because one or more SPB MTID Static managed objects still exist and have not been deleted for this SPB instance.
    2) Operation accepted.

12.25.2 The SPB MTID Static managed object

There is one SPB MTID Static managed object per IS-IS Multi-Topology Identifier (MTID) used for SPB operation. It contains the SPB MTID value and the ISIS-SPB Overload flag for this MTID. It is persistent over reboot. The management operations that can be performed on the SPB MTID Static managed object are as follows:

a) Create SPB MTID Static managed object (12.25.2.1)
b) Write SPB MTID Static managed object (12.25.2.2)
c) Read SPB MTID Static managed object (12.25.2.3)
d) Delete SPB MTID Static managed object (12.25.2.4)

12.25.2.1 Create SPB MTID Static managed object

12.25.2.1.1 Purpose

To create and configure an SPB MTID Static managed object on a Bridge.

12.25.2.1.2 Inputs

a) An MTID to support IS-IS MT operation.

12.25.2.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the MTID is already in use
   2) Operation accepted
b) A Topology Index value that uniquely identifies this MTID Static managed object.

12.25.2.2 Write SPB MTID Static managed object

12.25.2.2.1 Purpose

To configure an SPB MTID Static managed object.

12.25.2.2.2 Inputs

a) An MTID to support IS-IS MT operation.
b) The Overload flag value, which has ISIS “no transit” semantics, applied only in this SPB topology.

12.25.2.2.3 Outputs

a) The MTID value.
b) The Overload flag value, which has ISIS “no transit” semantics, but applied only in this SPB topology.

12.25.2.3 Read SPB MTID Static managed object

12.25.2.3.1 Purpose

To obtain information about an SPB MTID Static managed object.

12.25.2.3.2 Inputs

a) An MTID to support IS-IS MT operation.

12.25.2.3.3 Outputs

a) The MTID value.
b) The Overload flag value, which has ISIS “no transit” semantics, but applied only in this SPB topology.
c) A Topology Index value that uniquely identifies this MTID Static managed object.

12.25.2.4 Delete SPB MTID Static managed object

12.25.2.4.1 Purpose

To delete an SPB MTID Static managed object.

12.25.2.4.2 Inputs

a) An MTID to support IS-IS MT operation.

12.25.2.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because not all peer links in the SPB Adjacency Static Entry managed object for this MTID have an Administrative State of Disabled.
   2) Operation accepted.

12.25.3 The SPB Topology Instance Dynamic managed object

There is one SPB Topology Instance Dynamic managed object for each SPB MTID Static managed object. It contains the dynamic parameters computed for this Bridge as a consequence of its participation in SPB in the ISIS-SPB topology defined by the specified MTID within this instance of SPB. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object associated with the topology. It is deleted with the deletion of the SPB MTID Static managed object associated with the topology. The management operation that can be performed on the SPB Topology Instance Dynamic managed object is as follows:

a) Read SPB Topology Instance Dynamic managed object

12.25.3.1 Read SPB Topology Instance Dynamic managed object

12.25.3.1.1 Purpose

To obtain information about the dynamic parameters computed by this Bridge as a consequence of its participation in SPB in the ISIS-SPB topology defined by the specified MTID within this instance of SPB.

12.25.3.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.

12.25.3.1.3 Outputs

a) The Topology Index value that uniquely identifies this topology instance.
b) The value of the topology Agreement Digest (13.17.1) being advertised by this Bridge to its peers in this ISIS-SPB Topology. This includes all parameters defined in the Agreement Digest (28.4).
c) The value of the MCID (8.9, 13.5, 13.8) being advertised by this Bridge to its peers.
d) The value of the Auxiliary MCID (27.4.1, 28.12.2) being advertised by this Bridge to its peers.

12.25.4 The SPB ECT Static Entry managed object

There is one SPB ECT Static Entry managed object per Base VID allocated to SPB operation. A Base VID exists in the context of a single ISIS-SPB MTID. The static Entry contains the SPB configuration parameters for the forwarding plane associated with the Base VID. It is persistent over reboot. The management operations that can be performed on the ECT Static Entry managed object are as follows:

a) Create an SPB ECT Static Entry managed object (12.25.4.1)
b) Read an SPB ECT Static Entry managed object (12.25.4.2)
c) Delete an SPB ECT Static Entry managed object (12.25.4.3)

12.25.4.1 Create SPB ECT Static Entry managed object

12.25.4.1.1 Purpose

To create and configure and interrogate an SPB ECT Static Entry managed object on a Bridge.

12.25.4.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. This VID must have been assigned either to the reserved MSTID value 0xFFC for SPT Bridges in SPBM operation, or to the reserved MSTID value 0xFFD for SPBV (27.4) in the FID to MSTI Allocation table (12.12.2.2).
c) The identifier of the ECT Algorithm (ECT-ALGORITHM) to be used for this Base VID (Table 28-1, Table 44-1, Table 45-1). The Default is the LowPATHID 00-80-C2-01 (28.8).
d) The pre-configured value of the SPVID assigned to this Bridge if operating in SPBV mode. This input is ignored if auto-allocated is selected [item c) in 12.25.1.2.2]. This VID value must have been assigned to the SPVID-Pool-MSTID (27.4) in the FID to MSTI Allocation Managed Object (12.12.2.2).

12.25.4.1.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Topology Index value is not defined
    2) Operation rejected because the Base VID is already in use
    3) Operation rejected due to requested Base VID not assigned to specified SPB use
    4) Operation rejected due to requested SPVID not assigned to the SPBV pool
    5) Operation accepted

12.25.4.2 Read SPB ECT Static Entry managed object

12.25.4.2.1 Purpose

To obtain information about the SPB ECT Static Entry managed object for a Base VID.

12.25.4.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. The value 4095 is a wildcard indicating that information, from any Base VID assigned to SPB operation, is requested.

12.25.4.2.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Base VID is not assigned to SPB use
    2) Operation accepted
b) A Topology Index value that uniquely identifies this topology instance.
c) The Base VID.
d) The identifier of the ECT algorithm (ECT-ALGORITHM) to be used for this Base VID.
e) The value of the SPVID to be used by this Bridge for this Base VID if operating in SPBV mode.

12.25.4.3 Delete SPB ECT Static Entry managed object

12.25.4.3.1 Purpose

To delete the SPB ECT Static Entry managed object for a Base VID.

12.25.4.3.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID.

12.25.4.3.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Bridge has services currently assigned to this Base VID
    2) Operation rejected because the SPT Region has services currently using this Base VID
    3) Operation accepted

12.25.5 The SPB ECT Dynamic Entry managed object

There is one SPB ECT Dynamic Entry managed object per Base VID allocated to SPB operation. It contains the SPB dynamic parameters associated with the Base VID. This object is automatically created as a consequence of the creation of the SPB ECT Static Entry managed object. It is deleted with the deletion of the SPB ECT Static Entry managed object. The management operation that can be performed on the ECT Dynamic Entry managed object is as follows:

a) Read SPB ECT Dynamic Entry managed object

12.25.5.1 Read SPB ECT Dynamic Entry managed object

12.25.5.1.1 Purpose

To obtain information about the SPB ECT Dynamic Entry managed object for a Base VID.

12.25.5.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. The value 4095 is a wildcard indicating that information, from any Base VID assigned to SPB operation, is requested.

12.25.5.1.3 Outputs

a) The Topology Index value that uniquely identifies this topology instance.
b) The Base VID.
c) A flag identifying whether the operational mode of this Base VID is SPBV or SPBM.
d) A flag indicating that this Bridge has services currently assigned to this Base VID.
e) A flag indicating that the SPT Region has services currently using this Base VID.
f) A count of the number of ingress check failures (an error condition) on this Base VID since creation of this SPB ECT Dynamic Entry managed object.

12.25.6 The SPB Adjacency Static Entry managed object

There is one SPB Adjacency Static Entry managed object per port per ISIS-SPB topology. It contains the SPB configuration parameters for the port in a topology. It is persistent over reboot. The management operations that can be performed on the SPB Adjacency Static Entry managed object are as follows:

a) Write SPB Adjacency Static Entry managed object (12.25.6.1)
b) Read SPB Adjacency Static Entry managed object (12.25.6.2)

12.25.6.1 Write SPB Adjacency Static Entry managed object

12.25.6.1.1 Purpose

To configure an SPB Adjacency Static Entry managed object on a port for an ISIS-SPB topology.

12.25.6.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The system interface index of a port.
c) The value of the ieee802.1 SPB Link State metric for the link on this port. For MTID = 0, or when a single MTID only is in use, this value should be set equal to the Path Cost set in the CIST Port Parameters Managed Object (see 12.8.2.1 and 12.8.2.3).
d) The SPB administrative state of a port.

NOTE—Item c) – The primary function of IS-IS MT is to allow different link metrics to be associated with each topology, so that different routes are preferentially favored in different topologies. However, care must be taken when configuring IS-IS MT that CIST path costs are assigned to one topology, and that this topology is the one used to compute the CIST, in order that SPB calculates its part of the CIST consistently.

12.25.6.1.3 Outputs

a) The Topology Index value that uniquely identifies this topology instance.
b) The system interface index of the port.
c) The value of the ieee802.1 SPB Link State metric for the link on this port.
d) The SPB administrative state of this port.

12.25.6.2 Read SPB Adjacency Static Entry managed object

12.25.6.2.1 Purpose

To read back the parameters of an SPB Adjacency Static Entry managed object on a port for an ISIS-SPB topology.

12.25.6.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The system interface index of a port. The value of zero is a wildcard indicating information, for any interface on which SPB operation is enabled, is requested.

12.25.6.2.3 Outputs

a) The Topology Index value that uniquely identifies this topology instance.
b) The system interface index of the port.
c) The value of the ieee802.1 SPB Link State metric for the link on this port.
d) The SPB administrative state of this port.

12.25.7 The SPB Adjacency Dynamic Entry managed object

There is one SPB Adjacency Dynamic Entry managed object per port per ISIS-SPB topology. It contains the dynamically discovered SPB parameters for the port in that topology. The management operation that can be performed on the SPB Adjacency Dynamic Entry managed object is as follows:

a) Read SPB Adjacency Dynamic Entry managed object in a topology

12.25.7.1 Read SPB Adjacency Dynamic Entry managed object

12.25.7.1.1 Purpose

To obtain information about an SPB Adjacency Dynamic Entry managed object on a port.

12.25.7.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The system interface index of a port. The value of zero is a wildcard indicating information, for any interface on which SPB operation is enabled, is requested.
c) The SPB System Identifier of a peer attached to the port.

12.25.7.1.3 Outputs

a) The Topology Index value that uniquely identifies this topology instance.
b) The system interface index of the port.
c) The SPB System Identifier of the peer attached to the port.
d) The Bridge Port Number (same as item d1) in 12.4.1.2.3).
e) The SPB operational state of this port.
f) The IS-IS System name of the peer attached to the port.
g) The value of the topology Agreement Digest (13.17.1) being advertised by the peer. This includes all parameters defined in the Agreement Digest (28.4).
h) The value of the MCID (8.9, 13.5, 13.8) being advertised by the peer.
i) The value of the Auxiliary MCID (27.4.1, 28.12.2) being advertised by the peer.
j) The value of the Local Circuit ID of this node, used by ISIS to select a single adjacency if more than one link connects a pair of SPT Bridges.
k) The value of the Local Circuit ID of the peer node, used by ISIS to select a single adjacency if more than one link connects a pair of SPT Bridges.
l) The value of the Port Identifier on this node for the link selected by ISIS to form the adjacency, equal to the value read as item c) from the CIST Port Parameters Managed Object (see 12.8.2.1) on this node.
m) The value of the Port Identifier on the peer node for the link selected by ISIS to form the adjacency with this node.
n) An index pointing into the isisCircTable in the IS-IS MIB for cross-referencing.

12.25.8 The SPBM BSI Static Entry managed object

There is one SPBM BSI Static Entry managed object for each I-SID assigned to an SPBM VID on a CBP. It contains the SPBM configuration parameters for an I-SID. It is persistent over reboot. The management operations that can be performed on the SPBM BSI Static Entry managed object are as follows:

a) Write SPBM BSI Static Entry managed object (12.25.8.1)
b) Read SPBM BSI Static Entry managed object (12.25.8.2)

12.25.8.1 Write SPBM BSI Static Entry managed object

12.25.8.1.1 Purpose

To configure an SPBM BSI Static Entry managed object for an I-SID assigned to an SPBM VID on a CBP.

12.25.8.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The system interface index of a CBP.
c) The I-SID identifying the backbone service instance.
d) A B-VID associated with this I-SID. There may be more than one object for a given I-SID, allowing it to be associated with multiple B-VIDs. This B-VID may differ from the B-VID specified in 12.16.5.2 that governs the VID assigned to the I-SID at the CBP; for example, to allow changing ISIS-SPB parameters when moving an I-SID from one B-VID to another. The B-VID to I-SID association in this managed object is advertised in ISIS-SPB so that forwarding state for the association is installed throughout the SPT domain, in addition to CBP state installed by 12.16.5.2. It is only the B-VID defined in 12.16.5.2 on which a CBP transmits; however, a CBP must receive from any B-VID with which its I-SID has an association.
e) Multicast transmit indication bit [item e) in 28.12.10].
f) Multicast receive indication bit [item f) in 28.12.10].
g) Shared tree transmit indication bit [item g) in 28.12.10].
h) Tie-Break Mask value [item h) in 28.12.10].

12.25.8.1.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Topology Index value is not defined
    2) Operation rejected because the identified port does not exist or is not a CBP
    3) Operation rejected because the I-SID is not assigned to an SPBM VID
    4) Operation accepted

12.25.8.2 Read SPBM BSI Static Entry managed object

12.25.8.2.1 Purpose

To read back the parameters of an SPBM BSI Static Entry managed object for an I-SID assigned to an SPBM VID on a CBP.

12.25.8.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The system interface index of a CBP. The value of zero is a wildcard indicating information, for any interface on which SPB operation is enabled, is requested.
c) An I-SID identifying a backbone service instance. The value 0xFFFFFF is a wildcard indicating that information on all I-SIDs on the specified port(s) is requested.
d) A B-VID associated with this I-SID. The value 4095 is a wildcard indicating that information for any B-VID associated with the specified I-SID(s) is requested.

12.25.8.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined
   2) Operation rejected because the identified port does not exist or is not a CBP
   3) Operation rejected because the I-SID is not assigned to an SPBM VID
   4) Operation accepted
b) The Topology Index value that uniquely identifies this topology instance.
c) The system interface index of the port.
d) The I-SID identifying a backbone service instance.
e) The B-VID associated with this I-SID.
f) Multicast transmit indication bit [item e) in 28.12.10].
g) Multicast receive indication bit [item f) in 28.12.10].
h) Shared tree transmit indication bit [item g) in 28.12.10].
i) Tie-Break Mask value [item h) in 28.12.10].

If item b) in 12.25.8.2.2 is configured with the value 0, a list indexed by the CBP ports on the system containing item a) to item i) [with the exception of item a2)].

12.25.9 The SPB Topology Node Table managed object

There is one SPB Topology Node Table managed object per Bridge per ISIS-SPB topology. It is populated by ISIS-SPB with the nodal SPB parameters discovered for all SPT Bridges participating in that topology within the SPT Region. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object for that topology. It is deleted with the deletion of that SPB MTID Static managed object. The management operation that can be performed on the SPB Topology Node Table managed object is as follows:

a) Read SPB Topology Node Table managed object

12.25.9.1 Read SPB Topology Node Table managed object

12.25.9.1.1 Purpose

To obtain nodal information about all SPT Bridges in an SPT Region for an ISIS-SPB topology.

12.25.9.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The SPB System Identifier of ISIS-SPB on a remote Bridge. The value zero is a wildcard indicating that information, from all remote Bridges in the SPT region, is requested.

12.25.9.1.3 Outputs

A list, which may be empty, comprising one entry for each Bridge within the SPT Region of which the local IS-IS instance is aware. Each entry contains the following information about a remote Bridge:

a) The Topology Index value that uniquely identifies this topology instance
b) The SPB System Identifier of ISIS-SPB on the remote Bridge
c) The Bridge Priority [the value set in CIST Protocol Parameters (12.8.1.3) for the remote Bridge]
d) The SPSourceID (27.10) of the remote Bridge
e) The SPB System Name of the remote Bridge

If b) identifies a specific remote Bridge then the list above will comprise one entry per Base VID, as specified in item c), containing only information about the specific remote Bridge.

12.25.10 The SPB Topology ECT Table managed object

There is one SPB Topology ECT Table managed object per Bridge per ISIS-SPB topology. It is populated by ISIS-SPB with the nodal ECT parameters discovered for all SPT Bridges participating in that topology within the SPT Region. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object. It is deleted with the deletion of that SPB MTID Static managed object. The management operation that can be performed on the SPB Topology ECT Table managed object is as follows:

a) Read SPB Topology ECT Table managed object

12.25.10.1 Read SPB Topology ECT Table managed object

12.25.10.1.1 Purpose

To obtain nodal ECT information, including the binding of ECT Algorithms to Base VIDs, about all SPT Bridges in an SPT Region for an ISIS-SPB topology.

12.25.10.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The SPB System Identifier of ISIS-SPB on a remote Bridge. The value zero is a wildcard indicating information, for all System identifiers, is requested.
c) The Base VID. The value 4095 is a wildcard indicating that information, from any Base VID assigned for SPB operation, is requested.

12.25.10.1.3 Outputs

A list, which may be empty, comprising one entry for each Bridge within the SPT Region of which the local ISIS-SPB instance is aware. Each entry contains the following information about a remote Bridge:

a) The Topology Index value that uniquely identifies this topology instance
b) The SPB System Identifier of ISIS-SPB on the remote Bridge
c) The Base VID
d) The identifier of the ECT Algorithm being used
e) The SPB operational mode (SPBV or SPBM)
f) The SPVID allocation mode (manual or automatic)
g) The value of the SPVID when operating in SPBV mode
h) A flag indicating that this Bridge has services currently assigned to this Base VID

If item b) identifies a specific remote Bridge then the list above will comprise one entry per Base VID as specified in item c), containing only information about the specific remote Bridge.

12.25.11 The SPB Topology Edge Table managed object

There is one SPB Topology Edge Table managed object per Bridge per ISIS-SPB topology. It is populated by ISIS-SPB with the discovered Edge (link) parameters for that topology within the SPT Region, referenced by the System Identifiers of the pair of SPT Bridges forming the end-points. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object for that topology. It is deleted with the deletion of that SPB MTID Static managed object. The management operation that can be performed on the SPB Topology Edge Table managed object is as follows:

a) Read SPB Topology Edge Table managed object

12.25.11.1 Read SPB Topology Edge Table managed object

12.25.11.1.1 Purpose

To obtain information about all Edges interconnecting SPT Bridges within an SPT Region for an ISIS-SPB topology.

NOTE—The use of the ISIS Local Circuit ID for tie breaking enables a single Edge (adjacency) per node pair and a unique Port Identifier on each node for spanning tree compatibility; refer to 28.11 and the Read operation on SPB Adjacency Dynamic Entry managed object.

12.25.11.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The SPB System Identifier used by the near Bridge on an Edge. The value zero is a wildcard indicating information, for all System identifiers, is requested.
c) The SPB System Identifier used by the far Bridge on an Edge. The value zero is a wildcard indicating information, for all System identifiers, is requested.

12.25.11.1.3 Outputs

A list, which may be empty, comprising one entry for each Edge within the SPT Region of which the local IS-IS instance is aware. Each entry contains the following information about an Edge:

a) The Topology Index value that uniquely identifies this topology instance.
b) The SPB System Identifier used by the near Bridge on the Edge.
c) The SPB System Identifier used by the far Bridge on the Edge.
d) The value of the ieee802.1 SPB Link State metric for this Edge, which is being advertised by the near Bridge.
e) The value of the ieee802.1 SPB Link State metric for this Edge, which is being advertised by the far Bridge.

NOTE—The terms “near” and “far” are used locally solely to distinguish the two ends of the Edge and associated metric values, and do not signify any relationship between the SPT Bridges advertising the Edge and the local Bridge supporting the SPB Topology Edge Table managed object. As a consequence of this definition, in a stable topology two Edges are created per physical link, one advertised in a Link State PDU (LSP) by each Bridge.

12.25.12 The SPBM Topology Service Table managed object

There is one SPBM Topology Service Table managed object per Bridge per ISIS-SPB topology. It is populated by ISIS-SPB with the mapping of Service instances to SPT Bridges operating in SPBM mode participating in that topology discovered within the SPT Region. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object for that topology. It is deleted with the deletion of that SPB MTID Static managed object. The SPBM Topology Service Table managed object only exists to provide Region-wide visibility of I-SID instance locations. Configuration of local I-SID instances is performed using the BEB Management (12.16) and the mapping of VIPs to PIPs (and hence to the B-MAC address associated with an I-SID) by PIP Management (12.16.4).

The management operation that can be performed on the SPBM Topology Service Table managed object is as follows:

a) Read SPBM Topology Service Table managed object

12.25.12.1 Read SPBM Topology Service Table managed object

12.25.12.1.1 Purpose

To obtain information about the location of all I-SID instances within an SPT Region in an ISIS-SPB topology.

12.25.12.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The SPB System Identifier of an SPT Bridges operating in SPBM mode hosting an I-SID. The value zero is a wildcard indicating information, from all remote Bridges in the SPT region hosting any I-SIDs, is requested.
c) An I-SID value. The value 0xFFFFFF is a wildcard indicating that information, from the remote Bridge(s) specified in item b) above hosting any I-SID, is requested.
d) The Base VID associated with this I-SID instance. The value 4095 is a wildcard indicating that information, from any Base VID assigned to SPB operation, is requested.

12.25.12.1.3 Outputs

A list, which may be empty, comprising one entry for each I-SID assigned to a Base VID within the SPT Region of which the local IS-IS instance is aware. Each entry contains the following information about the I-SID:

a) The Topology Index value that uniquely identifies this topology instance.
b) The SPB System Identifier of the SPT Bridges operating in SPBM mode hosting an I-SID instance.
c) The I-SID value.
d) The Base VID associated with this I-SID (and hence the ECT-ALGORITHM applied to this service).
e) The B-MAC address associated with this I-SID. If multiple I-SID instances are configured on a single Bridge but are reachable by different B-MAC addresses, a separate record is returned for each B-MAC address associated with that I-SID.
f) The I-SID instance service characteristic; transmit-only, receive-only, or both [item e) and item f) in 28.12.10; item e) and item f) in 12.25.8.1].
g) If ECMP is supported, the shared tree transmit indication [item g) in 28.12.10; item g) in 12.25.8.1.2].
h) If ECMP is supported, the Tie-Break Mask value [item h) in 28.12.10; item h) in 12.25.8.1.2].

NOTE—In general, an I-SID will be assigned to a single Base VID. During the administratively mediated migration of traffic from one ECT-ALGORITHM to a new one, an I-SID may be assigned to two Base VIDs for the duration of the transition in order to achieve loss-less migration (28.9.2).

12.25.13 The SPBV Topology Service Table managed object

There is one SPBV Topology Service Table managed object per Bridge per ISIS-SPB topology. It is populated by ISIS-SPB with the mapping of group MAC addresses to SPT Bridges operating in SPBV mode participating in that topology discovered within the SPT Region. This object is automatically created as a consequence of the creation of the SPB MTID Static managed object. It is deleted with the deletion of that SPB MTID Static managed object. The SPBV Topology Service Table managed object only exists to provide Region-wide visibility of group MAC address instance locations. Local configuration of group MAC address instances is performed using the procedures for management of Static Filtering Entries (12.7.2), or MMRP procedures (10.9).

The management operation that can be performed on the SPBV Topology Service Table managed object is as follows:

a) Read SPBV Topology Service Table managed object

12.25.13.1 Read SPBV Topology Service Table managed object

12.25.13.1.1 Purpose

To obtain information about all group MAC address instances within an SPT Region in an ISIS-SPB topology.

12.25.13.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The SPB System Identifier of an SPT Bridges operating in SPBV mode hosting a group MAC address. The value zero is a wildcard indicating information, from all remote Bridges in the SPT region hosting group MAC addresses, is requested.
c) The group MAC address value. The value zero is a wildcard indicating information, about all Group MACs for the specific Bridge(s) with the System Identifier as specified by item b), is requested.

12.25.13.1.3 Outputs

A list, which may be empty, and comprising one entry for each group MAC address instance within the SPT Region of which the local IS-IS instance is aware. Each entry contains the following information about the group MAC address:

a) The Topology Index value that uniquely identifies this topology instance.
b) The SPB System Identifier of the SPT Bridges operating in SPBV mode hosting a group MAC address instance.
c) The group MAC address value.
d) The Base VID (and hence ECT-ALGORITHM applied to this service).
e) The group MAC address instance service characteristic; transmit-only, receive-only, or both.

If item b) identifies a specific remote Bridge hosting an group address, then the list above will comprise only information about the specific remote Bridge.

12.25.14 The ECMP ECT Static Entry managed object

There is one ECMP ECT Static Entry managed object per Tie-Break Mask. It contains the Bridge Priority to be used for shared tree root selection for that Tie-Break Mask value. It is persistent over reboot. The management operations that can be performed on the ECMP ECT Static Entry managed object are as follows:

a) Write ECMP ECT Static Entry managed object (12.25.14.1)
b) Read ECMP ECT Static Entry managed object (12.25.14.2)

12.25.14.1 Write ECMP ECT Static Entry managed object

12.25.14.1.1 Purpose

To configure a different Bridge Priority to be used solely for shared tree root selection for a given Tie-Break Mask (28.12.6.1, 28.8).

12.25.14.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Tie-Break Mask value [item d) in 28.12.6.1].
c) Bridge Priority [item e) in 28.12.6.1].

12.25.14.1.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined
   2) Operation accepted

12.25.14.2 Read ECMP ECT Static Entry managed object

12.25.14.2.1 Purpose

To read back the Bridge Priority for a given Tie-Break Mask.

12.25.14.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Tie-Break Mask value [item d) in 28.12.6.1].

12.25.14.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined
   2) Operation accepted
b) The Topology Index value that uniquely identifies this topology instance.
c) The Tie-Break Mask value [item d) in 28.12.6.1].
d) The Bridge Priority [item e) in 28.12.6.1].

12.26 Edge Virtual Bridging (EVB) management

The conformance requirements for EVB Bridges and EVB stations are defined in 5.23 and 5.24, respectively. Each C-VLAN component, ER (5.24.1), and Port-mapping S-VLAN component can be managed using the managed objects of 12.4 through 12.12 along with the EVB managed objects specified in this subclause.

An EVB Bridge system (Figure 12-4) supports the EVB managed objects defined in 12.26.1 through 12.26.3 and 12.27. Optionally, an EVB Bridge supports the managed objects for S-channels defined in 12.26.4.

An EVB station system (Figure 12-5) supports the EVB managed objects defined in 12.26.1, 12.26.3, 12.26.5, and 12.27. Optionally, an EVB station supports the managed objects for S-channels defined in 12.26.4.

The EVB-specific managed objects defined here:

a) Provide managed objects for identifying and configuring an EVB system and its system-wide default parameters for LLDP, Virtual Station Interface (VSI) Discovery and Configuration Protocol (VDP), and S-channel (12.26.1).
b) Provide managed objects for configuring the Station-facing Bridge Ports (SBPs) of EVB Bridges (12.26.2).
c) Provide a VSI table that contains the current VSI and VDP state for each VSI that is active in the EVB system (12.26.3).
d) Provide managed objects for configuring the Port-mapping S-VLAN components and S-channels (12.26.4).
e) Provide managed objects for configuring the URPs of the ERs (12.26.5).

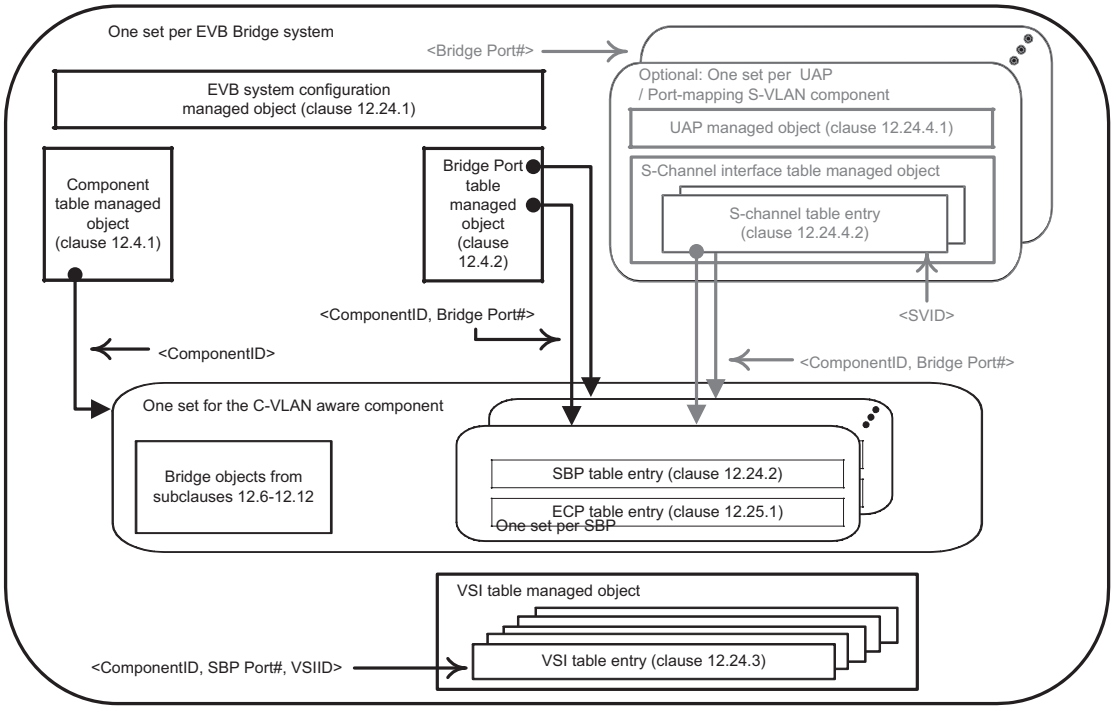
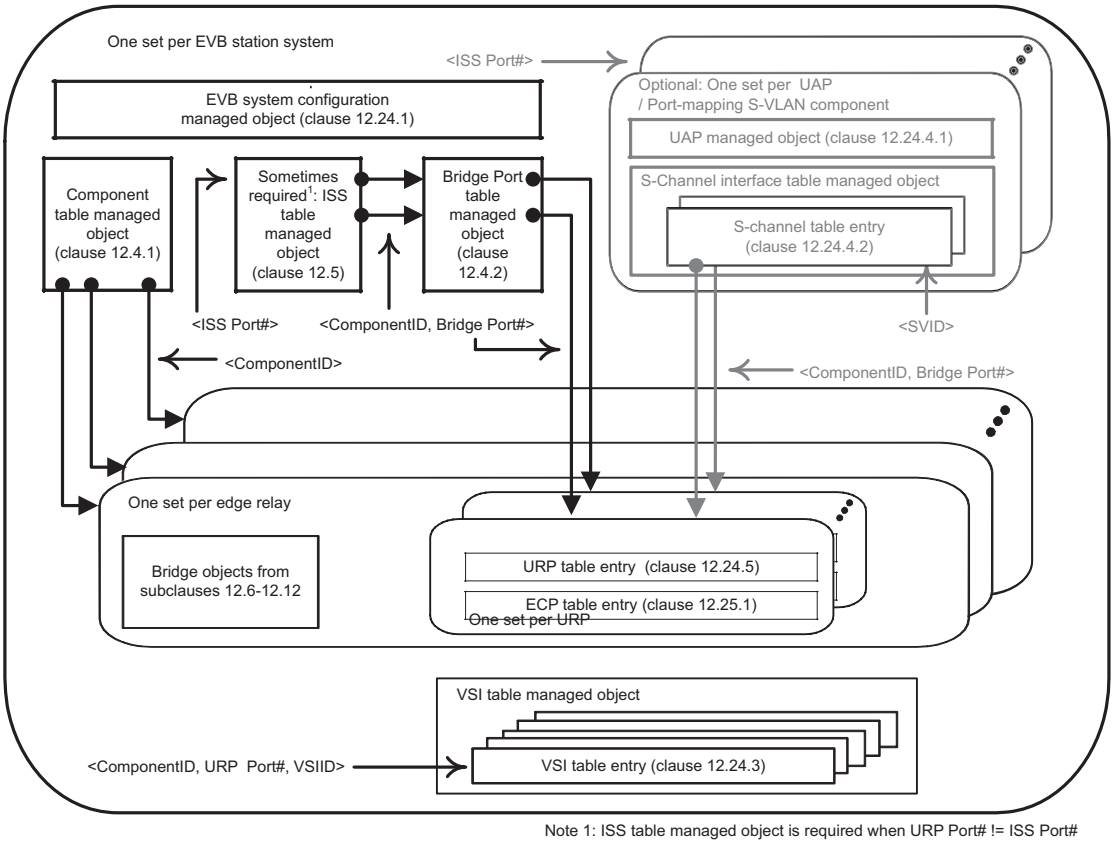


Figure 12-4—Relationships among EVB Bridge managed objects



Note 1: ISS table managed object is required when URP Port# != ISS Port#

Figure 12-5—Relationship among EVB station managed objects

For each EVB system, an EVB system configuration managed object exists containing the system-wide defaults used to initialize the other EVB objects.

Every Port of the EVB system (40.1, 40.2, 40.3) is uniquely identified by a ComponentID (12.3) and Port Number (12.3) [which together identify a Port Index (12.3)]. In EVB systems where the ISS and bound Bridge Port have different Port Numbers, an ISS table (12.5.1) allows determining the associated Bridge Port's ComponentID and Port Number from the scalar ISS Port Number. An example where the ISS table would be needed is an EVB station where the station has multiple LANs each attaching to different ERs and where the ERs each use the same Port Number (however different ComponentIDs) to identify their URPs (Figure 40-3). The ISS table is normally not necessary in an EVB Bridge since the single C-VLAN-aware component provides a Bridge Port Number that is unique within the EVB Bridge for every ISS, allowing the ISS and the Bridge Port to use the same Port Number independent from the ComponentID.

The ERs of an EVB station have two types of ports. Each ER DRP provides attachment to one or more VSIs. No special EVB objects are used to manage the DRPs. URPs can attach to a LAN that can be externally accessible or attach through an internal LAN to a CAP of an S-channel. URPs are managed using the URP table. Each URP table entry identifies a URP within the system and allows configuration and monitoring of LLDP and VDP for the URP (12.26.5). For each URP there is also a ECP table entry that allows configuration and monitoring of ECP (12.27).

NOTE 1—The most common case is that a single VSI is associated with each DRP.

The C-VLAN component of an EVB Bridge has two types of Ports. Each C-VLAN Bridge Port is externally accessible and does not provide any EVB capabilities. No special EVB objects are used to manage the C-VLAN Bridge Ports. Each SBP attaches to a LAN that can be externally accessible or attach though an internal LAN to a CAP of an S-channel. SBPs are managed using the SBP table. Each SBP table entry identifies a single SBP within the system and allows configuration and monitoring of LLDP and VDP for the SBP (12.26.2). For each SBP there is also a ECP table entry that allows configuration and monitoring of ECP (12.27).

Within each EVB station and EVB Bridge, a table holding the VSIs allows monitoring of the active VSIs (12.26.3). VSI table entries are keyed on the VSI Instance Identifier (VSIID) and the URP's or SBP's ComponentID and Port Number. During the movement of VSIs within the data center network (DCN) it is possible to have a transient condition where the same VSIID exists at two locations. When these two instances are at the same URP or SBP, they are indistinguishable; therefore, the table holds only the state for the most recent VSI command. However, when the movement is between different URPs or SBPs, the table will hold two copies of the same VSIID differentiated by the ComponentID and Port Number of the URPs or SBPs.

NOTE 2—In the case where a VSI is migrated between DRPs of the same ER, there is no reason to de-associate, as the table does not maintain any state that identifies the DRP of the ER to which the VSI is attached.

An association is identified by its URP and VSIID. If an association is established for a VSI, and a new association is established on the same URP for the same VSIID, then the new association replaces the old one. A subsequent de-association for that VSIID will remove the current association, regardless of the parameters.

In EVB systems supporting S-channels, the optional UAP table and S-channel interface table are used to configure and control the Port-mapping S-VLAN components and CDCP (12.26.4).

Each ISS that is bound to an Uplink Access Port (UAP) automatically has a Port-mapping S-VLAN component with a default S-channel (using S-VID 1). Each S-channel is identified by the ISS Port Number of the UAP and the S-VID, for SBPs, or S-channel Identifier (SCID), for URPs, identifying the S-channel. The default S-channel carries all the un-S-tagged traffic that traverses the Port-mapping S-VLAN component.

In an EVB Bridge system, S-channels are automatically connected to SBPs when the S-Channel is created. If the S-channel is the default S-channel, it is connected to the SBP with the same Port Number as the ISS bound to the UAP. If the S-channel is not the default S-channel, a new SBP is allocated to the S-channel (which has a Port Number different from any ISS Port Number where a UAP or C-VLAN Bridge Port could be bound) and connected to the CAP through an internal LAN (6.14). With CDCP enabled and operating in the 'B' role, the S-channel interface table entries are automatically created (deleted) by CDCP to fill requests from the peer CDCP operating the 'S' role.

In an EVB station, S-channels are connected to URPs by the operating system. The URP Port Numbers are not reserved, so the UAP's ISS Port Number may not be the same as the URP Port Number. The operating system is not required to automatically attach each S-channel to a URP; however, it can if it chooses. The URP Port Numbers have no restrictions beyond the normal requirement that every relay port be uniquely identified in the EVB system by a ComponentID and Port Number pair. With CDCP enabled and operating in the 'S' role, CDCP uses the S-channel interface table to build requests for creating (deleting) S-channels from the peer CDCP operating in the 'B' role and enables these S-channels after the peer grants an S-VID for use by the S-channel.

Management of the UAP, Port-mapping S-VLAN component and CDCP is achieved through the UAP table (12.26.4.1). The management of CAPs and their LAN attachments is accomplished by the S-channel interface table entries (12.26.4.2). A UAP table entry along with the Port-mapping S-VLAN creation rules specified in 12.26.4 are sufficient to manage the Port-mapping S-VLAN component. The Bridge managed objects in 12.4 through 12.12 can optionally be used, in addition to the objects of 12.26.4, to manage the Port-mapping S-VLAN components.

The following managed objects, illustrated in Figure 12-4 and Figure 12-5, define the semantics of the management operations specific to EVB Bridges and stations:

— The EVB system base managed object (12.26.1)
— The SBP table entry managed object (12.26.2)
— The VSI table entry managed object (12.26.3)
— The MAC/VID pair table entry managed object (12.26.3)
— The UAP table entry managed object (12.26.4)
— The S-channels interface table entry managed object (12.26.4)
— The URP table entry managed object (12.26.5)

12.26.1 EVB system base table

An instance of the EVB system base table (Table 12-22) can be implemented by an EVB Bridge or EVB station. It comprises the identifiers for an EVB system (Clause 40) and system-wide default parameters used to support EVB services (D.2.12, 40.4), VSI discovery (Clause 41), and ECP (43.3).

The management operations that can be performed on an EVB system table entry are as follows:

a) Read EVB system table entry
b) Update EVB system table entry

12.26.1.1 System identifiers

The evbSysType identifies the system type. The enumerated types for evbSysType are as follows:

a) sysB—EVB Bridge
b) sysS—EVB station

Table 12-22—EVB system base table

Name	Data type	Operations supported[a]	Conformance[b]	References
evbSysType	enumerated {sysB, sysS}	R	BE	5.23, 5.24
evbSysNumExternalPorts	unsigned [1...4095]	R	BE	12.4.2, 12.5.1
evbSysEvbLldpTxEnable	Boolean	RW	BE	D.2.12
evbSysEvbLldpManual	Boolean	RW	BE	D.2.12
evbSysEvbLldpGidCapable	Boolean	RW	BE	D.2.12
evbSysEcpDfltAckTimerInit	timer exp	RW	BE	D.2, 43.3.6.1
evbSysEcpDfltMaxTries	unsigned [0...7]	RW	BE	D.2, 43.3.7.4
evbSysVdpDfltRsrcWaitDelay	timer exp	RW	BE	D.2.12, 41.5.5.7
evbSysVdpDfltReinitKeepAlive	timer exp	RW	BE	D.2.12, 41.5.5.5

[a] R= Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system.

12.26.1.2 System defaults for EVB

The parameters evbSysEvbLldpTxEnable and evbSysEvbLldpManual are used to initialize the LLDP EVB objects for new SBPs and URPs. When evbSysLldpTxEnable is TRUE, a new SBP or URP will place the local EVB objects in the LLDP nearest Customer database; when FALSE, a new SBP or URP will not place the local EVB objects in the LLDP database. When evbSysLldpManual is FALSE, the operating configuration will be determined by the comparison between the local and remote LLDP EVB objects (automatic), regardless of the setting of evbSysLldpTxEnable. When evbSysLldpManual is TRUE, the configuration will be determined by the setting of the local EVB objects only (manual).

The evbSysLldpGidCapable parameter indicates if the port is capable of processing GroupIDs. GroupIDs can be used if both the EVB Bridge and EVB station indicate they are capable by setting the EVB LLDP object for GroupID capable to TRUE. On an EVB Station this means the station can provide GroupIDs rather than VIDs in VDP requests and accept VIDs in response from the EVB Bridge. On an EVB Bridge this means the Bridge can provide a VID corresponding to the GroupID provided by the EVB station.

The default value for evbSysEcpDfltAckTimerInit is 14, which provides a time of 164 ms. Systems are not required to implement smaller times and can reject requests to set the timers to small times; however, systems are required to implement 14 and above to allow fall back to the longest time proposed by the EVB Bridge or EVB station.

The default value for evbSysVdpDfltRsrcWaitDelay and evbSysVdpDfltReinitKeepAlive is system dependent. All systems support the values of 20 and above, which provide times of 10.5 seconds and greater. Systems are not required to implement smaller times and can reject requests to set the timers to small times; however, systems are required to implement 20 and above to allow fall back to the longest time proposed by the EVB Bridge or EVB station.

Table 12-23 shows how the system defaults are used to initialize the parameters in the SBP, URP, and ECP table entries.

Table 12-23—EVB system parameter defaults

System parameter	Default value	LLDP, SBP, URP, ECP entry parameter
evbSysEvbLldpTxEnable	TRUE	LLDP Transmit Enable
evbSysEvbLldpManual	FALSE	sbpLldpManual, urpLldpManual
evbSysEvbLldpGidCapable	system dependent	LLDP GID Capable
evbSysEcpDfltAckTimerInit	14, for 164 milliseconds	ecpAdminAckTimerInit
evbSysEcpDfltMaxTries	3	ecpAdminMaxTries
evbSysVdpDfltRsrcWaitDelay	system dependent	sbpVdpAdminRsrcWaitDelay, urpVdpAdminRsrcWaitDelay
evbSysVdpDfltReinitKeepAlive	system dependent	sbpVdpAdminReinitKeepAlive, urpVdpAdminReinitKeepAlive

12.26.2 SBP table entry

SBP table entries (Table 12-24) may be created explicitly or implicitly as a result of creating an entry in the S-channel interface table. When an SBP table entry is created, the port type in the Port table entry (Table 12-2) changes to type ‘Station-facing Bridge Port’. When an SBP table entry is deleted, the Port table entry returns to type C-VLAN Bridge Port.

Table 12-24—SBP table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
sbpComponentID	ComponentID	R	B	12.4.1.5
sbpPortNumber	Port Number	R	B	12.4.2
sbpLldpManual	Boolean	RW	B	—
sbpVdpOperRsrcWaitDelay	timer exp	R	B	D.2.12, 41.5.5.7
sbpVdpOperReinitKeepAlive	timer exp	R	B	D.2.12, 41.5.5.5
sbpVdpOperToutKeepAlive	unsigned	R	B	D.2.12, 41.5.5.13

[a] R = Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system.

Whenever a new SBP table entry is created, a new entry is also created in the ECP table (12.27) keyed under the ComponentID and Port Number of the SBP. Whenever an SBP table entry is deleted, the corresponding entry in the ECP table is deleted.

The management operations that can be performed on an SBP table entry are as follows:

a) Read SBP table entry
b) Update SBP table entry
c) Create SBP table entry
d) Delete SBP table entry

12.26.3 VSI table entry

Each EVB system maintains a table of the active VSIs. The structure of a VSI table entry is shown in Table 12-25. This read-only table provides the current operation parameters of each VSI along with the VDP state associated with the VSI. The table is keyed on the SBP's or URP's ComponentID and Port Number and on the VSIID. The operation that can be performed on the VSI table is as follows:

a) Read entry for a ComponentID, Port Number, and VSIID

Table 12-25—VSI table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
evbVsiComponentID	ComponentID	R	BE	12.4.1.5
evbVsiPortNumber	Port Number	R	BE	12.4.2
evbVsiIDType	enumerated	R	BE	41.2.6, Table 41-5
evbVsiID	Latin1 String (SIZE(16))	R	BE	41.2.7
evbVsiTimeSinceCreate	time interval	R	BE	Clause 41
evbVsiVdpOperCmd	enumerated	R	BE	41.2.1, Table 41-1
evbVsiOperRevert	Boolean	R	BE	41.2.3
evbVsiOperHard	Boolean	R	BE	41.2.3
evbVsiOperReason	unsigned (0..15)	R	BE	41.2.3
evbVsiMgrID	Latin1 String (SIZE(1))	R	BE	41.1.3
evbVsiType	Latin1 String (SIZE(3))	R	BE	41.2.4
evbVsiTypeVersion	Latin1 String (SIZE(1))	R	BE	41.2.5
evbVsiMvFormat	Latin1 String (SIZE(1))	R	BE	41.2.8
evbVsiNumMACs	unsigned	R	BE	41.2.9
evbVdpMachineState	enumerated	R	BE	41.5.5.14
evbVdpCmdsSucceeded	counter	R	BE	41.5
evbVdpCmdsFailed	counter	R	BE	41.5
evbVdpCmdsReverts	counter	R	BE	41.5

[a] R = Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system.

Each EVB Bridge or EVB station maintains a table of the VID/MACs on each VSI. The structure of a VSI MAC/VLAN table entry is shown in Table 12-26. This read-only table provides the current GroupID/VID/MAC assignments for each VSI. The operations that can be performed on the VSI table are as follows:

b) Read entries for a ComponentID, Port Number, and VSIID
c) Read entries for a ComponentID and Port Number

Table 12-26—VSI MAC/VLAN table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
evbMvComponentID	ComponentID	R	BE	12.4.1.5
evbMvPortNumber	Port Number	R	BE	12.4.2
evbMvVsiIDType	enumerated	R	BE	41.2.6, Table 41-5
evbMvVsiID	Latin1 String (SIZE(16))	R	BE	41.2.7
evbMvVsiGroupID	unsigned	R	BE	41.2.9
evbMvVsiVID	unsigned (1..4094)	R	BE	41.2.9
evbMvVsiMAC	MAC address	R	BE	41.2.9
evbMvVsiIpAddress	IP address	R		41.2.9

[a] R= Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system.

12.26.4 S-channel configuration and management

The S-channel managed objects are not required unless the system implements S-channels.

Creating a UAP table entry (40.2) causes a Port-mapping S-VLAN component (15.6) to be instantiated and sets the portType parameter of the Port table entry (12.4.2) to type ‘Uplink Access Port’. The Port-mapping S-VLAN component automatically includes a default S-channel with one CAP that can attach to an SBP or a URP through an internal LAN (6.14). Each UAP is identified by the ISS Port Number where the UAP is attached. The default S-channel and CAP shall be identified by the S-VID 1 and SCID 1.

Table 12-27—UAP table entry parameters

UAP table name	Default values
uapSchCdcpAdminEnable	TRUE
uapSchCdcpAdminRole	schS if EVB station and schB if EVB Bridge
uapSchCdcpAdminChnCap	1
uapSchAdminCdcpSvidPoolLow	0
uapSchAdminCdcpSvidPoolHigh	0

12.26.4.1 UAP table entry

The management operations that can be performed on the UAP table entry (Table 12-28) managed object are as follows:

a) Read UAP table entry
b) Update UAP table entry
c) Create UAP table entry
d) Delete UAP table entry

Table 12-28—UAP table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
uapISSPortNumber	Port Number	R	BE	12.4.2, 12.5.1
uapComponentID	ComponentID	R	be	12.4.1.5
uapPortNumber	Port Number	R	be	12.4.2
uapSchCdcpAdminEnable	Boolean	RW	BE	42.4.2
uapSchCdcpAdminRole	enumerated	RW	BE	42.4.2
uapSchCdcpAdminChnCap	unsigned [1...167]	RW	BE	42.4.1
uapSchCdcpOperChnCap	unsigned [1...167]	R	BE	42.4.8
uapSchAdminCdcpSvidPoolLow	unsigned [0,2...4094]	RW	BE	42.4.7
uapSchAdminCdcpSvidPoolHigh	unsigned [0,2...4094]	RW	BE	42.4.7
uapSchOperState	enumerated	R	BE	42.4.14
uapSchCdcpRemoteEnabled	Boolean	R	BE	42.4.14
uapSchCdcpRemoteRole	enumerated	R	BE	42.4.12

[a] R = Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system; b = Optional for an EVB Bridge system; e = Optional for an EVB station system.

Table 12-27 shows the default values for the UAP table entry parameters.

The available SVIDs determined by the range of uapSchAdminCdcpSvidPoolLow and uapSchAdminCdcpSvidPoolHigh limit the S-channel capacity indicated by uapSchCdcpAdminChnCap to the available SVIDs plus one for the default S-channel. If the capacity is greater than the VID range plus one, then the VID range overrides the capacity (i.e., the actual capacity is never bigger than the available VID range plus one).

12.26.4.2 S-channel interface table entry

The S-channel interface table entry applies to each internal S-channel configured on an EVB Bridge or EVB station, as shown in Table 12-29. The management operations that can be performed on an S-channel interface table entry are as follows:

a) Read S-channel interface table entry
b) Update S-channel interface table entry
c) Create S-channel interface table entry
d) Delete S-channel interface table entry

If the S-channel interface table is being used with a UAP operating in the cdcpS role, then the table is keyed on schUapISSPortNumber and schScid. If the S-channel interface table is being used with a UAP operating in the cdcpB role, then the table is keyed on the schUapISSPortNumber and schSvid.

The schComponentID and schCapPortNumber refer to the Port-mapping S-VLAN component and the Port, which may also be identified by the schISSPortNumber and S-VID (or SCID).

The schSbpOrUrpComponentID and schSbpOrUrpPortNumber are the ComponentID and Port Number of the attached SBP or URP.

Table 12-29—S-channel interface table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
schUapISSPortNumber	Port Number	R	BE	12.4.2, 12.5.1
schScid	unsigned [1...4094]	R	bE	42.4.3
schSvid	unsigned [0...4094]	R	BE	42.4.3
schComponentID	ComponentID	R	be	42.1, 12.4.1.5
schCapPortNumber	Port Number	R	be	42.1, 12.4.2
schSbpOrUrpComponentID	ComponentID	RW	BE	12.4.1.5
schSbpOrUrpPortNumber	Port Number	RW	BE	12.4.2

[a] R= Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system; b = Optional for an EVB Bridge system; e = Optional for an EVB station system.

12.26.5 ER management

ERs can be built dynamically or statically within an EVB station. Each ER is assigned a ComponentID that is unique for the EVB station system. An ER always has a single URP that exists as long as the ER exists. The DRPs of an ER may be built either along with the ER or on demand.

12.26.5.1 URP table entry

When a URP table entry is created, a corresponding Component table entry is created for the ER along with a Port table entry for the URP. When a URP table entry is deleted, the corresponding Component table entry is deleted along with the corresponding Port table entry.

When each URP table entry is created, a corresponding entry is created in the ECP table (12.27) and keyed under the ComponentID and Port Number of the URP. Whenever a URP table entry is deleted, the corresponding entry in the ECP table is deleted.

The management operations that can be performed on the URP table entry (Table 12-30) managed object are as follows:

a) Read URP table entry
b) Update URP table entry
c) Create URP table entry
d) Delete URP table entry

Table 12-30—URP table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
urpComponentID	ComponentID	R	E	12.4.1.5
urpPortNumber	Port Number	R	E	12.4.2
urpBindToISSPortNumber	unsigned [0...4095]	RW	e	12.5.1
urpLldpManual	Boolean	RW	E	
urpVdpOperRsrcWaitDelay	timer exp	R	E	D.2.12, 41.5.5.7
urpVdpOperRespWaitDelay	unsigned	R	E	D.2.12, 41.5.5.9
urpVdpOperReinitKeepAlive	timer exp	R	E	D.2.12, 41.5.5.5

[a] R = Read-only access; RW = Read/Write access.
[b] E = Required for an EVB station system; e = Optional for an EVB station system.

12.27 Edge Control Protocol (ECP) management

12.27.1 ECP table entry

The management operation that can be performed on the ECP table entry managed object is as follows:

a) Read ECP table entry

ECP table entries (Table 12-31) are created or deleted implicitly as a result of the creation or deletion of other port objects.

Table 12-31—ECP table entry

Name	Data type	Operations supported[a]	Conformance[b]	References
ecpComponentID	ComponentID	R	BE	12.4.1.5
ecpPortNumber	Port Number	R	BE	12.4.2
ecpOperAckTimerInit	timer exp	R	BE	D.2.12, 43.3.7.1
ecpOperMaxRetries	unsigned [0...7]	R	BE	D.2.12, 43.3.7.4
ecpTxFrameCount	counter	R	BE	Clause 43
ecpTxRetryCount	counter	R	BE	Clause 43
ecpTxFailures	counter	R	BE	Clause 43
ecpRxFrameCount	counter	R	BE	Clause 43

[a] R = Read-only access; RW = Read/Write access.
[b] B = Required for an EVB Bridge system; E = Required for an EVB station system.

12.28 Path Control and Reservation (PCR) management

The VLAN Bridges that support IS-IS implement the following SPB managed objects because they are required for IS-IS operations in a Bridged Network. Therefore, these SPB managed objects are required for explicit path control via IS-IS, i.e., for PCR operations:

— SPB System managed object (12.25.1)
— SPB MTID Static managed object (12.25.2)
— SPB Topology Instance Dynamic managed object (12.25.3)
— SPB ECT Static Entry managed object (12.25.4)
— SPB ECT Dynamic Entry managed object (12.25.5)
— SPB Adjacency Static Entry managed object (12.25.6)
— SPB Adjacency Dynamic Entry managed object (12.25.7)
— SPBM BSI Static Entry managed object (12.25.8)
— SPB Topology Node Table managed object (12.25.9)
— SPB Topology ECT Table managed object (12.25.10)
— SPB Topology Edge Table managed object (12.25.11)
— SPBM Topology Service Table managed object (12.25.12)
— SPBV Topology Service Table managed object (12.25.13)

The above listed SPB managed objects shall be used to configure PCR operations in SPT Bridges as specified in Clause 45. For instance, if a VLAN is under explicit path control via IS-IS, then the corresponding explicit ECT Algorithm value of Table 45-1 has to be used for the VLAN's Base VID when the SPB ECT Static Entry managed object (12.25.4) is created.

NOTE—The SPBM BSI Static Entry managed object (12.25.8) and the SPBM Topology Service Table managed object (12.25.12) are not required if no backbone Service Instance is present in the SPT Region.

Managed objects dedicated to PCR are needed only for Maximally Redundant Trees (MRTs). Due to the dependence on SPB managed objects, the PCR managed objects are specified as part of the SPB managed object hierarchy as illustrated in Figure 12-3. The following are the PCR managed objects in an SPT Bridge:

a) The PCR ECT Static Entry managed object (12.28.1)
b) The PCR Topology ECT Table managed object (12.28.2)

The SPVID parameter of an ISIS-SPB sub-TLV and an SPB managed object does not convey Shortest Path VID if it refers to an explicit tree (Clause 45), but the SPVID parameter is used to carry another type of VID as specified by 45.1.3, e.g., an MRT VID. These VIDs are always configured and never auto-allocated.

If the ECT Algorithm takes the value of the LTS ECT Algorithm (Table 45-1) and it is a learning VLAN (45.1.3), i.e., the VLAN's Base VID is allocated to the SPBV-MSTID (0xFFD), then the Bridge's VID [also allocated to the SPBV-MSTID, and not to the SPVID pool (SPVID-Pool-MSTID: 0xFFF) as is done for Shortest Path Bridging operation] has to be configured in place of the SPVID parameter of the SPB ECT Static Entry managed object [item d) in 12.25.4.1.2].

If the ECT Algorithm is one of the MRT algorithms (Table 45-1), then MRT VID values are domain-wide for a non-learning VLAN, whereas they are Bridge-local for a learning VLAN. If it is a learning VLAN (45.1.3), i.e., the VLAN's Base VID is allocated to the SPBV-MSTID, then the Bridge's MRT VIDs (also allocated to the SPBV-MSTID) have to be configured as the MRT-Blue VID and MRT-Red VID parameters of the PCR ECT Static Entry managed object (12.28.1). MRT VIDs are configured; they cannot be auto-allocated. The Base VID's SPVID entry in the SPB ECT Static managed object (12.25.2) is ignored for learning VLANs if the MRTs protect each other. If the MRTs protect an SPT for a learning VLAN, then a Shortest Path VID (a real SPVID allocated to the SPVID-Pool-MSTID) has to be associated with the SPT Bridge, in addition to its MRT VIDs, which is provided as specified by 12.25. The Shortest Path VID is configured via the SPB ECT Static Entry managed object (see item d) in 12.25.4.1.2] and its allocation

method (automatic or manual) is configured via the SPB System managed object (see item c) in 12.25.1.2.2].

12.28.1 The PCR ECT Static Entry managed object

Each Bridge has one PCR ECT Static Entry managed object per Base VID assigned with MRT operation (45.3.3, 45.3.4). The static Entry contains the MRT VID configuration parameters for the Base VID. It is persistent over reboot. The management operations that can be performed on the ECT Static Entry managed object are as follows:

a) Create a PCR ECT Static Entry managed object (12.28.1.1)
b) Read a PCR ECT Static Entry managed object (12.28.1.2)
c) Write a PCR ECT Static Entry managed object (12.28.1.3)
d) Delete a PCR ECT Static Entry managed object (12.28.1.4)

12.28.1.1 Create PCR ECT Static Entry managed object

12.28.1.1.1 Purpose

To create, configure, and interrogate a PCR ECT Static Entry managed object on a Bridge.

12.28.1.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. This VID has been allocated either to the SPBM-MSTID (0xFFC) for non-learning VLANs or to the SPBV-MSTID (0xFFD) for learning VLANs in the FID to MSTI Allocation table (12.12.2.2). An SPB ECT Static Entry managed object (12.25.4) has to be created for the Base VID and Topology Index prior to the creation of the PCR ECT Static Entry managed object.
c) The MRT-Blue VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Blue VID has to be allocated to the same MSTID as the Base VID. If it is a non-learning VLAN, i.e., the Base VID is allocated to the SPBM-MSTID (0xFFC), and the MRTs are used to protect each other, then the value of the MRT-Blue VID has to take the value of the Base VID. An MRT-Blue VID is always assigned by configuration. In the case of a learning VLAN or if the MRTs protect SPTs of a non-learning VLAN, the values of Base VID, MRT-Blue VID, and MRT-Red VID are all different.
d) The MRT-Red VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Red VID has to be allocated to the same MSTID as the Base VID. An MRT-Red VID is always assigned by configuration.

12.28.1.1.3 Outputs

a) Operation status. This takes one of the following values:
    1) Operation rejected because the Topology Index value is not defined.
    2) Operation rejected because the SPB ECT Static Entry managed object does not exist for the Base VID and Topology Index.
    3) Operation rejected because the requested Base VID was not assigned with MRT operation.
    4) Operation rejected due to MRT-Blue VID not allocated to the same MSTID as the Base VID.
    5) Operation rejected due to MRT-Red VID not allocated to the same MSTID as the Base VID.
    6) Operation accepted.

12.28.1.2 Read PCR ECT Static Entry managed object

12.28.1.2.1 Purpose

To obtain information about the PCR ECT Static Entry managed object for a Base VID.

12.28.1.2.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. The value 4095 is a wildcard indicating that information on any Base VID assigned with MRT operation is requested.

12.28.1.2.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected
   2) Operation accepted
b) A Topology Index value that uniquely identifies this topology instance.
c) A list of <Base VID, MRT-Blue VID, MRT-Red VID> 3-tuples assigned with MRT operation. The list is null if no VLAN is assigned with MRT operation. The list comprises a single 3-tuple if the Base VID parameter is not the wildcard (12.28.1.2.2).

12.28.1.3 Write PCR ECT Static Entry managed object

12.28.1.3.1 Purpose

To configure a PCR ECT Static Entry managed object for a Base VID.

12.28.1.3.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID. This VID has been allocated either to the SPBM-MSTID (0xFFC) for non-learning VLANs, or to the SPBV-MSTID (0xFFD) for learning VLANs in the FID to MSTI Allocation table (12.12.2.2). An SPB ECT Static Entry managed object (12.25.4) has to be created for the Base VID and Topology Index prior to the creation of the PCR ECT Static Entry managed object.
c) The MRT-Blue VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Blue VID has to be allocated to the same MSTID as the Base VID. If it is a non-learning VLAN, i.e., the Base VID is allocated to the SPBM-MSTID (0xFFC), and the MRTs are used to protect each other, then the value of the MRT-Blue VID has to take the value of the Base VID. An MRT-Blue VID is always assigned by configuration. In the case of a learning VLAN or if the MRTs protect SPTs of a non-learning VLAN, the values of Base VID, MRT-Blue VID, and MRT-Red VID are all different.
d) The MRT-Red VID assigned with the Base VID of the corresponding SPB ECT Static Entry managed object. The MRT-Red VID has to be allocated to the same MSTID as the Base VID. An MRT-Red VID is always assigned by configuration.

12.28.1.3.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Topology Index value is not defined.
   2) Operation rejected because the SPB ECT Static Entry managed object does not exist for the Base VID and Topology Index.
   3) Operation rejected because the requested Base VID was not assigned with MRT operation.
   4) Operation rejected due to MRT-Blue VID not allocated to the same MSTID as the Base VID.
   5) Operation rejected due to MRT-Red VID not allocated to the same MSTID as the Base VID.

6) Operation accepted.

12.28.1.4 Delete PCR ECT Static Entry managed object

12.28.1.4.1 Purpose

To delete the PCR ECT Static Entry managed object for a Base VID.

12.28.1.4.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) A Base VID.

12.28.1.4.3 Outputs

a) Operation status. This takes one of the following values:
   1) Operation rejected because the Bridge has services currently assigned with this Base VID.
   2) Operation rejected because the SPT Region has services currently using this Base VID.
   3) Operation rejected because PCR ECT Static Entry managed object does not exist for the Base VID.
   4) Operation accepted.

12.28.2 The PCR Topology ECT Table managed object

There is one PCR Topology ECT Table managed object per Bridge per IS-IS topology. It is populated by IS-IS with the nodal ECT parameters discovered for all SPT Bridges participating in that topology within the SPT Region. This object is automatically created as a consequence of the creation of a PCR ECT Static Entry managed object for the given IS-IS topology. It is automatically deleted with the deletion of the last PCR ECT Static Entry managed object for the given IS-IS topology. The management operation that can be performed on the PCR Topology ECT Table managed object is as follows:

a) Read PCR Topology ECT Table managed object

12.28.2.1 Read PCR Topology ECT Table managed object

12.28.2.1.1 Purpose

To obtain nodal information from all SPT Bridges of an SPT Region on the binding of Base VIDs to the MRT algorithms in an IS-IS topology.

12.28.2.1.2 Inputs

a) A Topology Index value that uniquely identifies a topology instance.
b) The System Identifier of a remote Bridge. The value zero is a wildcard indicating the information on all System identifiers is requested.
c) The Base VID. The value 4095 is a wildcard indicating that information on any Base VID assigned with MRT operation is requested.

12.28.2.1.3 Outputs

A list comprising one entry for each Base VID assigned to MRT operation at a Bridge within the SPT Region that the local IS-IS instance is aware. The list can be empty. Each entry contains the following information about a remote Bridge:

a) The Topology Index value that uniquely identifies this topology instance
b) The System Identifier of the remote Bridge

c) The Base VID
d) The VLAN's operational mode (learning or non-learning)
e) MRT-Blue VID
f) MRT-Red VID

If item b) identifies a specific remote Bridge, then the above list comprises one entry per Base VID as specified in item c), containing only information about the specific remote Bridge.

12.29 Managed objects for scheduled traffic

The Bridge enhancements for support of scheduled traffic are defined in 8.6.8 and 8.6.8.4.

This managed resource comprises the following object:

a) The Gate Parameter Table (12.29.1)

12.29.1 The Gate Parameter Table

There is one Gate Parameter Table per Port of a Bridge component. Each table row contains a set of parameters that supports the enhancements for scheduled traffic (8.6.8.4), as detailed in Table 12-32. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of ports and components.

Table 12-32—The Gate Parameter Table

Name	Data type	Operations supported[a]	Conformance[b]	References
queueMaxSDUTable[c]	sequence of queueMaxSDU	RW	BE	8.6.8.4, 12.29.1.1, 12.29.1.1.1
GateEnabled	Boolean	RW	BE	8.6.9.4.14
AdminGateStates	gateStatesValue	RW	BE	8.6.9.4.5, 12.29.1.2, 12.29.1.2.2
OperGateStates	gateStatesValue	R	BE	8.6.9.4.21, 12.29.1.2, 12.29.1.2.2
AdminControlListLength	unsigned integer	RW	BE	8.6.9.4.6, 12.29.1.2
OperControlListLength	unsigned integer	R	BE	8.6.9.4.22, 12.29.1.2
AdminControlList	sequence of GateControlEntry	RW	BE	8.6.9.4.2, 12.29.1.2, 12.29.1.2.1
OperControlList	sequence of GateControlEntry	R	BE	8.6.9.4.18, 12.29.1.2, 12.29.1.2.1
AdminCycleTime	RationalNumber (seconds)	RW	BE	8.6.9.4.3, 12.29.1.3

Table 12-32—The Gate Parameter Table *(continued)*

Name	Data type	Operations supported[a]	Conformance[b]	References
OperCycleTime	RationalNumber (seconds)	R	BE	8.6.9.4.19, 12.29.1.3
AdminCycleTimeExtension	Integer (nanoseconds)	RW	BE	8.6.9.4.4
OperCycleTimeExtension	Integer (nanoseconds)	R	BE	8.6.9.4.20
AdminBaseTime	PTPtime	RW	BE	8.6.9.4.1, 12.29.1.4
OperBaseTime	PTPtime	R	BE	8.6.9.4.17, 12.29.1.4
ConfigChange	Boolean	RW	BE	8.6.9.4.7
ConfigChangeTime	PTPtime	R	BE	8.6.9.4.9, 12.29.1.4
TickGranularity	Integer (tenths of nanoseconds)	R	BE	8.6.9.4.16
CurrentTime	PTPtime	R	BE	8.6.9.4.10, 12.29.1.4
ConfigPending	Boolean	R	BE	8.6.9.3, 8.6.9.4.8
ConfigChangeError	Integer	R	BE	8.6.9.3.1
SupportedListMax	Integer	R	BE	12.29.1.5

[a] R= Read only access; RW = Read/Write access.

[b] B = Required for Bridge or Bridge component support of enhancements for scheduled traffic; E = Required for end station support of enhancements for scheduled traffic.

[c] The number of queues supported by a Port is available from the traffic class table (12.6.3)

12.29.1.1 The queueMaxSDUTable structure and data types

The queueMaxSDUTable consists of up to 8 entries, one per traffic class supported by the implementation, each entry consisting of a queueMaxSDU value (12.29.1.1.1) and a TransmissionOverrun counter.

12.29.1.1.1 queueMaxSDU

An unsigned integer value, denoting the maximum SDU size supported by the queue.

12.29.1.1.2 TransmissionOverrun

A counter that is incremented when the implementation detects that the transmission gate associated with a queue has closed and a frame that originated from the queue is still being transmitted by the MAC.

12.29.1.2 The gate control list structure and data types

The AdminControlList and OperControlList are ordered lists containing AdminControlListLength or OperControlListLength entries, respectively. Each entry represents a gate operation as defined in Table 8-7. Each entry in the list is structured as a GateControlEntry (12.29.1.2.1).

12.29.1.2.1 GateControlEntry

A GateControlEntry consists of an operation name, followed by up to 2 parameters associated with the operation, as detailed in Table 8-7. The first parameter, if present, is a gateStatesValue (12.29.1.2.2); the second parameter, if present, is a timeIntervalValue (12.29.1.2.3).

12.29.1.2.2 gateStatesValue

A list of up to 8 tuples, one for each traffic class supported by the Port, each of which consists of a traffic class number in the range 0–7 and a gate state that is an enumerated value representing the gate state, *open* or *closed*, for that traffic class (see GateState in Table 8-7).

12.29.1.2.3 timeIntervalValue

An unsigned integer, denoting a TimeInterval in nanoseconds (see TimeInterval in Table 8-7).

12.29.1.3 RationalNumber

A rational number represented by an integer numerator and an integer denominator.

12.29.1.4 PTPtime

A time value, expressed as a PTP timescale (see IEEE Std 802.1AS).

12.29.1.5 SupportedListMax

The maximum value supported by this Port of the AdminControlListLength and OperControlListLength parameters. It is available for use by schedule computation software to determine the port’s control list capacity prior to computation.

12.29.2 Timing points for scheduled traffic

Table 12-32 specifies times (e.g., AdminBaseTime) with reference to the on-the-wire timing point at which the start of a frame crosses the boundary between the physical network media and the PHY. This is the message timestamp point specified by IEEE Std 802.1AS for various media.

Figure 12-6 shows both the on-the-wire timing point and the transmission selection timing point within the interface stack (above MAC and PHY) that is used for gate open/close as described in 8.6.8.4. Each timing point will have variance. A delay exists between the transmission selection timing point and the on-the-wire timing point. This delay will have variance that is bounded (minimum/maximum).

The Bridge contains the information needed in order to compute the minimum/maximum delay from the transmission selection timing point to the on-the-wire timing point. The Bridge shall adjust using the minimum delay, such that a frame's on-the-wire timing point occurs no earlier than the gate events represented in managed objects.

NOTE 1—As an example, consider an IEEE 802.3 port configured to transmit a single traffic class with known frame lengths, where the managed objects are configured for a cycle of open for two milliseconds, then closed for two milliseconds. If a one millisecond burst of frames is transmitted through the Bridge to the port, the preamble and SFD can be transmitted during the closed window, but no other symbol of a frame can be transmitted from the PHY during the closed window (including the FCS).

NOTE 2—Although the managed objects apply to a Bridge, the preceding specification of on-the-wire timing point can be applied to an end station.

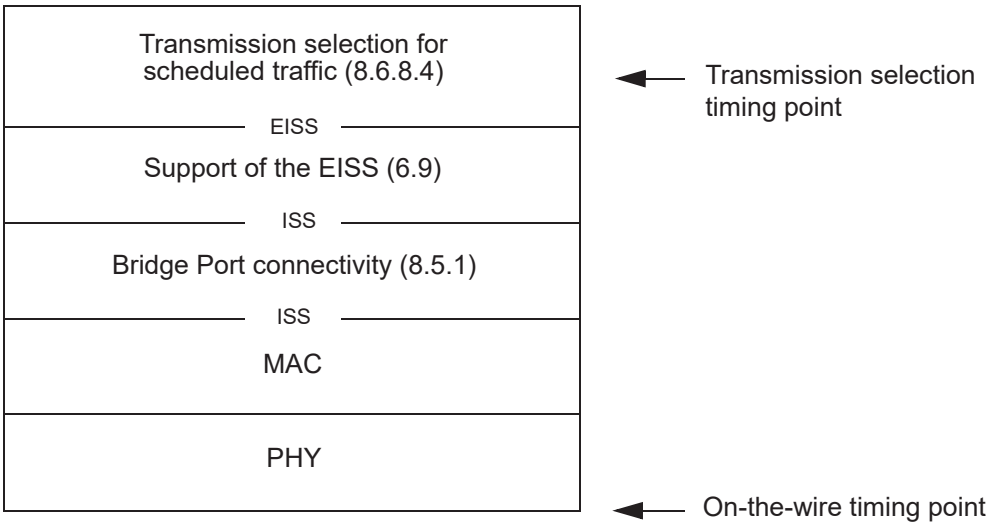


Figure 12-6—Timing points for scheduled traffic

12.30 Managed objects for frame preemption

The Bridge enhancements for support of frame preemption are defined in 8.6.8, 8.6.8.4, and 6.7.2.

This managed resource comprises the following object:

a) Frame Preemption Parameter Table (12.30.1)

12.30.1 Frame Preemption Parameter table

There is one Frame Preemption Parameter table per Port of a Bridge component or end station. Each table row contains a set of parameters that supports the enhancements for frame preemption (6.7.2), as detailed in Table 12-33. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of ports and components.

Table 12-33—Frame Preemption Parameter table

Name	Data type	Operations supported[a]	Conformance[b]	References
framePreemptionStatusTable	sequence of framePreemptionAdminStatus values	RW	BE	6.7.2, 12.30.1.1, 12.30.1.1.1.
holdAdvance	Integer, nanoseconds	R	BE	Table 8-7, 12.30.1.2
releaseAdvance	Integer, nanoseconds	R	BE	Table 8-7, 12.30.1.3
preemptionActive	Boolean	R	BE	12.30.1.4
holdRequest	Integer {hold (1), release (2)}	R	BE	Table 8-7, 12.30.1.5

[a] R = Read only access; RW = Read/Write access

[b] B = Required for Bridge or Bridge component support of enhancements for frame preemption; E = Required for end station support of enhancements for frame preemption.

12.30.1.1 framePreemptionStatusTable structure and data types

The framePreemptionStatusTable (6.7.2) consists of 8 framePreemptionAdminStatus values (12.30.1.1.1), one per priority.

12.30.1.1.1 framePreemptionAdminStatus

This parameter is the administrative value of the preemption status for the priority. It takes value *express* if frames queued for the priority are to be transmitted using the express service for the Port, or *preemptable* if frames queued for the priority are to be transmitted using the preemptable service for the Port and preemption is enabled for the Port.

Priorities that all map to the same traffic class should be constrained to use the same value of preemption status.

12.30.1.2 holdAdvance object

The holdAdvance object contains an integer value representing the maximum number of nanoseconds that can elapse between issuing a HOLD (12.30.1.5) to the MAC and the MAC ceasing to transmit any preemptable frame that is in the process of transmission or any preemptable frames that are queued for transmission, including any MAC-specific delay before transmission of an express frame could start once preemptable frame transmission has ceased. This object exists per Port, and is a characteristic of the underlying MAC.

12.30.1.3 releaseAdvance object

The releaseAdvance object contains an integer value representing the maximum number of nanoseconds that can elapse between issuing a RELEASE (12.30.1.5) to the MAC and the MAC being ready to resume transmission of preemptable frames, in the absence of there being any express frames available for transmission. This object exists per Port, and is a characteristic of the underlying MAC.

12.30.1.4 preemptionActive object

TRUE if preemption is both supported by the MAC and currently active.

12.30.1.5 holdRequest object

The holdRequest object contains an enumerated integer value, with *hold (1)* indicating that a MM_CTL.request(HOLD) has been issued, and release (2) indicating that a MM_CTL.request(RELEASE) has been issued. This object exists per Port.

NOTE 1—In order that the operations enumerated in the table occur at the specified times (8.6.8.4), an implementation needs to trigger the MM_CTL.request in advance, as appropriate.

NOTE 2—In order to determine support of frame preemption by the Bridge, a network management application could attempt to read the preemptionActive object. If the read operation returns an error, frame preemption is not supported. Determining whether the MAC supports preemption could similarly be achieved by examining the objects in the MAC MIB.

12.31 Managed objects for per-stream classification and metering

The Bridge enhancements for support of per-stream classification and metering are defined in 8.6.5.2, 8.6.5.3, 8.6.5.4, 8.6.5.5, and 8.6.5.6. The associated state machines are defined in 8.6.10 and 8.6.11.

This managed resource comprises the following objects:

a) The Stream Parameter Table (12.31.1)
b) The Stream Filter Instance Table (12.31.2)
c) The Stream Gate Instance Table (12.31.3)
d) The Flow Meter Instance Table (12.31.4)
e) The Scheduler Instance Table (12.31.5)
f) The Scheduler Group Instance Table (12.31.6)
g) The Scheduler Port Parameter Table (12.31.7)
h) The Scheduler Timing Characteristics Table (12.31.8)

12.31.1 The Stream Parameter Table

There is one Stream Parameter Table per Bridge component. The table contains a set of parameters that supports PSFP (8.6.5.2.1) and ATS (8.6.5.2.2), as detailed in Table 12-34. Tables can be created or removed dynamically in implementations that support dynamic configuration of Bridge components.

Table 12-34—The Stream Parameter Table

Name	Data type	Operations supported[a]	Conformance[b]	References
MaxStreamFilterInstances	integer	R	PSFP, ATS	8.6.5.3, 12.31.2
MaxStreamGateInstances	integer	R	PSFP, ATS	8.6.5.4, 12.31.3
MaxFlowMeterInstances	integer	R	PSFP, ats	8.6.5.5, 12.31.4
SupportedListMax	integer	R	PSFP, ats	8.6.5.4, 12.31.4
MaxSchedulerInstances	integer	R	psfp, ATS	8.6.5.4, 12.31.4
MaxSchedulerGroupInstances	integer	R	psfp, ATS	8.6.5.4, 12.31.4

[a] R= Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.1.1 MaxStreamFilterInstances

The maximum number of Stream Filter instances supported by this Bridge component (8.6.5.3).

12.31.1.2 MaxStreamGateInstances

The maximum number of Stream Gate instances supported by this Bridge component (8.6.5.4).

12.31.1.3 MaxFlowMeterInstances

The maximum number of Flow Meter instances supported by this Bridge component (8.6.5.5).

12.31.1.4 SupportedListMax

The maximum value supported by this Bridge component of the AdminControlListLength (8.6.9.4.6) and OperControlListLength (8.6.9.4.22) parameters. It is available for use by schedule computation software to determine the Bridge component's control list capacity prior to computation.

12.31.1.5 MaxSchedulerInstances

The maximum number of ATS scheduler instances supported by this Bridge component (8.6.5.6).

12.31.1.6 MaxSchedulerGroupInstances

The maximum number of ATS scheduler group instances supported by this Bridge component (8.6.5.6).

12.31.2 The Stream Filter Instance Table

There is one Stream Filter Instance Table per Bridge component. Each table row contains a set of parameters that defines a single Stream Filter (8.6.5.3), as detailed in Table 12-35. The table rows form an ordered list of filter instances, the order being determined by the StreamFilterInstance parameter. Tables can be created or removed dynamically in implementations that support dynamic configuration of Bridge components. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of stream filters.

12.31.2.1 StreamFilterInstance

An integer index value that determines the place of the stream filter in the ordered list of stream filter instances. The values of StreamFilterInstance are ordered according to their integer value; smaller values appear earlier in the ordered list.

12.31.2.2 stream_handle specification data type

The stream_handle specification data type allows either of the following to be represented:

a) A stream_handle value, represented as an integer
b) The wild card value

12.31.2.3 priority specification data type

The priority specification data type allows either of the following to be represented:

a) A priority value, represented as an integer
b) The wild card value

12.31.2.4 MaxSDUSize

The MaxSDUSize parameter defines the maximum SDU size to be accepted by the stream filter (8.6.5.3). A value of 0 disables the maximum SDU size filtering for frames associated with the stream filter.

12.31.2.5 StreamGateInstanceID

The StreamGateInstanceID parameter identifies the stream gate instance (12.31.3) that is associated with the stream filter. The relationship between stream filters and stream gates is many to one; a given stream filter can be associated with only one stream gate, but there can be multiple stream filters associated with a given stream gate.

Table 12-35—Stream Filter Instance Table

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamFilterInstance	integer	R	PSFP, ATS	8.6.5.3
StreamHandleSpec	stream_handle specification	RW	PSFP, ATS	8.6.5.3
PrioritySpec	priority specification	RW	PSFP, ATS	8.6.5.3
MaximumSDUSize	integer	RW	PSFP, ATS	8.6.5.3.1, 12.31.2.5
StreamGateInstanceID	integer	RW	PSFP, ATS	8.6.5.2, 8.6.5.4
FlowMeterInstanceID	integer	RW	PSFP, ats	8.6.5.5, 12.31.2.5
FlowMeterEnable	Boolean	RW	PSFP, ats	
SchedulerInstanceID	integer	RW	psfp, ATS	
SchedulerEnable	Boolean	RW	psfp, ATS	
MatchingFramesCount	counter	R	PSFP, ats	8.6.5.3
PassingFramesCount	counter	R	PSFP, ats	8.6.5.3, 8.6.5.4
NotPassingFramesCount	counter	R	PSFP, ats	8.6.5.3, 8.6.5.4
PassingSDUCount	counter	R	PSFP, ats	8.6.5.3, 8.6.5.3.1
NotPassingSDUCount	counter	R	PSFP, ats	8.6.5.3, 8.6.5.3.1
REDFramesCount	counter	R	PSFP, ats	8.6.5.3
StreamBlockedDueToOversizeFrameEnable	Boolean	RW	PSFP, ATS	8.6.5.3, 8.6.5.3.1
StreamBlockedDueToOversizeFrame	Boolean	RW	PSFP, ATS	8.6.5.3, 8.6.5.3.1

[a] R= Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.2.6 FlowMeterInstanceID and FlowMeterEnable

If FlowMeterEnable is set to TRUE, the FlowMeterInstanceID parameter identifies the flow meter instance (12.31.4) that is associated with the stream filter. The relationship between stream filters and flow meters is many to one; a given stream filter can be associated with only one flow meter, but there can be multiple stream filters associated with a given flow meter. If FlowMeterEnable is set to FALSE, no flow meter instance is associated with the stream filter.

12.31.2.7 SchedulerInstanceID and SchedulerEnable

If SchedulerEnable is set to TRUE, the SchedulerInstanceID parameter identifies the ATS scheduler instance (12.31.5) that is associated with the stream filter. The relationship between stream filters and ATS schedulers is many to one; a given stream filter can be associated with only one ATS scheduler, but there can be multiple stream filters associated with a given ATS scheduler instance. If SchedulerEnable is set to FALSE, no ATS scheduler instance is associated with the stream filter.

12.31.3 The Stream Gate Instance Table

There is one Stream Gate Instance Table per Bridge component. Each table row contains a set of parameters that defines a single Stream Gate (8.6.5.4), as detailed in Table 12-36. Tables can be created or removed dynamically in implementations that support dynamic configuration of Bridge components. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of stream gates.

Table 12-36—The Stream Gate Instance Table

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamGateInstance	integer	R	PSFP, ATS	8.6.5.4
StreamGateEnabled	Boolean	RW	PSFP, ATS	8.6.9.4.14
StreamGateAdminGateStates	StreamGateStatesValue	RW	PSFP, ATS	8.6.10.4, 12.29.1.2.2
StreamGateOperGateStates	StreamGateStatesValue	R	PSFP, ATS	8.6.10.5, 12.29.1.2.2
StreamGateAdminControlListLength	unsigned integer	RW	PSFP, ats	8.6.9.4.6, 12.31.3.2
StreamGateOperControlListLength	unsigned integer	R	PSFP, ats	8.6.9.4.22, 12.31.3.2
StreamGateAdminControlList	sequence of StreamGateGateControl Entry	RW	PSFP, ats	8.6.9.4.2, 12.31.3.2, 12.31.3.2.2
StreamGateOperControlList	sequence of StreamGateGateControl Entry	R	PSFP, ats	8.6.9.4.18, 12.31.3.2, 12.31.3.2.2
StreamGateAdminCycleTime	RationalNumber	RW	PSFP, ats	8.6.9.4.3, 12.29.1.3
StreamGateOperCycleTime	RationalNumber (seconds)	R	PSFP, ats	8.6.9.4.19, 12.29.1.3
StreamGateAdminCycleTime Extension	Integer (nanoseconds)	RW	PSFP, ats	8.6.9.4.4
StreamGateOperCycleTimeExtension	Integer (nanoseconds)	R	PSFP, ats	8.6.9.4.20
StreamGateAdminBaseTime	PTPtime	RW	PSFP, ats	8.6.9.4.1, 12.29.1.4
StreamGateOperBaseTime	PTPtime	R	PSFP, ats	8.6.9.4.17, 12.29.1.4

Table 12-36—The Stream Gate Instance Table *(continued)*

Name	Data type	Operations supported[a]	Conformance[b]	References
StreamGateConfigChange	Boolean	RW	PSFP, ats	8.6.9.4.7
StreamGateConfigChangeTime	PTPtime	R	PSFP, ats	8.6.9.4.9, 12.29.1.4
StreamGateTickGranularity	Integer (tenths of nanoseconds)	R	PSFP, ats	8.6.9.4.16
StreamGateCurrentTime	PTPtime	R	PSFP, ats	8.6.9.4.10, 12.29.1.4
StreamGateConfigPending	Boolean	R	PSFP, ats	8.6.9.3, 8.6.9.4.8
StreamGateConfigChangeError	Integer	R	PSFP, ats	8.6.9.3.1
StreamGateAdminIPV	IPV	RW	PSFP, ATS	8.6.5.4, 8.6.10.6, 12.31.3.3
StreamGateOperIPV	IPV	RW	PSFP, ats	8.6.5.4, 8.6.10.7, 12.31.3.3
StreamGateGateClosedDueToInvalid Rx-Enable	Boolean	RW	PSFP, ats	8.6.5.4
StreamGateGateClosedDueToInvalid Rx	Boolean	RW	PSFP, ats	8.6.5.4
StreamGateGateClosedDueToOctets ExceededEnable	Boolean	RW	PSFP, ats	8.6.5.4
StreamGateGateClosedDueToOctets Exceeded	Boolean	RW	PSFP, ats	8.6.5.4

[a] R= Read only access; RW = Read/Write access.

[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.3.1 StreamGateInstance

An integer table index that allows the stream gate to be referenced from Stream Filter Instance Table entries.

12.31.3.2 The gate control list structure and data types

The AdminControlList and OperControlList are ordered lists containing AdminControlListLength or OperControlListLength entries, respectively. Each entry represents a gate operation as defined in Table 8-4. Each entry in the list is structured as a GateControlEntry (12.31.3.2.2).

12.31.3.2.1 StreamGateStatesValue

The StreamGateStatesValue indicates the desired gate state, *open* or *closed*, for the stream gate.

12.31.3.2.2 StreamGateControlEntry

A StreamGateControlEntry consists of an operation name, followed by three parameters associated with the operation, as detailed in Table 8-4. The first parameter is a StreamGateStatesValue (12.31.3.2.1); the second parameter is an IPV value (12.31.3.2.3), and the third parameter is a timeIntervalValue (12.31.3.2.4).

12.31.3.2.3 IPV value

The IPV value indicates the IPV (12.31.3.3) to be associated with frames that pass the gate (8.6.10.7).

12.31.3.2.4 timeIntervalValue

An unsigned integer, denoting a TimeInterval in nanoseconds (see TimeInterval in Table 8-4).

12.31.3.3 The Internal priority value specification (IPV) data type

The IPV data type represents an IPV value (8.6.5.4); this is either the null value or an internal priority value.

12.31.3.4 Representation of times

Table 12-36 specifies times (e.g., StreamGateAdminBaseTime) with reference to the on-the-wire timing point at which the start of a frame crosses the boundary between the physical network media and PHY. This is the message timestamp point specified by IEEE Std 802.1AS for various media.

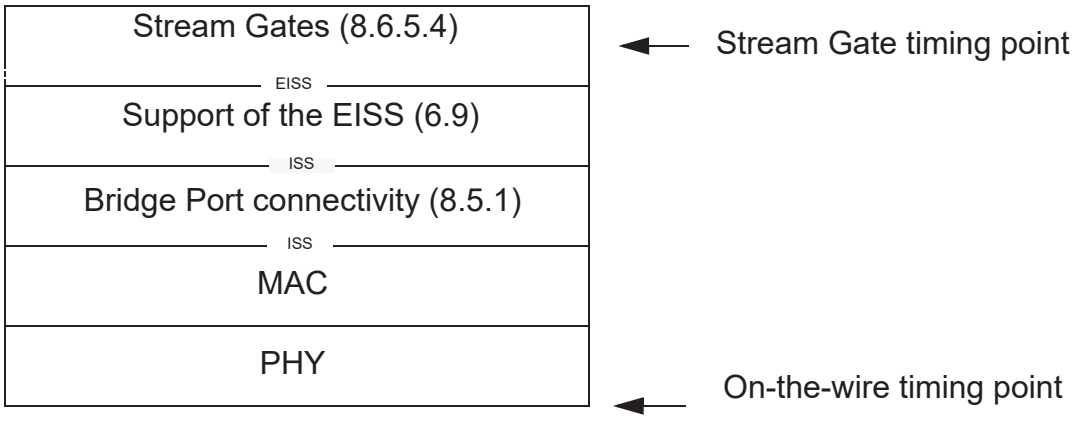


Figure 12-7—Timing points for PSFP

Figure 12-7 shows both the on-the-wire timing point and the Stream Gate timing point within the interface stack (above MAC and PHY) that is used for gate open/close as described in 8.6.5.4. Each timing point will have variance. A delay exists between the on-the-wire timing point and the Stream Gate timing point. This delay will have variance that is bounded (minimum/maximum).

The Bridge contains the information needed in order to compute the minimum/maximum delay from the on-the-wire timing point to the Stream Gate timing point. The Bridge shall adjust using the maximum delay, such that a frame's on-the-wire timing point occurs no later than the gate events represented in managed objects.

NOTE—Although the managed objects apply to a Bridge, the preceding specification of on-the-wire timing point can be applied to an end station.

12.31.4 The Flow Meter Instance Table

There is one Flow Meter Instance Table per Bridge component. Each table row contains a set of parameters that defines a single Flow Meter Instance (8.6.5.5), as detailed in Table 12-37. Tables can be created or removed dynamically in implementations that support dynamic configuration of Bridge components. Rows in the table can be created or removed dynamically in implementations that support dynamic configuration of flow meters.

Table 12-37—The Flow Meter Instance Table

Name	Data type	Operations supported[a]	Conformance[b]	References
FlowMeterInstanceID	integer	R	PSFP, ats	8.6.5.2, 8.6.5.5
CIR	integer, bit/second	RW	PSFP, ats	8.6.5.5
CBS	integer, octets	RW	PSFP, ats	8.6.5.5
EIR	integer, bit/second	RW	PSFP, ats	8.6.5.5
EBS	integer, octets	RW	PSFP, ats	8.6.5.5
CF	integer, 0 or 1	RW	PSFP, ats	8.6.5.5
CM	enumerated, color-blind or color-aware	RW	PSFP, ats	8.6.5.5
DropOnYellow	Boolean	RW	PSFP, ats	8.6.5.5
MarkAllFramesRedEnable	Boolean	RW	PSFP, ats	8.6.5.5
MarkAllFramesRed	Boolean	RW	PSFP, ats	8.6.5.5

[a] R= Read only access; RW = Read/Write access.

[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.5 The Scheduler Instance Table

There is one Scheduler Instance Table per Bridge component. Each table row in the Scheduler Instance Table comprises a set of parameters that defines a single ATS scheduler instance, as detailed in Table 12-38.

NOTE—ATS scheduler groups establish the relationship between ATS scheduler instances and the per port management variables (12.31.7), as described in 8.6.5.6. As a result, the scheduler instance table does not contain references to ports.

12.31.5.1 SchedulerInstanceID

An integer table index that allows the ATS scheduler instance to be referenced from Stream Filter Instance Table entries.

12.31.5.2 CommittedBurstSize

As specified in 8.6.11.3.5.

Table 12-38—The Scheduler Instance Table

Name	Data type	Operations supported[a]	Conformance[b]	References
SchedulerInstanceID	integer	R	psfp, ATS	8.6.5.6, 12.31.5.1
CommittedBurstSize	integer, bits	RW	psfp, ATS	8.6.5.6, 8.6.11.3.5, 12.31.5.2
CommittedInformationRate	integer, bits/s	RW	psfp, ATS	8.6.5.6, 8.6.11.3.6, 12.31.5.3
SchedulerGroupInstanceID	integer	RW	psfp, ATS	8.6.5.6, 12.31.5.4

[a] R= Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.5.3 CommittedInformationRate

As specified in 8.6.11.3.6.

12.31.5.4 SchedulerGroupInstanceID

The SchedulerGroupInstanceID parameter identifies the ATS scheduler group (12.31.6) that is associated with the ATS scheduler instance. Multiple scheduler instance can be associated to one ATS scheduler group, as detailed in 8.6.5.6.

12.31.6 The Scheduler Group Instance Table

There is one Scheduler Group Instance Table per Bridge component. Each table row in the Scheduler Group Instance Table comprises a set of parameters that defines a single ATS scheduler group instance (8.6.5.6), as detailed in Table 12-39.

Table 12-39—The Scheduler Group Instance Table

Name	Data type	Operations supported[a]	Conformance[b]	References
SchedulerGroupInstanceID	integer	R	psfp, ATS	8.6.5.6, 12.31.6.1
MaxResidenceTime	integer, nanoseconds	RW	psfp, ATS	8.6.5.6, 12.31.6.2

[a] R = Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.6.1 SchedulerGroupInstanceID

An integer table index that allows the ATS scheduler group instance to be referenced from Scheduler Instance Table entries.

12.31.6.2 MaxResidenceTime

As specified in 8.6.11.3.13.

12.31.7 The Scheduler Port Parameter Table

There is one Scheduler Port Parameter Table per Bridge. Each table row in the Scheduler Port Parameter Table comprises a set of parameters shared by all ATS scheduler instance associated with a reception Port, as detailed in Table 12-40.

Table 12-40—The Scheduler Port Parameter Table

Name	Data type	Operations supported[a]	Conformance[b]	References
PortNumber	integer	R	psfp, ATS	12.31.7.1
DiscardedFramesCount	integer	R	psfp, ATS	8.6.5.6, 8.6.11.3.7, 12.31.7.2

[a] R = Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.7.1 PortNumber

An unique index of the associated Bridge Port (12.4.2).

12.31.7.2 DiscardedFramesCount

As specified in 8.6.5.6 and 8.6.11.3.7.

12.31.8 The Scheduler Timing Characteristics Table

There is one Scheduler Timing Characteristics Table per Bridge component. Each row in this table comprises the timing characteristics of a reception Port transmission Port pair, as detailed in Table 12-41.

12.31.8.1 ReceptionPortNumber

An unique index of the associated reception Port of the Bridge (12.4.2).

12.31.8.2 TransmissionPortNumber

An unique index of the associated transmission Port of the Bridge (12.4.2).

Table 12-41—The Timing Characteristics Table

Name	Data type	Operations supported[a]	Conformance[b]	References
ReceptionPortNumber	integer	R	psfp, ATS	12.31.8.1
TransmissionPortNumber	integer	R	psfp, ATS	12.31.8.2
ClockOffsetVariationMax	integer	R	psfp, ATS	8.6.11.2, 12.31.8.3
ClockRateDeviationMax	integer	R	psfp, ATS	8.6.11.2, 12.31.8.4
ArrivalRecognitionDelayMax	integer	R	psfp, ATS	8.6.11.3.1, 12.31.8.5
ProcessingDelayMin	integer	R	psfp, ATS	8.6.11.3.2, 12.31.8.6
ProcessingDelayMax	integer	R	psfp, ATS	8.6.11.3.2, 12.31.8.7

[a] R = Read only access; RW = Read/Write access.
[b] PSFP = Required for Bridge, Bridge component, or end station support of PSFP.
psfp = Optional for Bridge, Bridge component, or end station support of PSFP.
ATS = Required for Bridge or Bridge component support of ATS.
ats = Optional for Bridge or Bridge component support of ATS.

12.31.8.3 ClockOffsetVariationMax

As specified in 8.6.11.2, in nanoseconds, rounded to the next numerically higher representable value.

12.31.8.4 ClockRateDeviationMax

As specified in 8.6.11.2, in ppm, rounded to the next numerically higher representable value.

12.31.8.5 ArrivalRecognitionDelayMax

As specified in 8.6.11.3.1, in nanoseconds, rounded to the next numerically higher representable value.

12.31.8.6 ProcessingDelayMin

As specified in 8.6.11.3.2, in nanoseconds, rounded to the next numerically lower representable value.

12.31.8.7 ProcessingDelayMax

As specified in 8.6.11.3.2, in nanoseconds, rounded to the next numerically higher representable value.

12.32 Stream reservation remote management

Clause 46 defines Time-Sensitive Networking (TSN) configuration, including a Centralized Network Configuration (CNC) station that uses managed objects for configuration of each Bridge. This subclause specifies managed objects within the Bridge that can be used by the TSN CNC station or any other management component.

This managed resource comprises the following objects:

c) Bridge Delay (12.32.1)
d) Propagation Delay (12.32.2)
e) Static Trees (12.32.3)
f) MRP External Control (12.32.4)

12.32.1 Bridge Delay

This subclause specifies attributes of a managed object that is used to determine the delay of frames as they pass through the Bridge's relay. There is one Bridge Delay managed object per Port pair per traffic class of a Bridge component. Each set of Bridge Delay attributes is accessed using three indices: ingress Port, egress Port, and traffic class. The set of managed object attributes is shown in Table 12-38.

Table 12-38—Bridge Delay attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
independentDelayMin	unsigned integer	R	B	12.32.1.1
independentDelayMax	unsigned integer	R	B	12.32.1.1
dependentDelayMin	unsigned integer	R	B	12.32.1.2
dependentDelayMax	unsigned integer	R	B	12.32.1.2

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of Stream reservation remote management; b = Optional for Bridge or Bridge component support of Stream reservation remote management.

For each set of Bridge Delay attributes, the total delay through the Bridge consists of the delay that is independent of frame length, plus the delay that is dependent on frame length.

Each delay is provided as a range, with both minimum attribute and maximum attribute.

The delays represent the worst-case range per the design of the Bridge, and are not measured. If the Bridge design varies based on the configuration of features in the Bridge, the delays are returned according to the current configuration of the Bridge.

NOTE 1—In order to obtain the most accurate delays, the TSN CNC typically configures the Stream from Talker to Listeners, and then reads the delays for the Ports that ingress/egress that Stream. For example, use of IEEE Std 802.1CB could change the implementation in the Bridge, and therefore it is best to configure those features in the Bridge prior to reading the delays.

Each delay is provided as if the corresponding frame encounters zero delay for transmission selection (8.6.8). This occurs when the queue for the frame's traffic class is empty, the frame's traffic class has permission to transmit, and the egress Port is idle (not transmitting).

NOTE 2—Computation of delay factors due to use of multiple traffic classes, frame preemption, traffic shaping, and traffic scheduling is the responsibility of the TSN CNC, and therefore these factors are not included in the delay attributes of this managed object. For example, assume that a frame of a TSN Stream encounters 12 µs of delay due to traffic scheduling (i.e., waiting for gate to open), 5 µs due to a previous frame of the same traffic class, and 700 ns to 800 ns of hardware delay (e.g., PHYs and relay). For this example, independentDelayMin is 700, and independentDelayMax is 800 (i.e., the extra 17 µs for queuing/scheduling is not included in this managed object).

12.32.1.1 independentDelayMin/Max

These attributes provide the portion of delay that is independent of frame length.

Each length-independent delay attribute is an unsigned integer in units of nanoseconds.

The independentDelayMin attribute provides the minimum length-independent delay for a frame to forward from ingress Port to egress Port for this traffic class. If the actual delay is a fraction of a nanosecond, independentDelayMin shall be the greatest integer number of nanoseconds that is less than or equal to the actual delay.

The independentDelayMax attribute provides the maximum length-independent delay for a frame to forward from ingress Port to egress Port for this traffic class. If the actual delay is a fraction of a nanosecond, independentDelayMax shall be the least integer number of nanoseconds that is greater than or equal to the actual delay.

NOTE 1—Since the minimum to maximum range is intended to be worst-case, the rules for handling a fraction of a nanosecond are intended to result in the widest range.

The delay begins when the message timestamp point of the ingress frame passes the reference plane marking the boundary between the network media and PHY. The delay ends when the message timestamp point of the egress frame passes the reference plane marking the boundary between the network media and PHY. The message timestamp point is specified by IEEE Std 802.1AS for various media, near the start of the frame.

NOTE 2—This delay includes all aspects of length-independent delay for a frame that is forwarded, including handling of error conditions.

12.32.1.2 dependentDelayMin/Max

These attributes provide the portion of delay that is dependent on frame length, where frame length is the number of octets that transfer across the MAC Service interfaces. Each length-dependent delay attribute specifies the time for a single octet of the frame to transfer from ingress to egress.

Each length-dependent delay attribute is an unsigned integer in units of picoseconds.

The dependentDelayMin attribute provides the minimum length-dependent delay from ingress Port to egress Port for this traffic class. If the actual delay is a fraction of a picosecond, dependentDelayMin shall be the greatest integer number of picoseconds that is less than or equal to the actual delay.

The dependentDelayMax attribute provides the maximum length-dependent delay from ingress Port to egress Port for this traffic class. If the actual delay is a fraction of a picosecond, dependentDelayMax shall be the least integer number of picoseconds that is greater than or equal to the actual delay.

NOTE—The length-dependent delay typically includes the time to receive and store each octet of the frame, and this time depends on the link speed of the ingress Port. For example, if the ingress Port is operating at 1 Gb/s, both dependentDelayMin and dependentDelayMax can return 8000. If an internal communication mechanism exists within the Bridge's architecture (i.e., in the relay), the time for that mechanism is added to the frame-dependent delay. For example, if a 100 Mb/s serial link connects the ingress and egress Ports, the previous example with 1 Gb/s link speed can return 88000 for both dependentDelayMin and dependentDelayMax.

12.32.2 Propagation Delay

This subclause specifies attributes of a managed object used to determine the delay along the network media (e.g., cable) for a frame transmitted from the specified Port of this station to the neighboring Port on a different station. There is one Propagation Delay managed object per Port of a station (i.e., Bridge or end station). The set of managed object attributes is shown in Table 12-39.

Table 12-39—Propagation Delay attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
txPropagationDelay	unsigned integer	R	BE	12.32.2.1

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of Stream reservation remote management; E = Required for end station support of Stream reservation remote management.

12.32.2.1 txPropagationDelay

The txPropagationDelay begins when the message timestamp point of an egress frame passes the reference plane marking the boundary between the network media and PHY of this station's Port. The txPropagationDelay ends when the message timestamp point of an ingress frame on the neighboring station's Port passes the reference plane marking the boundary between the network media and PHY. The message timestamp point is specified by IEEE Std 802.1AS for various media, near the start of the frame.

The txPropagationDelay attribute is an unsigned integer in units of nanoseconds. If the actual propagation delay is measured to a fraction of a nanosecond, the txPropagationDelay value shall be least integer number of nanoseconds that is greater than or equal to the actual delay.

NOTE 1—Propagation delay in one direction of transmit is not necessarily the same as propagation delay of transmit in the reverse direction. In order to determine if a delay asymmetry exists, management can read the txPropagationDelay attribute on the neighboring station's Port. The txPropagationDelay attribute of the neighboring station's Port effectively provides the propagation delay for receiving frames on this station's Port.

NOTE 2—The txPropagationDelay attribute is typically measured using a time synchronization protocol. For example, when IEEE Std 802.1AS is in use, the value of this attribute can be obtained using the managed objects neighborPropDelay and delayAsymmetry.

NOTE 3—One of the primary purposes of the txPropagationDelay attribute is to add to Bridge Delay in order to compute total latency for a Stream. Although time synchronization protocols based on IEEE Std 1588 typically measure propagation delay to units of 2–16 ns, that degree of precision is not required for txPropagationDelay, since Bridge Delay is expressed as nanoseconds.

12.32.3 Static Trees

This subclause specifies attributes of a managed object used to determine if the static trees feature is supported by the Bridge. There is one Static Trees managed object that applies to the Bridge. The set of managed object attributes is shown in Table 12-40.

Table 12-40—Static Trees attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
staticTreesSupported	Boolean	R	B	12.32.3.1

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of Stream reservation remote management.

12.32.3.1 staticTreesSupported

For some use cases, the TSN CNC needs to configure static (persistent) trees through Bridges from Talker to Listeners (e.g., for use of IEEE Std 802.1CB). The Traffic Engineering Multiple Spanning Tree Instance Identifier (TE-MSTID) can be leveraged for these use cases. A VLAN ID is allocated to the TE-MSTID in the MST Configuration Table if it is not under control of either a spanning tree protocol or IS-IS. Static Filtering Entries (8.8.1) specify frame forwarding and filtering for VLAN IDs allocated to the TE-MSTID.

The TE-MSTID feature is used as the basis of a set of features called Provider Backbone Bridge Traffic Engineering (PBB-TE) as specified in 25.10. For many TSN CNCs, use of the TE-MSTID feature is essential, but the additional features of PBB-TE are not necessary. The TSN CNC uses the staticTreesSupported attribute to determine that TE-MSTID is supported by the Bridge. A Bridge that supports PBB-TE without support of Stream reservation remote management is not required to implement the staticTreesSupported attribute.

A Bridge that supports Stream reservation remote management shall return the value TRUE from the staticTreesSupported attribute, and shall support the TE-MSTID as specified in 5.5.2.

NOTE—In order to determine support for TE-MSTID by the Bridge, the TSN CNC attempts to read the staticTreesSupported attribute. If the read operation returns an error, or if the read returns FALSE, then the TSN CNC concludes that TE-MSTID is not supported.

12.32.4 MRP External Control

In the Centralized network/distributed user model shown in Figure 46-2, user configuration data is exchanged in a distributed manner by each Talker/Listener end station, and the network is configured in a centralized manner (using a CNC). A Bridge near the Talker/Listener acts as a proxy with the CNC. One protocol solution for this model is to use the MRP protocol for user data (i.e., MSRP, MVRP, and/or MMRP applications), and a network management protocol as the proxy with the network manager (i.e., CNC). This enables the end stations to use the same MRP protocol as the Fully distributed model of Figure 46-1.

This subclause specifies attributes of a managed object that the network manager uses to:

a) Disable MRP attribute propagation (MAP) for the MRP Participant of a Bridge Port.
b) Read MRP attribute registrations that the MRP Participant receives.
c) Write MRP attribute values for the MRP Participant to declare.

There is one MRP External Control managed object for each MRP Participant (per Port per MRP application per MAP Context, as specified in 10.2 and 10.3.1).

For the MSRP application, although 35.2.4.5 implies that a single MAP Context exists, the specifications of 35.1.3.1 ensure that every distinct value of vlan_identifier propagates along the corresponding VLAN context (10.3.1). Therefore, for the purposes of indexing this managed object, MSRP uses the vlan_identifier as the MAP Context identifier.

The set of managed object attributes is shown in Table 12-41.

12.32.4.1 externalControl

When the externalControl attribute is FALSE, MRP attributes propagate on the MRP Participant according to the specifications for MAP in 10.3 and specifications of the MRP Application (e.g., 35.2.4). Ports with the externalControl attribute FALSE are considered as candidates for the MRP Application's MAP Context. The remaining attributes of this managed object (12.32.4.2 through 12.32.4.8) are ignored by Ports with the externalControl attribute FALSE.

Table 12-41—MRP External Control attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
externalControl	Boolean	RW	B	12.32.4.1
indicationList	octet string	R	B	12.32.4.2
indicationListLength	unsigned integer	R	B	12.32.4.3
indicationChangeCounter	counter	R	B	12.32.4.4
adminRequestList	octet string	RW	B	12.32.4.5
adminRequestListLength	unsigned integer	RW	B	12.32.4.6
operRequestList	octet string	R	B	12.32.4.7
operRequestListLength	unsigned integer	R	B	12.32.4.8

[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component when both Stream reservation remote management and the corresponding MRP application are supported.

When the externalControl attribute is TRUE, the MRP Participant is removed from the MRP Application's MAP Context. The MRP Participant performs all other aspects of MRP, including MRP operation (10.6), MRP specifications (10.7), and MRPDU encodings (10.8). The remaining attributes of this managed object (12.32.4.2 through 12.32.4.8) act as an application component as specified in 10.2. The application component stores MAD indications for registration received on the Port, and invokes MAD requests for declarations on the Port.

The default value of the externalControl attribute is FALSE.

12.32.4.2 indicationList

As specified in 10.2, the MAD_Join.indication primitive is invoked in the application component when MRP detects that an MRP attribute has joined (i.e., registered), and the MAD_Leave.indication primitive is invoked in the application component when MRP detects that the MRP attribute has left (i.e., no longer registered). When the externalControl attribute is TRUE, the indicationList attribute stores the list of all joined MRP attributes for the MRP Participant.

When the MAD_Join.indication primitive is invoked, the MRP Participant forms a sequence of octets, *temporaryIndication*, from the MAD_Join.indication parameters as follows:

d) The first octet of *temporaryIndication* contains the *attribute_type* parameter.
e) The second octet of *temporaryIndication* contains the length of the *attribute_value* parameter as a single octet.
f) Subsequent octets of *temporaryIndication* contain the sequence of octets for the *attribute_value* parameter.

NOTE 1—The *new* parameter is not used for indicationList.

The MRP Participant searches the indicationList to determine if the same octets as *temporaryIndication* (i.e., same *attribute_type* and *attribute_value*) exist. If no match is found, the contents of *temporaryIndication* are appended to the end of indicationList. The result of this specification is that the indicationList consists of an octet string that represents multiple MAD_Join.indication primitives in the order initially invoked.

When the MAD_Leave.indication primitive is invoked, the MRP Participant forms a sequence of octets, *temporaryIndication*, as specified for MAD_Join.indication. The MRP Participant searches the indicationList to determine if the same octets as *temporaryIndication* exist. If a match is found, the attribute's octets (i.e., matching *temporaryIndication)* are removed from the indicationList.

NOTE 2—When the indication's *attribute_type* is Listener Vector Attribute Type, the Listener's Declaration Type (35.2.1.3) is encoded as the last octet of *attribute_value*, even though the Declaration Type is not encoded in the MRP FirstValue (10.8.2.7), but the MRP FourPackedEvent (10.8.2.10.2). For the Listener Enhanced Vector Attribute Type, the Listener's Declaration Type is not encoded as the last octet, since the equivalent information is available in the ListenerStatus element (46.2.5.1).

The default value of the indicationList attribute is the empty octet string.

NOTE 3—The attribute encoding of indicationList does not correspond directly to the MRPDU. For example, if the received MRPDU uses NumberOfValues of three, then the MRPDU encodes only one attribute value (FirstValue), whereas indicationList encodes three distinct attribute type/length/value triplets.

When the externalControl attribute is FALSE, the indicationList attribute is ignored by the MRP Participant, and returns the empty octet string.

12.32.4.3 indicationListLength

The indicationListLength attribute returns the number of octets in the indicationList attribute.

When the externalControl attribute is FALSE, the indicationListLength attribute returns zero.

12.32.4.4 indicationChangeCounter

The indicationChangeCounter attribute increments by one for each change to indicationList as specified in 12.32.4.2.

The default value of the indicationChangeCounter attribute is zero.

When the externalControl attribute is FALSE, the indicationChangeCounter attribute returns zero.

12.32.4.5 adminRequestList

The adminRequestList attribute provides the administrative value of the current list of MAD requests for the MRP Participant (operRequestList). Changes to adminRequestList result in invocation of MAD_Join.request and MAD_Leave.request primitives (12.32.4.7). Each attribute in adminRequestList is encoded as the *attribute_type* parameter as a single octet, followed by the length of the *attribute_value* parameter as a single octet, followed by a sequence of octets for the *attribute_value* parameter.

NOTE—The *new* parameter is not used for adminRequestList.

The default value of the adminRequestList attribute is the empty octet string.

When the externalControl attribute is TRUE, the adminRequestList attribute is copied to the operRequestList attribute as soon as possible according to the implementation. For example, the implementation could copy the list between each MRPDU transmit, or it could copy the list after all attributes in the previous operRequestList complete transmission as MRPDUs.

When the externalControl attribute is FALSE, the adminRequestList attribute is ignored by the MRP Participant, but it retains its value.

12.32.4.6 adminRequestListLength

The adminRequestListLength attribute provides the administrative value for the number of octets in adminRequestList.

The default value of the adminRequestListLength attribute is zero.

When the externalControl attribute is TRUE, the adminRequestListLength attribute is copied to the operRequestListLength attribute at the same time that the adminRequestList attribute is copied to the operRequestList attribute.

When the externalControl attribute is FALSE, the adminRequestListLength attribute is ignored by the MRP Participant, but it retains its value.

12.32.4.7 operRequestList

The operRequestList attribute is the operational value of the current list of MAD requests for the MRP Participant. Prior to copying adminRequestList to operRequestList, the lists are compared as follows:

g) If an attribute exists in adminRequestList that does not exist in operRequestList, invoke MAD_Join.request for that attribute, with the *new* parameter set TRUE.
h) If an attribute exists in operRequestList that does not exist in adminRequestList, invoke MAD_Leave.request for that attribute.

When the comparison is complete, adminRequestList is copied to operRequestList.

The default value of the operRequestList attribute is the empty octet string.

12.32.4.8 operRequestListLength

The operRequestListLength attribute is the operational value of the adminRequestListLength attribute, and it is copied at the same time that adminRequestList attribute is copied to operRequestList.

The default value of the operRequestListLength attribute is zero.

13. Spanning tree protocols

The spanning tree algorithms and protocols specified by this standard provide simple and full connectivity throughout a Bridged Network comprising arbitrarily interconnected Bridges. Each Bridge can use Rapid Spanning Tree Algorithm and Protocol (RSTP), Multiple Spanning Tree Algorithm and Protocol (MSTP), or Shortest Path Bridging (SPB) protocols.

NOTE 1—The spanning tree protocols specified by this standard supersede the STP specified in IEEE Std 802.1D revisions prior to 2004 ([B10], [B11]), but facilitate migration by interoperating with the latter without configuration restrictions beyond those previously imposed by STP. However, networks that include Bridges using STP can reconfigure slowly and constrain active topologies.

NOTE 2—Although the active topologies determined by the spanning tree protocols connect all the components of a Bridged Network, filtering (MVRP, etc.) can restrict frames to a subset of each active topology.

RSTP assigns all frames to a Common Spanning Tree (CST), without being aware of the active topology assignments made by MSTP or SPB that allow frames to follow separate paths within Multiple Spanning Tree (MST) or Shortest Path Tree (SPT) Regions. Each of these regions comprises MST or SPT Bridges that consistently assign any given frame to the same active topology (see 8.4) and the LANs that interconnect those Bridges. These regions and other Bridges and LANs are connected into the CST, to provide loop-free network wide connectivity even if active topology assignments or spanning tree protocols differ locally.

MSTP and SPB connect all Bridges and LANs with a single Common and Internal Spanning Tree (CIST) that supports the automatic determination of each region, choosing its maximum possible extent. The connectivity calculated for the CIST provides the CST for interconnecting the regions, and an Internal Spanning Tree (IST) within each region. MSTP calculates a number of independent Multiple Spanning Tree Instances (MSTIs) within each region, and ensures that frames with a given VID are assigned to one and only one of the MSTIs or the IST within the region (or reserved for use by SPB or PBB-TE), that the assignment is consistent among all Bridges within the region, and that the stable connectivity of each MSTI and the IST at the boundary of the region matches that of the CST. SPB calculates symmetric sets of SPTs, each rooted at a Bridge within a region, and ensures that frames for any given VLAN are assigned to the same symmetric SPT set within the region (or to the IST, an MSTI, or PBB-TE). Within an SPT Region, all Bridges that receive a given shortest path bridged frame assign that frame to the same SPT. The assignment process is specified in Clause 27, and can be done in one of two ways: by using additional VIDs (SPBV, Clause 3), or by using the frame's MAC addresses (SPBM, Clause 3). SPT Bridges use the VID of each received frame to decide whether to use the IST, MSTI, PBB-TE, SPBV, or SPBM. ISIS-SPB can dynamically allocate the additional VIDs (SPVIDs) used by SPBV mode, and ensure that their allocation is consistent within a region.

Spanning Tree Protocol Entities transmit and receive BPDUs (Clause 14) to convey parameters used by RSTP and MSTP to calculate CST, CIST, and MSTI spanning trees. BPDUs also convey parameters that all the spanning tree protocols use to interoperate with each other, that determine the extent of MST and SPT Regions, and that ensure that temporary loops are not created when neighboring Bridges are acting on different topology information. SPB uses ISIS-SPB (see Clause 28) to share information used to calculate the IST and SPTs, and to perform that calculation. SPT BPDU information that ensures loop-free connectivity even if neighboring Bridges' views of the topology differ (13.17) is also carried in SPB Hello PDUs (28.12.2).

This clause:

a) Specifies protocol design and support requirements (13.1, 13.2) and design goals (13.3).
b) Provides an overview of RSTP (13.4), MSTP (13.5), SPBV, and SPBM (13.6) operation.
c) Describes how the spanning tree protocols interoperate and coexist (13.7).

d) Specifies how spanning tree priority vectors (13.9) are calculated (13.10, 13.11) and used to assign the Port Roles (13.12) that determine the Port States, i.e., forwarding and learning (8.4), for each tree.
e) Shows that RSTP, MSTP, and ISIS-SPB provide stable connectivity (13.13).
f) Describes how spanning tree priority vectors are communicated (13.14) and changed (13.15).
g) Describes how Port Roles are used to change Port States without introducing loops (13.16).
h) Recommends defaults and ranges for the parameters that determine each tree's topology (13.18).
i) Describes the updating of learned station location information when a tree reconfigures (13.19).
j) Specifies additional controls that can speed reconfiguration or prevent unwanted outcomes (13.20).
k) Describes how loops are prevented when a LAN is only providing one-way connectivity (13.21), and can be prevented when the network includes Bridges whose protocol operation can fail (13.23).
l) Describes how a Bridge's protocol processing can be 'hot upgraded' in an active network (13.22).
m) Specifies RSTP, MSTP, and support for SPB using state machines (13.24–13.40).
n) Specifies the use and configuration of the spanning tree protocols for the special cases of a Provider Edge Bridge's CEPs (13.41), a BEB's VIPs (13.42), and an L2 Gateway Port connecting a customer to a provider (13.20, 13.40).

NOTE 3—Readers of this specification are urged to begin by familiarizing themselves with RSTP.

Clause 14 specifies the format of BPDUs. Clause 27 describes the uses of SPB. Clause 28 specifies ISIS-SPB. The text of this clause (Clause 13) takes precedence should any conflict be apparent between it and the text in other parts of this standard (in particular, Clause 12, Clause 14, and Annex A). Within this clause (Clause 13) the state machine specifications (13.24–13.40) take precedence over the general description (13.1–13.23). A distinctive font is used to highlight references to state machine variables, procedures, and STATES in the general description.

13.1 Protocol design requirements

The spanning tree algorithm and its associated protocols operate in Bridged Networks of arbitrary physical topology comprising MST or SST Bridges connecting shared media or point-to-point LANs, to support, preserve, and maintain the quality of the MAC Service in all its aspects as specified by Clause 6.

RSTP configures the Port State (8.4) of each Bridge Port. MSTP configures the Port State for the CIST and each MSTI, and verifies the allocation of VIDs to FIDs and FIDs to trees. ISIS-SPB configures the Port State for the CIST and each SPT, configures the VID Translation Table for each Bridge Port, allocates FIDs to SPT sets, and assigns frames to SPTs using SPVIDs or MAC addresses (for SPBV and SPBM, respectively, see Clause 27). Operating both independently and together RSTP, MSTP, and ISIS-SPB meet the following requirements:

a) They configure one or more active topologies that fully connect all physically connected LANs and Bridges, and stabilize (with high probability) within a short, known bounded interval after any change in the physical topology, maximising service availability (6.5.1).
b) The active topology for any given frame remains simply connected at all times (6.5.3, 6.5.4), and will (with high probability) continue to provide simple and full connectivity for frames even in the presence of administrative errors (e.g., in the allocation of VIDs to MSTIs).
c) The configured stable active topologies are unicast multicast congruent, downstream congruent, and reverse path congruent (symmetric) (3.285, 3.74, 6.3).
d) The same symmetric active topology is used, in a stable network, for all frames using the same FID, i.e., between any two LANs all such frames are forwarded through the same Bridge Ports (6.3).
e) The active topology for a given VID can be chosen by the network administrator to be a common spanning tree, one of multiple spanning trees (if MSTP is implemented), or shortest path (if ISIS-SPB is implemented).
f) Each active topology is predictable, reproducible, and manageable, allowing Configuration Management (following traffic analysis) to meet Performance Management goals (6.5 and 6.5.10).

g) The configured network can support VLAN-unaware end stations, such that they are unaware of their attachment to a single LAN or a Bridged Network, or their use of a VID (6.2).
h) The communications bandwidth on any particular LAN is always a small fraction of the total available bandwidth (6.5.10).

NOTE—The spanning tree protocols cannot protect against temporary loops caused by the interconnection of LANs by devices other than Bridges (e.g., LAN repeaters) that operate invisibly with respect to support of the MAC ISS and the MAC_Operational status parameter (IEEE Std 802.1AC).

13.2 Protocol support requirements

In order for the spanning tree protocols to operate, the following are required:

a) A unique group MAC address used by the Spanning Tree Protocol Entities (8.10) of participating Bridges or Bridge components (5.2), and recognized by all the Bridges attached to a LAN.
b) An identifier for each Bridge or Bridge component, unique within the Bridged Network.
c) An identifier for each Bridge Port, unique within a Bridge or Bridge component.

Values for each of these parameters shall be provided by each Bridge. The unique MAC address that identifies the Spanning Tree Protocol Entities of MAC Bridges, VLAN Bridges (5.9), and C-VLAN components (5.5) is the Bridge Group Address (Table 8-1). The unique MAC address that identifies the Spanning Tree Protocol Entities of S-VLAN components is the Provider Bridge Group Address (Table 8-2).

To allow management of active topology (for RSTP, MSTP, or SPB) means of assigning values to the following are required:

d) The relative Bridge Priority of each Bridge in the network
e) A Port Path Cost for each Bridge Port
f) The relative Port Priority of each Bridge Port

13.2.1 MSTP support requirements

MSTP does not require any additional configuration, provided that communication between end stations is supported by a number of VLANs. However, to realize the improved throughput and associated frame loss and transit delay performance improvements made possible by the use of multiple spanning trees, the following are required:

a) Assessment of the probable distribution of traffic between VLANs and between sets of communicating end stations using those VLANs.
b) Per MSTI assignment of Bridge Priority and Internal Port Path Costs to configure the MSTIs.
c) Consistent assignment of VIDs to MSTIDs within each potential MST Region (3.165).
d) Administrative agreement on the Configuration Name and Revision Level used to represent the assignments of VIDs to MSTIDs.

13.2.2 SPB support requirements

In order for the ISIS-SPB protocol to operate, the following are required:

a) An MTID indicating the topology information to be used for route calculation.
b) An IS-IS Area Address for the IS-IS routing area.
c) An IS-IS system ID for the SPT Bridge, normally the Bridge Identifier.
d) A group MAC address for use by IS-IS SPB (Table 8-17).
e) A Base VID for each SPB VLAN.

f) An ECT-ALGORITHM identifying the algorithm for calculating SPTs and selecting from among Equal Cost Trees.

SPBV can provide both CST and SPT support for VLANs without further configuration. To support default SPB operation this standard specifies a default configuration for SPT Bridges (13.8).

13.3 Protocol design goals

All the spanning tree protocols meet the following goal, which simplifies operational practice:

a) Bridges do not have to be individually configured before being added to the network, other than having their MAC addresses assigned through normal procedures.
b) In normal operation, the time taken to configure the active topology of a network comprising point-to-point LANs is independent of the timer values of the protocol.

RSTP and MSTP meet the following goal, which limits the complexity of Bridges and their configuration:

c) The memory requirements associated with each Bridge Port are independent of the number of Bridges and LANs in the network.

It is highly desirable that the operation of ISIS-SPB supports updating of the SPB configuration so that:

d) SPT Bridges can be added to a region without disrupting communication for existing VLANs.
e) Additional VLANs can be supported by SPB without disrupting communication for the VLANs that are already supported by SPB, or for those VLANs that are supported by RSTP or MSTP.
f) SPB support can be enabled or disabled for individual VLANs that are being used to support user communication, with the minimum of frame loss on those VLANs.

13.4 RSTP overview

RSTP configures the Port State (8.4) of each Bridge Port in the Bridge Local Area Network. RSTP ensures that the stable connectivity provided by each Bridge between its ports and by the individual LANs attached to those ports is predictable, manageable, full, simple, and symmetric. RSTP further ensures that temporary loops in the active topology do not occur if the network has to reconfigure in response to the failure, removal, or addition of a network component, and that erroneous station location information is removed from the FDB after reconfiguration.

Each of the Bridges in the network transmits Configuration Messages (13.14). Each message contains spanning tree priority vector (13.9) information that identifies one Bridge as the Root Bridge of the network, and allows each Bridge to compute its own lowest path cost to that Root Bridge before transmitting its own Configuration Messages. A Port Role (13.12) of Root Port is assigned to the one port on each Bridge that provides that lowest cost path to the Root Bridge, and a Port Role of Designated Port to the one Bridge Port that provides the lowest cost path from the attached LAN to the Root Bridge. Alternate Port and Backup Port roles are assigned to Bridge Ports that can provide connectivity if other network components fail.

State machines associated with the Port Roles maintain and change the Port States that control forwarding (8.6) and learning (8.7) of frames. In a stable network, Root Ports and Designated Ports are Forwarding, while Alternate, Backup, and Disabled Ports are Discarding. Each Port’s role can change if a Bridge, Bridge Port, or LAN fails, is added to, or removed from network. Port state transitions to Learning and Forwarding are delayed, and ports can temporarily transition to the Discarding state to prevent loops and to ensure that misordering (6.5.3) and duplication (6.5.4) rates remain negligible.

RSTP provides rapid recovery of connectivity to minimize frame loss (6.5.2). A new Root Port, and Designated Ports attached to point-to-point LANs, can transition to Forwarding without waiting for protocol timers to expire. A Root Port can transition to Forwarding without transmitting or receiving messages from other Bridges, while a Designated Port attached to a point-to-point LAN can transition when it receives an explicit agreement transmitted by the other Bridge attached to that LAN. The forwarding transition delay used by a Designated Port attached to a shared media LAN is long enough for other Bridges attached to that LAN to receive and act on transmitted messages, but is independent of the overall network size. If all the LANs in a network are point-to-point, RSTP timers define worst-case delays that only occur if protocol messages are lost or rate transmission limits are exceeded.

A Bridge Port attached to a LAN that has no other Bridges attached to it may be administratively configured as an Edge Port. RSTP monitors the LAN to ensure that no other Bridges are connected, and may be configured to automatically detect an Edge Port. Each Edge Port transitions directly to the Forwarding Port State, since there is no possibility of it participating in a loop.

13.4.1 Computation of the active topology

The Bridge with the best Bridge Identifier is selected as the Root Bridge. The unique Bridge Identifier for each Bridge is derived, in part, from the Bridge Address (8.13.8) and, in part, from a manageable priority component (13.26). The relative priority of Bridges is determined by the numerical comparison of the unique identifiers, with the lower numerical value indicating the better identifier.

Every Bridge has a Root Path Cost associated with it. For the Root Bridge this is zero. For all other Bridges, it is the sum of the Port Path Costs on the least cost path to the Root Bridge. Each port’s Path Cost may be managed, 13.18 recommends default values for ports attached to LANs of various speeds.

The Bridge Port on each Bridge with the lowest Root Path Cost is assigned the role of Root Port for that Bridge (the Root Bridge does not have a Root Port). If a Bridge has two or more ports with the same Root Path Cost, then the port with the best Port Identifier is selected as the Root Port. Part of the Port Identifier is fixed and different for each port on a Bridge, and part is a manageable priority component (13.26). The relative priority of Bridge Ports is determined by the numerical comparison of the unique identifiers, with the lower numerical value indicating the better identifier.

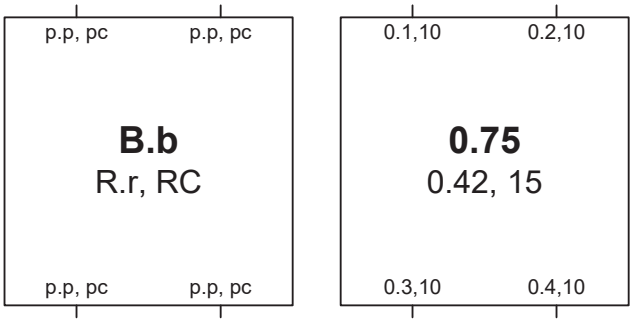
Each LAN in the Bridged Network also has an associated Root Path Cost. This is the Root Path Cost of the lowest cost Bridge with a Bridge Port connected to that LAN. This Bridge is selected as the Designated Bridge for that LAN. If there are two or more Bridges with the same Root Path Cost, then the Bridge with the best priority (least numerical value) is selected as the Designated Bridge. The Bridge Port on the Designated Bridge that is connected to the LAN is assigned the role of Designated Port for that LAN. If the Designated Bridge has two or more ports connected to the LAN, then the Bridge Port with the best priority Port Identifier (least numerical value) is selected as the Designated Port.

In a Bridged Network whose physical topology is stable, i.e., RSTP has communicated consistent information throughout the network, every LAN has one and only one Designated Port, and every Bridge with the exception of the Root Bridge has a single Root Port connected to a LAN. Since each Bridge provides connectivity between its Root Port and its Designated Ports, the resulting active topology connects all LANs (is “spanning”) and will be loop-free (is a “tree”).

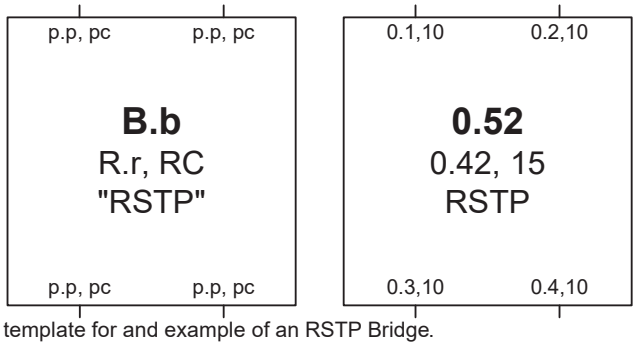
Any Bridge Port that is enabled, but not a Root or Designated Port, is a Backup Port if that Bridge is the Designated Bridge for the attached LAN, and an Alternate Port otherwise. An Alternate Port offers an alternate path in the direction of the Root Bridge to that provided by the Bridge’s own Root Port, whereas a Backup Port acts as a backup for the path provided by a Designated Port in the direction of the leaves of the spanning tree. Backup Ports exist only where there are two or more connections from a given Bridge to a given LAN; hence, they (and the Designated Ports that they back up) can only exist where the Bridge has two or more ports attached to a shared media LAN, or directly connected by a point-to-point LAN.

13.4.2 Example topologies

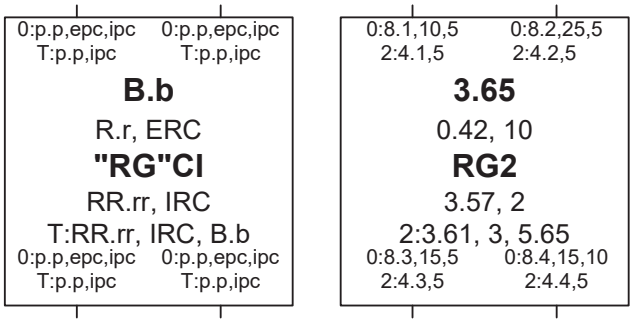
The spanning tree examples in this clause use the conventions of Figure 13-1.



A template for and example of an STP Bridge. **B.b** is the Bridge Identifier (including the manageable priority component **B.**). **R.r** and **RC** are the Root Identifier, Root Path Cost, and the Designated Bridge Identifier, for the Root Port. **p.p, pc** are the Port Identifier (with manageable priority **p.**) and the Port Path Cost for a Bridge Port.



A template for and example of an RSTP Bridge.



A template for and an example of an MSTP Bridge. **B.b** is the CIST Bridge Identifier. **R.r**, **ERC**, **RR.rr** are the CIST Root Identifier, External Root Path Cost, and Regional Root Identifier. **CI** identifies the Configuration Identifier for the Bridge. **RR.rr, IRC** the CIST Regional Root Identifier and the Internal Root Path Cost. **T:RR.rr, IRC, B.b**, is the Regional Root Identifier, Internal Root Path Cost IRC, and Bridge Identifier for the MSTI with MSTID **T**.
0:p.p, epc, ipc are the CIST Port Identifier, External Port Path Cost, and Internal Port Path Cost for a Bridge Port. **T:p.p, ipc** are the Port Identifiers and their Regional Costs for MSTI **T**.
Any of the above information may be selectively omitted if deemed irrelevant for the purposes of a diagram.

A LAN

Connections between Bridges and LANs indicate the Port Role and Port State by means of their end point symbols, and in some examples, may show the transmission of BPDUs from a Port onto a LAN by means of arrowheads, as shown in the following table.

Port Role	Port State	Legend
Designated	Discarding Learning Forwarding	
& operEdge	Forwarding	
Root Port or Master Port	Discarding Learning Forwarding	
Alternate	Discarding Learning Forwarding	
Backup	Discarding Learning Forwarding	
Disabled	-	
Transmitted Bpdus		
Designated Designated Proposal		
Root Root Agreement		

NOTE—These diagrammatic conventions allow the representation of Alternate and Backup Ports that are in Learning or Forwarding states; this can happen as a transitory condition due to implementation-dependent delays in switching off Learning and/or Forwarding on a Port that changes role from Designated or Root to Alternate or Backup.

Figure 13-1—Diagrammatic conventions for spanning tree topologies

Figure 13-2 shows a simple, redundantly connected, structured wiring configuration, with Bridges connected by point-to-point LANs A through N, and a possible spanning tree active topology of the same network. Bridge 111 has been selected as the Root (though one cannot tell simply by looking at the active topology which Bridge is the Root).

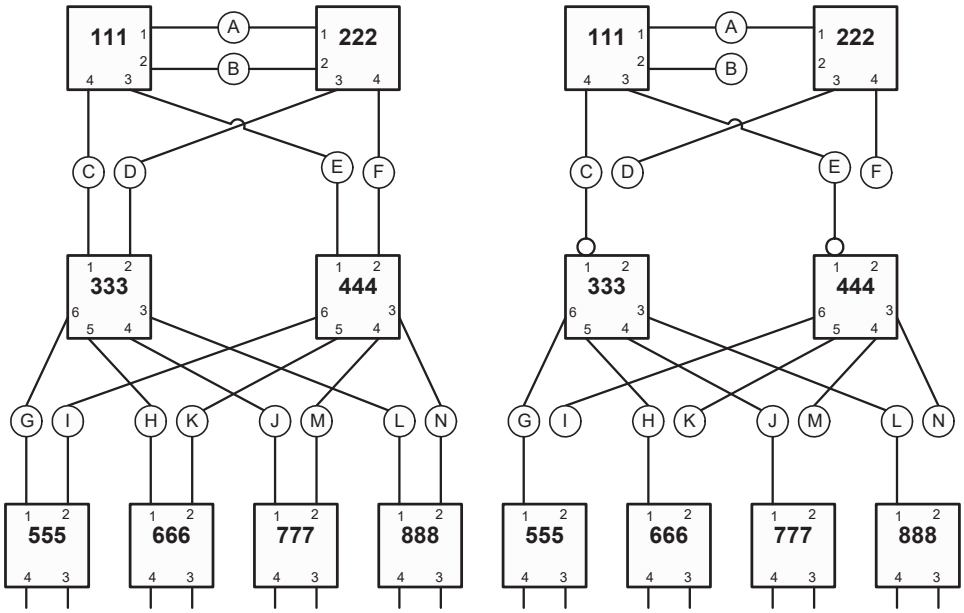


Figure 13-2—Physical topology and active topology

Figure 13-3 shows the Port Roles and Port States of each Bridge Port. It can be seen that Bridge 111 is the Root, as its Ports are all Designated Ports, each of the remaining Bridges have one Root Port.

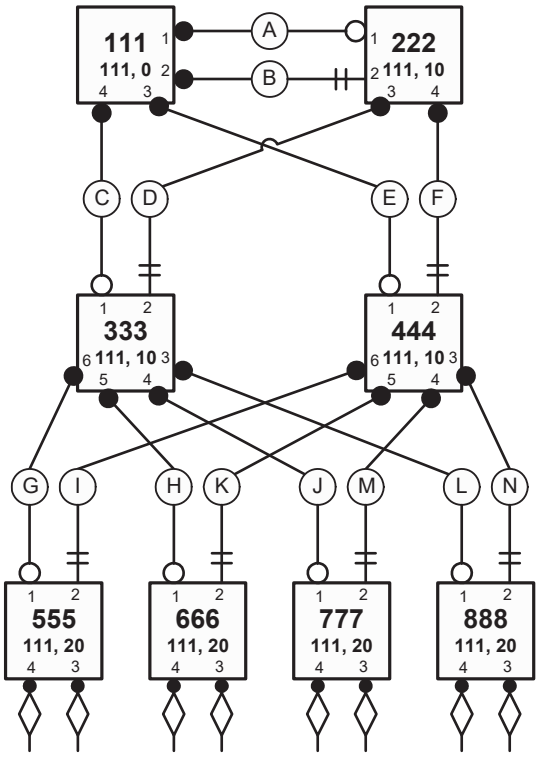


Figure 13-3—Port Roles and Port States

Figure 13-4 shows the result of connecting two of the ports of Bridge 888 to the same LAN. As port 4 of Bridge 888 has worse priority than port 3 and both offer the same Root Path Cost, port 4 will be assigned the Backup Port Role and will therefore be in the Discarding Port State. Should port 3 or its connection to LAN O fail, port 4 will be assigned the Designated Port Role and will transition to the Forwarding Port State.

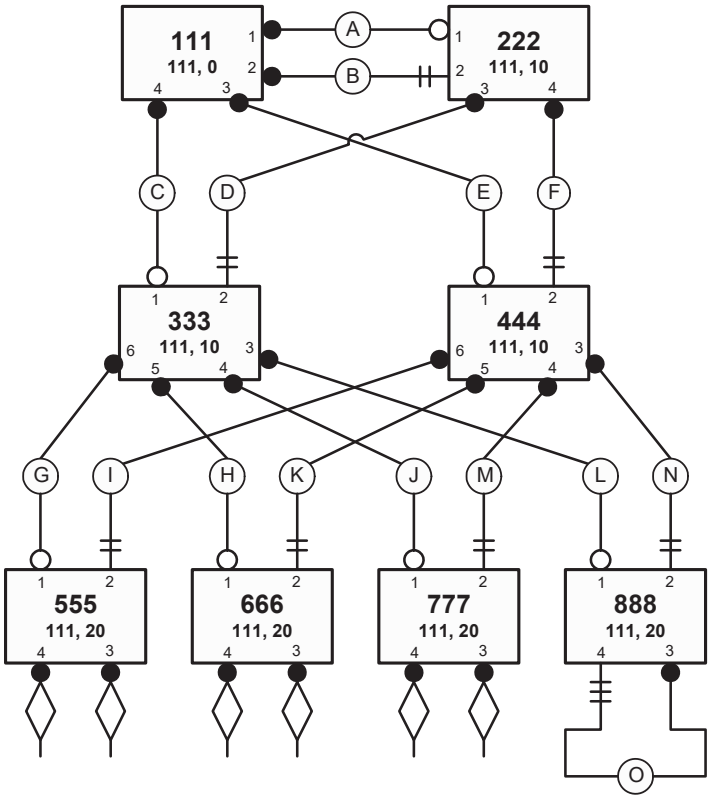


Figure 13-4—A Backup Port

Figure 13-5 shows a “ring” topology constructed from point-to-point links, as in some resilient backbone configurations. Bridge 111 is the Root, as in previous examples.

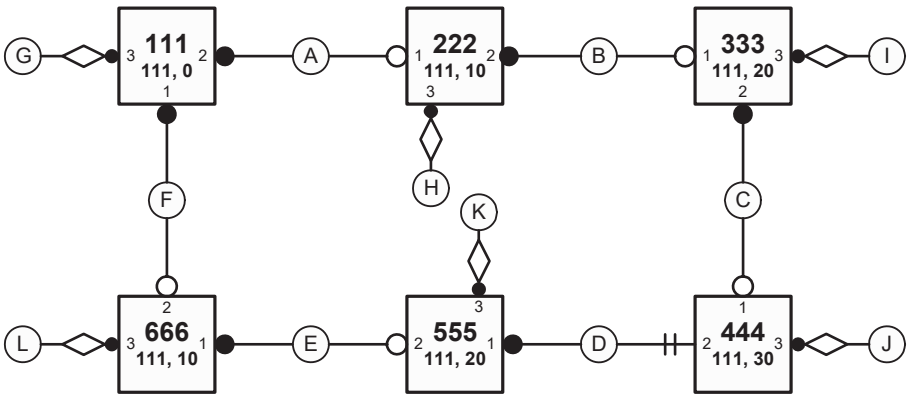


Figure 13-5—“Ring Backbone” example

13.5 MSTP overview

MSTP specifies the following:

a) An MST Configuration Identifier (MCID) (13.8) that allows each Bridge to advertise its assignment, to a specified MSTI or to the IST, of frames with any given VID.
b) A priority vector (13.9) that comprises Bridge identifier and path cost information for constructing a deterministic and manageable single spanning tree active topology, the CIST, that:
    1) Fully and simply connects all Bridges and LANs in a Bridged Network.
    2) Permits the construction and identification of MST Regions of Bridges and LANs that are guaranteed fully connected by the Bridges and LANs within each region.
    3) Ensures that paths within each MST Region are always preferred to paths outside the region.
c) An MSTI priority vector (13.9), comprising information for constructing a deterministic and independently manageable active topology for any given MSTI within each region.
d) Comparisons and calculations performed by each Bridge in support of the distributed spanning tree algorithm (13.10). These select a CIST priority vector for each Bridge Port, based on the priority vectors and MCIDs received from other Bridges and on an incremental Path Cost associated with each reception port. The resulting priority vectors are such that in a stable network:
    1) One Bridge is selected to be the CIST Root of the Bridged Network as a whole.
    2) A minimum cost path to the CIST Root is selected for each Bridge and LAN, thus preventing loops while ensuring full connectivity.
    3) The one Bridge in each MST Region whose minimum cost path to the Root is not through another Bridge using the same MCID is identified as its region's CIST Regional Root.
    4) Conversely, each Bridge whose minimum cost path to the Root is through a Bridge using the same MCID is identified as being in the same region as that Bridge.
e) Priority vector comparisons and calculations performed by each Bridge for each MSTI (13.11). In a stable network:
    1) One Bridge is independently selected for each MSTI to be the MSTI Regional Root.
    2) A minimum cost path to the MSTI Regional Root that lies wholly within the region is selected for each Bridge and LAN.
f) CIST Port Roles (13.12) that identify the role in the CIST active topology played by each port on a Bridge:
    1) The Root Port provides the minimum cost path from the Bridge to the CIST Root (if the Bridge is not the CIST Root) through the Regional Root (if the Bridge is not a Regional Root).
    2) A Designated Port provides the least cost path from the attached LAN through the Bridge to the CIST Root.
    3) Alternate or Backup Ports provide connectivity if other Bridges, Bridge Ports, or LANs fail or are removed.
g) MSTI and SPT Port Roles (13.12) that identify the role played by each port on a Bridge for each MSTI's or SPT's active topology within and at the boundaries of a region.
    1) The Root Port provides the minimum cost path from the Bridge to the Regional Root (if the Bridge is not the Regional Root for the tree).
    2) A Designated Port provides the least cost path from the attached LAN though the Bridge to the Regional Root.
    3) A Master Port provides connectivity from the region to a CIST Root that lies outside the region. The Bridge Port that is the CIST Root Port for the CIST Regional Root is the Master Port for all MSTIs and SPTs.
    4) Alternate or Backup Ports provide connectivity if other Bridges, Bridge Ports, or LANs fail or are removed.
h) State machines and state variables associated with each spanning tree (CIST, MSTI, or SPT), port, and port role, to select and change the Port State (8.4, 13.24) that controls the processing and forwarding of frames assigned to that tree by a MAC Relay Entity (8.3).

13.5.1 Example topologies

Figure 13-6 is an example Bridged Network, using the conventions of Figure 13-1, and chosen to illustrate MSTP calculations rather than as an example of a common or desirable physical topology.

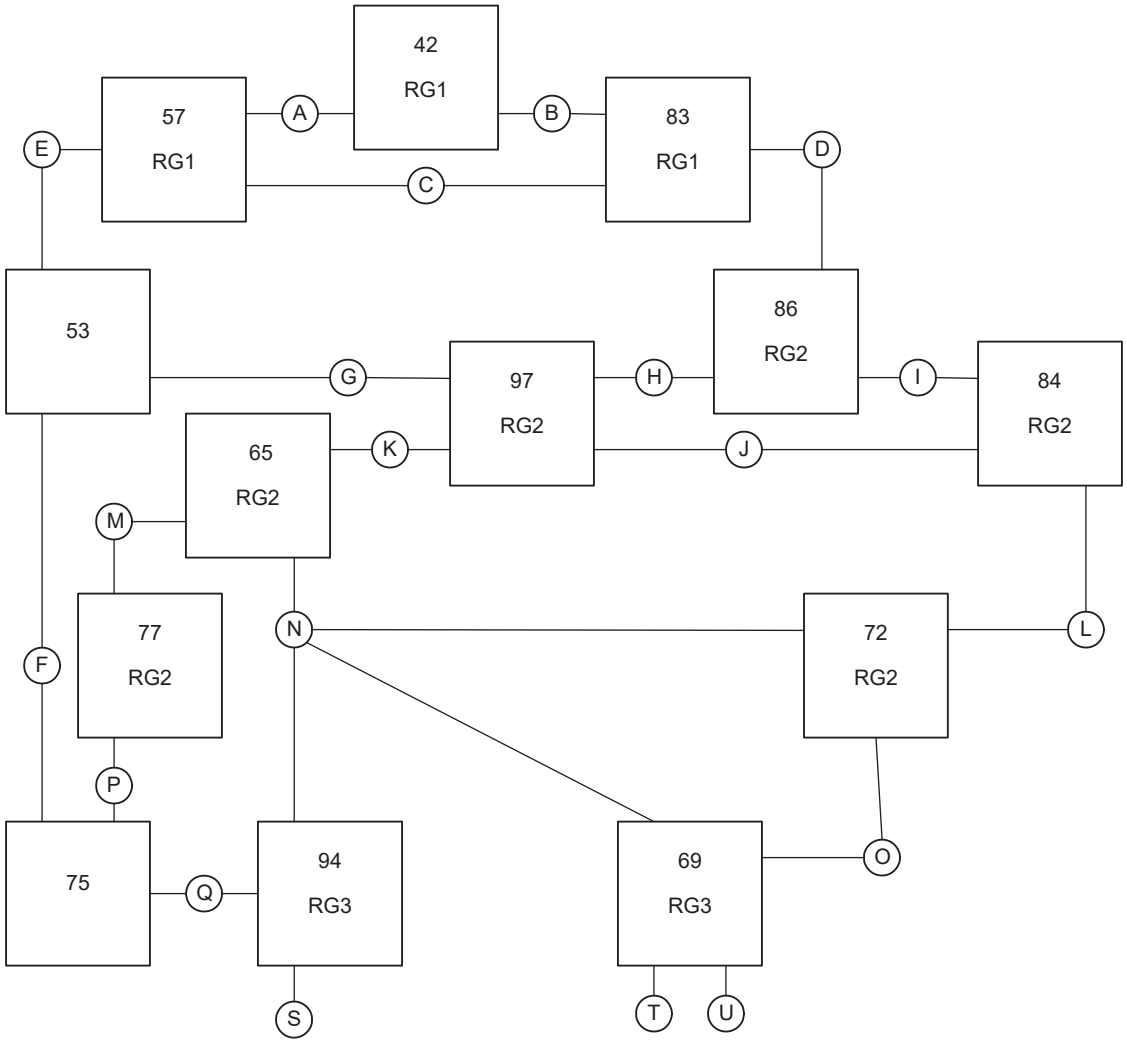


Figure 13-6—An MST Bridge network

Figure 13-7 is the same network showing Bridges and LANs with better CIST spanning tree priorities higher on the page, and including CIST priority vectors, port roles, and MST Regions. In this example:

a) Bridge 0.42 is the CIST Root because it has the best (numerically lowest) Bridge Identifier.
b) Bridges 0.57 and 2.83 are in the same MST Region (1) as 0.42, because they have the same MCID as the latter. Because they are in the same MST Region as the CIST Root, their External Root Path Cost is 0, and their CIST Regional Root is the CIST Root.
c) LANs A, B, C, and D are in Region 1 because their CIST Designated Bridge is a Region 1 MST Bridge, and no STP Bridges are attached to those LANs. LAN E is not in an MST Region (or in its own region—an equivalent view) because it is attached to Bridge 0.53, which is not an MST Bridge.
d) Bridges 0.77, 0.65, 0.97, 0.86, 3.84, and 3.72 are in the same MST Region (2) since they have the same MCID and are interconnected by LANs for which one of them is the CIST Designated Bridge.

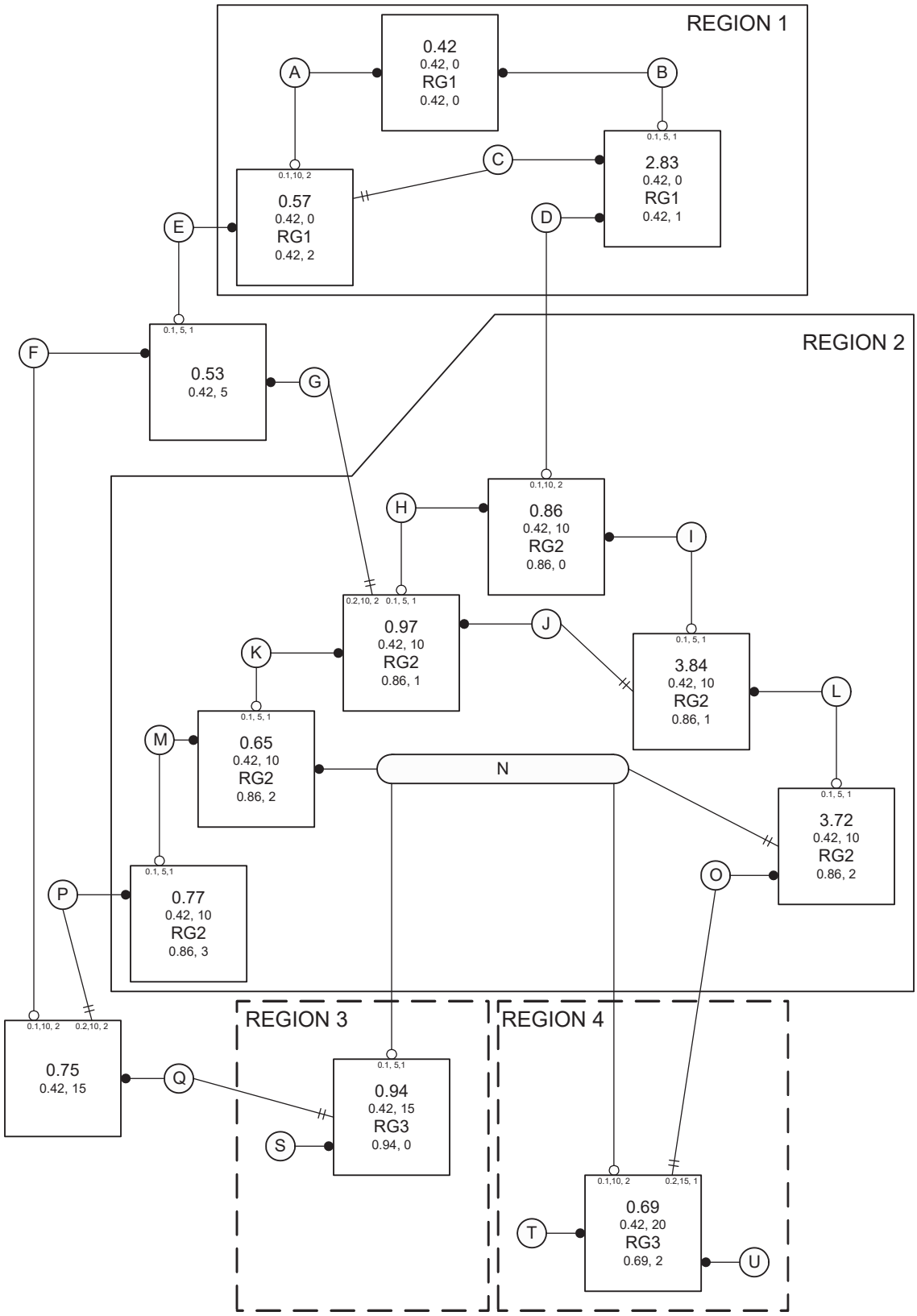


Figure 13-7—CIST Priority Vectors, Port Roles, and MST Regions

e) Bridge 0.86 is the CIST Regional Root for Region 2 because it is has the lowest External Root Path Cost through a Boundary Port.
f) LAN N is in Region 2 because its CIST Designated Bridge is in Region 2. Frames assigned to different MSTIDs may reach N from Bridge 0.86 (for example) by either Bridge 0.65 or Bridge 3.72, even though Bridges 0.94 and 0.69 with MCIDs that differ from those for Bridges in Region 2 are attached to this shared LAN.
g) Bridges 0.94 and 0.69 are in different regions, even though they have the same MCID, because the LAN that connects them (N) is in a different region.

Figure 13-8 shows a possible active topology of MSTI 2 within Region 2.

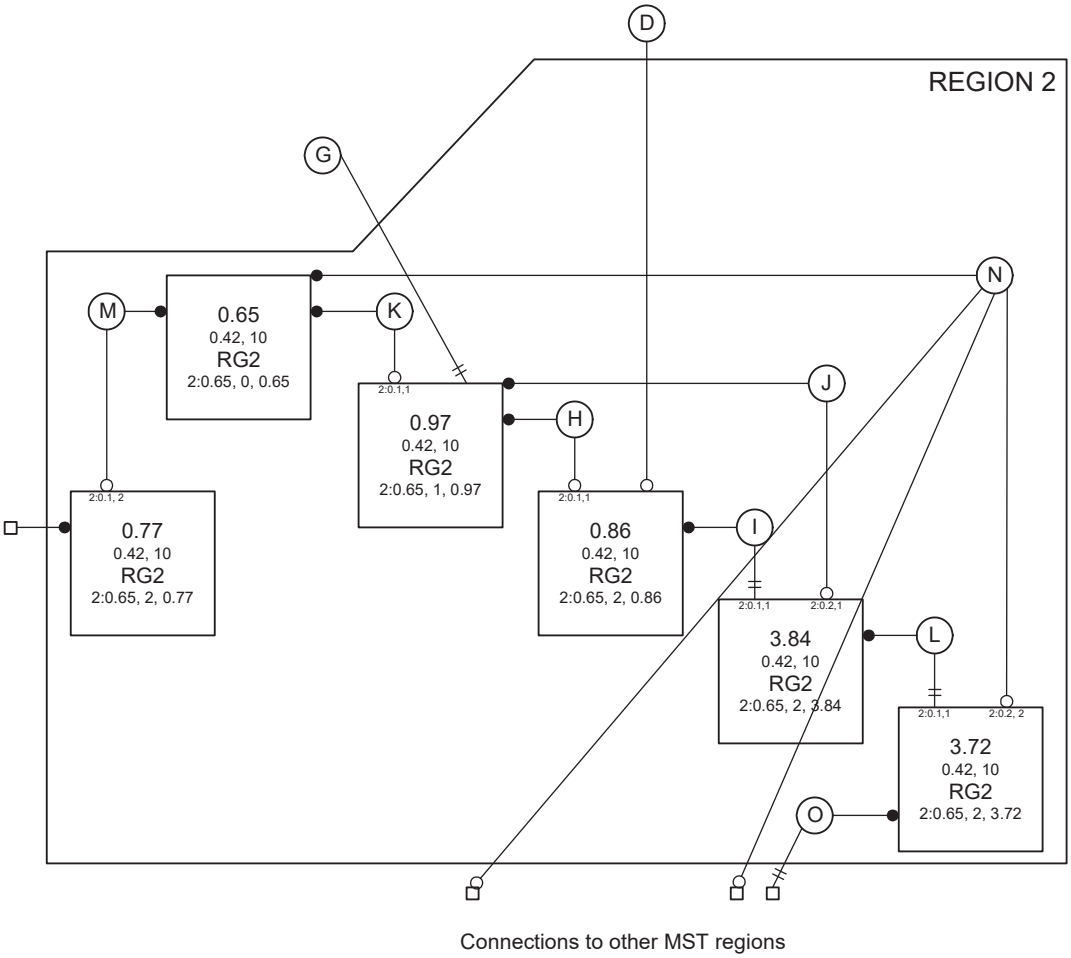


Figure 13-8—MSTI Active Topology in Region 2

h) Bridge 0.65 has been chosen as the MSTI Regional Root because it has the best (numerically the lowest) Bridge Identifier of all Bridges in the region for this MSTI.
i) The connectivity between the whole of Region 2 and Region 1 is provided through a single Bridge Port, the Master Port on Bridge 0.86. This port was selected for this role because it is the CIST Root Port on the CIST Regional Root for the region (see Figure 13-7).
j) The connectivity between the whole of Region 2 and LANs and Bridges outside the region for the MSTI is the same as that for the CIST. This connectivity is similar to that which might result by replacing the entire region by a single SST Bridge. The region has a single Root Port (this port is the Master Port for each MSTI) and a number of Designated Ports.

13.5.2 Relationship of MSTP to RSTP

MSTP is based on RSTP, extended so frames for different VLANs can follow different trees within regions.

a) The same fundamental spanning tree algorithm selects the CIST Root Bridge and Port Roles, but extended priority vector components are used within (13.9, 13.10) in each region. As a result each region resembles a single Bridge from the point of view of the CST as calculated by RSTP.
b) Each MSTI's Regional Root Bridge and Port Roles are also computed using the same fundamental spanning tree algorithm with modified priority vector components (13.11).
c) Different Bridges may be selected as the Regional Root for different MSTIs by modifying the manageable priority component of the Bridge Identifier differently for the MSTIs.
d) MST Configuration Identification is not applicable to RSTP.
e) The Port Roles used by the CIST (Root, Designated, Alternate, Backup, or Disabled Port) are the same as those of RSTP. The MSTIs use the additional port role Master Port. The Port States associated with each spanning tree and port are the same as those of RSTP.
f) The state variables for each Bridge Port for each tree and for the Bridge itself are those specified for RSTP as per port and per Bridge with a few exceptions, additions, and enhancements.
g) The performance parameters specified for RSTP apply to the CIST, with a few exceptions, additions, and enhancements. A simplified set of performance parameters apply to the MSTIs.
h) This standard specifies RSTP state machines and procedures as a subset of MSTP.

13.5.3 Modeling an MST or SPT Region as a single Bridge

The nominal replacement of an entire region by a single RST Bridge leads to little impact on the remainder of the Bridged Network. This design is intended to assist those familiar with RSTP to comprehend and verify MSTP, and to administer networks using MSTP. Treating the MST Regions as single Bridges provides the network administrator with a natural hierarchy. The internal management of MST Regions can be largely separated from the management of the active topology of the network as a whole.

The portion of the active topology of the network that connects any two Bridges in the same MST Region traverses only MST Bridges and LANs in that region and never Bridges of any kind outside the region; in other words, connectivity within the region is independent of external connectivity. This is because the protocol parameters that determine the active topology of the network as a whole, the Root Identifier and Root Path Cost (known in the MSTP specification as the CIST Root Identifier and CIST External Root Path Cost) are carried unchanged throughout and across the MST Region, so Bridges within the region will always prefer spanning tree information that has been propagated within the region to information that has exited the region and is attempting to reenter it.

NOTE 1—No LAN can be in more than one MST Region at a time, so two Bridges (0.11 and 0.22 say) that would otherwise be in the same region by virtue of having the same MST Configuration and of being directly connected by a LAN, may be in distinct regions if that is a shared LAN with other Bridges attached (having a different MST Configuration) and no other connectivity between 0.11 and 0.22 and lying wholly within their region is available. The region that the shared LAN belongs to may be dynamically determined. No such dynamic partitioning concerns arise with single Bridges. Obviously the sharing of LANs between administrative regions militates against the partitioning of concerns and should only be done following careful analysis.

The Port Path Cost (MSTP's External Port Path Cost) is added to the Root Path Cost just once at the Root Port of the CIST Regional Root, the closest Bridge in the region to the Root Bridge of the entire network. The Message Age used by STP and RSTP is also only incremented at this port. If the CIST Root is within a region, it also acts as the Regional Root, and the Root Path Cost and Message Age advertised are zero, just as for a single Bridge.

Within an MST Region, each MSTI operates in much the same way as an independent instance of RSTP with dedicated Regional Root Identifier, Internal Root Path Cost, and Internal Port Path Cost parameters.

Moreover, the overall spanning tree (the CIST) includes a fragment (the IST) within each MST Region that can be viewed as operating in the same way as an MSTI with the Regional Root as its root.

NOTE 2—Since an MST Region behaves like a single Bridge and does not partition (except in the unusual configuration involving shared LANs noted above), it has a single Root Port in the CST active topology. Partitioning a network into two or more regions can therefore force nonoptimal blocking of Bridge Ports at the boundaries of those regions.

13.6 SPB overview

Clause 27 provides a comprehensive overview of SPT Bridges using SPBV and SPBM mode operation. This subclause (13.6) summarizes aspects of SPB operation that relate to the transmission and reception of BPDUs, and their role in providing interoperability with RSTP and MSTP, and in carrying the agreements that ensure that each SPT provides loop-free connectivity throughout an SPT Region. The details of agreements are considered in 13.17, the assignment of frames to SPTs in 8.4 and Clause 27, and protocols and procedures to allow plug-and-play generation of SPVIDs in Clause 28.

Considerations of backward and forward compatibility and interoperability figure largely in this clause (Clause 13) and to some extent these consideration revolve around the notion of MST or SPT Region, with each region capable of using different protocols or different configurations. These considerations should not be allowed to obscure the fact that the ideal network configuration (from the point of view of connectivity and bandwidth efficiency) comprises a single region, or possibly one core region with RST Bridges attached, and that separate regions are most likely to arise when continued connectivity is being provided by the CST as configuration changes are made to Bridges in the network. If an SPT Region is bounded by BEBs or LAN with no other Bridges attached, B-VLANs can be supported by SPBM mode, with frames assigned to SPTs using their MAC addresses, while other B-VLANs and S-VLANs can be supported by SPBV mode, with frames assigned to each SPT by SPVID. In both cases, however, SPTs are calculated in the same way and the effects on this clause (Clause 13) are limited to allowing loop mitigation (6.5.4.2) for unicast frames supported by SPBM mode as well as loop prevention (6.5.4.1). The need for unicast multicast congruence (Clause 3), the simplification possible by not introducing differences between SPBM mode unicast forwarding and the other uses of SPTs, and the need for source address lookup to support loop mitigation means that all shortest path bridged frames are assigned to an SPT rooted at the source Bridge and follow the standard bridging paradigm of multicast distribution with filtering, even when the frame has a single destination and the path to the destination is known through the use of routing protocol (ISIS-SPB).

NOTE—When loop mitigation is used for unicast frames, the Port State used to prevent loops (as expressed by the state machine variables forwarding and learning) need only apply to frames with group destination addresses.

SPT Bridges send and receive BPDUs in order to advertise their presence to, and recognize the presence of, other Bridges. The requirement for loop-free SPT connectivity also means that SPT Bridges have to communicate with their nearest neighbors, when calculations that follow the reception of ISIS-SPB messages have been completed rather than as a part of the IS-IS protocol itself. The agreements (13.17) that satisfy this requirement could be separated conceptually from other uses of BPDUs, but the opportunity to share common information elements, synchronization of neighbor state, and an overall reduction in the number of protocol frames sent make it convenient to use BPDUs to integrate its specification with the other protocol variables, procedures, and state machines in this clause (13.24–13.40). Agreement Protocol variables with exactly the same semantics are also carried in SPB Hello PDUs. The protocol handles duplicated and misordered agreement information, so that updated information can be received from SPB Hello PDUs or both SPB Hello PDUs and BPDUs.

SPT Bridges use the configuration and active topology management parameters (Bridge Identifiers, Port Path Costs) already required for the CIST. They also retain MSTP capabilities as a subset of their operation, though it is always possible to configure zero MSTIs.

13.7 Compatibility and interoperability

RSTP, MSTP, and the ISIS-SPB are designed to interoperate with each other and with STP. This subclause (13.7) reviews aspects of their design that are important to meeting that requirement. ISIS-SPB and SPT BPDUs include the functionality provided by MSTP and MST BPDUs, so the compatibility with RSTP and STP provided by the latter extends to SPB.

13.7.1 Designated Port selection

Correct operation of the spanning tree protocols requires that all Bridge Ports attached to any given LAN agree on a single CIST Designated Port after a short interval sufficient for any Bridge Port to receive a configuration message from that Designated Port.

A unique spanning tree priority (13.9) is required for each Bridge Port for STP, which has no other way of communicating port roles. Since port numbers on different Bridges are not guaranteed to be unique, this necessitates the inclusion of the transmitting Bridge's Bridge Identifier in the STP BPDU. RSTP and MSTP's Port Protocol Migration state machines (13.32) ensure that all Bridges attached to any LAN with an attached STP Bridge send and receive STP BPDUs exclusively.

NOTE 1—This behavior satisfies the requirement for unique, agreed Designated Port for LANs with attached STP Bridges, but means that an MST Region cannot completely emulate a single Bridge since the transmitted Designated Bridge Identifier can differ on Bridge Ports at the region's boundary.

MSTP transmits and receives the Regional Root Identifier and not the Designated Bridge Identifier in the BPDU fields recognized by RSTP (14.4) to allow both the MST and the RST Bridges potentially connected to a single LAN to perform comparisons (13.9, 13.10) between all spanning tree priority vectors transmitted that yield a single conclusion about which RST Bridge or MST Region includes the Designated Port. MST and RST BPDUs convey the transmitting port's CIST Port Role. This is checked on receipt by RSTP when receiving messages from a Designated Bridge, thus ensuring that an RST Bridge does not incorrectly identify one MST Bridge Port as being Designated rather than another, even while omitting the competing Bridge Ports' Designated Bridge Identifiers from comparisons.

NOTE 2—This ability of MST Bridges to communicate the full set of MSTP information on shared LANs to which RST Bridges are attached avoids the need for the Port Protocol Migration machines to detect RST Bridges. Two or more MST and one or more RST Bridges may be connected to a shared LAN, with full MSTP operation. This includes the possibility of different MSTI Designated Ports (see 13.5.1).

13.7.2 Force Protocol Version

A Force Protocol Version parameter, controlled by management, permits emulation of aspects of the behavior of earlier versions of spanning tree protocol that are not strictly required for interoperability. The value of this parameter applies to all Bridge Ports.

a) STP BPDUs, rather than MST BPDUs, are transmitted if Force Protocol Version is 0.
b) RST BPDUs, rather than MST BPDUs, are transmitted if Force Protocol Version is 2. RST BPDUs omit the MCID and all MSTI Information.
c) All received BPDUs are treated as being from a different MST Region if Force Protocol Version is 0 or 2.
d) Rapid transitions are disabled if Force Protocol Version is 0. This allows MST Bridges to support applications and protocols that can be sensitive to the increased rates of frame duplication and misordering that can arise under some circumstances, as discussed in Annex P.
e) The MSTP state machines allow full MSTP behavior if Force Protocol Version is 3 or more.
f) SPT BPDUs are transmitted if Force Protocol Version is 4 or more.

NOTE—Force Protocol Version does not support multiple spanning trees with rapid transitions disabled.

13.8 MST Configuration Identifier (MCID)

It is essential that all Bridges within an MST or SPT Region agree on the allocation of VIDs to spanning trees. If the allocation differs, frames for some VIDs may be duplicated or not delivered to some LANs at all. MST and SPT Bridges check that they are allocating VIDs to the same spanning trees as their neighbors in the same region by transmitting and receiving MCIDs in BPDUs. Each MCID includes a Configuration Digest that is compact but designed so that two matching identifiers have a very high probability of denoting the same allocation of VIDs to MSTIDs (Clause 3, 8.4) even if the identifiers are not explicitly managed. Suitable management practices for equipment deployment and for choosing Configuration Names and Revision Levels (see below) can guarantee that the identifiers will differ if the VID to tree allocation differs within a single administrative domain.

An MST or SPT Region comprises one or more MST or SPT Bridges with the same MCIDs, interconnected by and including LANs for which one of those Bridges is the Designated Bridge for the CIST and which have no Bridges attached that cannot receive and transmit RST BPDUs.

SPT BPDUs are a superset of MST BPDUs received and validated by MST Bridges as if they were MST BPDUs, so MSTP operates within an SPT Region just as if it were an MST Region. However, each shortest path VLAN is represented by a reserved MSTID value that is included in the Configuration Digest, so an SPT Region contains only SPT Bridges.

Each MCID contains the following components:

a) A Configuration Identifier Format Selector, the value 0 encoded in a fixed field of one octet to indicate the use of the following components as specified in this standard.
b) The Configuration Name, a variable length text string encoded within a fixed field of 32 octets, conforming to IETF RFC 2271's definition of SnmpAdminString. If the Configuration Name is less than 32 characters, the text string should be terminated by the NUL character, with the remainder of the 32-octet field filled with NUL characters. Otherwise, the text string is encoded with no terminating NUL character.
c) The Revision Level, an unsigned integer encoded within a fixed field of 2 octets.
d) The Configuration Digest, a 16-octet signature of type HMAC-MD5 (see IETF RFC 2104) created from the MST Configuration Table (Clause 3, 8.9). To calculate the digest, the table is considered to contain 4096 consecutive two octet elements, where each element of the table (with the exception of the first and last) contains an MSTID value encoded as a binary number, with the first octet being most significant. The first element of the table contains the value 0, the second element the MSTID value corresponding to VID 1, the third element the MSTID value corresponding to VID 2, and so on, with the next to last element of the table containing the MSTID value corresponding to VID 4094, and the last element containing the value 0. The key used to generate the signature consists of the 16-octet string specified in Table 13-1.

Table 13-1—Configuration Digest Signature Key

Parameter	Mandatory value
Configuration Digest Signature Key	0x13AC06A62E47FD51F95D2BA243CD0346

NOTE—The formulation of the signature as described above does not imply that a separate VID to MSTID translation table has to be maintained by the implementation; rather that it should be possible for the implementation to derive the logical contents of such a table, and the signature value as specified above, from the other configuration information maintained by the implementation, as described in Clause 12.

The Configuration Digests of some VID to MSTID translations are shown in Table 13-2 to help verify implementations of this specification.

Table 13-2—Sample Configuration Digest Signature Keys

VID to MSTID translation	Configuration Digest
All VIDs map to the CIST, no VID mapped to any MSTI	0xAC36177F50283CD4B83821D8AB26DE62
All VIDs map to MSTID 1	0xE13A80F11ED0856ACD4EE3476941C73B
Every VID maps to the MSTID equal to (VID modulo 32) + 1	0x9D145C267DBE9FB5D893441BE3BA08CE

It is recommended that MST Bridge implementations provide an easily selectable or default configuration comprising a Configuration Name of the Bridge Address as a text string using the Hexadecimal Representation specified in IEEE Std 802, a Revision Level of 0, and a Configuration Digest representing a VID to MSTID translation table containing the value 0 for every element. Such a table represents the mapping of all VIDs to the CIST. Since the Bridge Address is unique to each Bridge, no two Bridges using this default configuration will be identified as belonging to the same region.

It is recommended that SPT Bridge implementations provide an easily selectable or default configuration comprising a Configuration Name of 'IEEE802.1 SPB Default', a Revision Level of 0, and a Configuration Digest representing an MST Configuration Table containing the value 0xFFD for VID 1, the value 0xFFF for VIDs 3600 to 3999, and the value 0 for every other element. Such a table represents the mapping of the default PVID to SPBV, an SPVID pool containing VIDs 3600 to 3999, and mapping all other VLANs to the CIST. This will allow SPT Bridges using the default configuration to form an SPT Region and operate the default VLAN in SPBV mode.

An Auxiliary MCID (14.4, 27.4.1, 28.12.2) is specified for SPB configuration and is conveyed in SPT BPDUs and SPB Hello PDUs. When a configuration change that cannot introduce loops is made, the previous MCID can be retained in the Auxiliary MCID, allowing a neighboring Bridge whose configuration has not yet been changed to maintain communication without creating a region boundary. This allows an operator to increase the number of SPVIDs available to SPBV mode or the number of Base VIDs for SPBV or SPBM modes (for example) without disrupting communication. To avoid creating a region boundary all the Bridges have to be configured so they are all using the same new MCID before any other change can be made.

13.9 Spanning tree priority vectors

Priority vectors permit concise specification of each protocol’s computation of the active topology, both in terms of the entire network and of the operation of individual Bridges in support of the distributed algorithm. MST, RST, and STP Bridges use *spanning tree priority vector* information in Configuration Messages (13.14), sent and received from neighboring Bridges, to assign Port Roles that determine each port’s participation in a fully and simply connected active topology based on one or more spanning trees. SPT Bridges use ISIS-SPB to disseminate the information necessary to calculate Port Roles throughout SPT Regions, and to perform those calculations, but also use this Configuration Message information for the CIST to ensure that neighboring Bridges agree on that active topology, and to receive the information if the CIST Root lies outside their SPT Region.

CIST priority vectors comprise the following components:

a) CIST Root Identifier, the Bridge Identifier of the CIST Root.
b) CIST External Root Path Cost, the inter-regional cost from the transmitting Bridge to the CIST Root.
c) CIST Regional Root Identifier, the Bridge Identifier of the single Bridge in a region whose CIST Root Port connects to a LAN in a different region, or of the CIST Root if that is within the region.
d) CIST Internal Root Path Cost, the cost to the CIST Regional Root.
e) CIST Designated Bridge Identifier, the Bridge Identifier for the transmitting Bridge for the CIST.
f) CIST Designated Port Identifier, the Port Identifier for the transmitting port for the CIST.
g) CIST Receiving Port Identifier (not conveyed in Configuration Messages, used as tie-breaker between otherwise equal priority vectors within a receiving Bridge).

The first two components of the CIST priority vector are significant throughout the network. The CIST External Root Path Cost transmitted by a Bridge is propagated along each path from the CIST Root, is added to at Bridge Ports that receive the priority vector from a Bridge in a different region, and thus accumulates costs at the Root Ports of Bridges that are not MST or SPT Bridges or are CIST Regional Roots and is constant within a region. The CIST Internal Root Path Cost is only significant and defined within a region. The last three components are used as locally significant tie breakers, not propagated within or between regions. The set of all CIST spanning tree priority vectors is thus totally ordered.

Since RSTP is not aware of regions, RSTP specifications also refer to the CIST Root Identifier and CIST External Root Path Cost simply as the Root Bridge Identifier and Root Path Cost, respectively, and omit the CIST Internal Root Path Cost (as does STP). MSTP encodes the CIST Regional Root Identifier in the BPDU field used by RSTP to convey the Designated Bridge Identifier (14.1.1), so an entire region appears to an RSTP-capable Bridge as a single Bridge. RSTP's CST use of CIST priority vectors can be conveniently specified by the use of the zero for the Internal Root Path Cost and the same values for both the Regional Root Identifier and Designated Bridge Identifier.

NOTE 1—The path to the CIST Root from a Bridge with a CIST Root Port within a region always goes to or through the CIST Regional Root.

NOTE 2—STP lacks the fields necessary for MST Bridges to communicate the Designated Bridge Identifier to resolve a potential priority vector tie, and MSTP BPDUs are not sent on a LAN to which an STP Bridge is attached.

Each MSTI priority vector comprises the following components for the particular MSTI in a given region:

h) MSTI Regional Root Identifier, the Bridge Identifier of the MSTI Regional Root
i) MSTI Internal Root Path Cost, the path cost to the MSTI Regional Root
j) MSTI Designated Bridge Identifier, the Bridge Identifier for the transmitting Bridge for this MSTI
k) MSTI Designated Port Identifier, the Port Identifier for the transmitting port for this MSTI
l) MSTI Receiving Port Identifier (not conveyed in Configuration Messages)

The set of priority vectors for a given MSTI is only defined within a region. Within each region they are totally and uniquely ordered. A CIST Root Identifier, CIST External Root Path Cost, and CIST Regional Root Identifier tuple defines the connection of the region to the external CST and is required to be associated with the source of the MSTI priority vector information when assessing the agreement of information for rapid transitions to forwarding, but plays no part in priority vector calculations.

As each Bridge and Bridge Port receives priority vector information from Bridges and ports closer to the Root, calculations and comparisons are made to decide which priority vectors to record, and what information to pass on. Decisions about a given port's role are made by comparing the priority vector components that could be transmitted with that received by the port. For all components, a lesser numerical value is better, and earlier components in the above lists are more significant. As each Bridge Port receives

information from ports closer to the Root, additions are made to one or more priority vector components to yield a worse priority vector for potential transmission through other ports of the same Bridge.

NOTE 3—The consistent use of lower numerical values to indicate better information is deliberate as the Designated Port that is closest to the Root Bridge, i.e., has a numerically lowest path cost component, is selected from among potential alternatives for any given LAN (13.9). Adopting the conventions that lower numerical values indicate better information, that where possible more significant priority components are encoded earlier in the octet sequence of a BPDU (14.1), and that earlier octets in the encoding of individual components are more significant (14.2) allow concatenated octets that compose a priority vector to be compared as if they were a multiple octet encoding of a single number, without regard to the boundaries between the encoded components. To reduce the confusion that naturally arises from having the lesser of two numerical values represent the better of the two, i.e., that chosen all other factors being equal, this clause uses the following consistent terminology. Relative numeric values are described as "least," "lesser," "equal," and "greater," and their comparisons as "less than," "equal to," or "greater than," while relative spanning tree priorities are described as "best," "better," "the same," "different," and "worse" and their comparisons as "better than," "the same as," "different from," and "worse than." The operators "<" and "=" represent less than and equal to, respectively. The terms "superior" and "inferior" are used for comparisons that are not simply based on priority but include the fact that a priority vector can replace an earlier vector transmitted by the same Bridge Port. All of these terms are defined for priority vectors in terms of the numeric comparison of components below (13.10, 13.11).

NOTE 4—To ensure that the CIST and each MSTI's view of the boundaries of each region remain in synchronization at all times, each BPDU carries priority vector information for the CIST as well as for MSTIs. Associating the CIST Root Identifier, External Path Cost, and Regional Root Identifier with the priority vector information for each MSTI does not therefore raise a requirement to transmit these components separately. A single bit per MSTI vector, the Agreement flag, satisfies the requirement to indicate that the vector beginning with the MSTI Regional Root Identifier for that specific MSTI has always been associated with the single CIST Root Identifier, etc. transmitted in the BPDU.

To allow the active topology to be managed for each tree through adjusting the relative priority of different Bridges and Bridge Ports for selection as the CIST Root, a CIST or MSTI Regional Root, Designated Bridge, or Designated Port, the priority component of the Bridge's Bridge Identifier can be independently chosen for the CIST and for each MSTI. The priority component used by the CIST for its CIST Regional Root Identifier can also be chosen independently of that used for the CIST Root Identifier. Independent configuration of Port Path Cost and Port Priority values for the CIST and for each MSTI can also be used to control selection of the various roles for the CIST and for each MSTI.

In principle an SPT priority vector could be defined within an SPT Region, comprising a Regional Root Identifier and Internal Root Path Cost, and would reflect the construction of each SPT (lowest Internal Root Path Cost from each Bridge and LAN to the Regional Root). However, the set of such vectors cannot be totally ordered by the addition of purely local tie-breaker components: as each SPT Set has to be symmetric. Clause 28 specifies ISIS-SPB's calculation of SPTs.

13.10 CIST Priority Vector calculations

The *port priority vector* is the priority vector held for the port when the reception of BPDUs and any pending update of information has been completed:

port priority vector = *{RootID : ExtRootPathCost :*
RRootID : IntRootPathCost :
DesignatedBridgeID : DesignatedPortID : RcvPortID}

The *message priority vector* is the priority vector conveyed in a received Configuration Message. For a Bridge with Bridge Identifier *B* receiving a Configuration Message on a port P_B from a Designated Port P_D on Bridge *D* claiming a CIST Root Identifier of $R_{D,}$ a CIST External Root Path Cost of ERC_D, a CIST Regional Root Identifier of $RR_{D,}$ and a CIST Internal Root Path Cost of IRC_D:

$$message\ priority\ vector = \{R_D : ERC_D : RR_D : IRC_D : D : P_D : P_B\}$$

If *B* is not in the same region as *D*, the Internal Root Path Cost has no meaning to *B* and is set to 0.

NOTE 1—If a Configuration Message is received in an RST or STP BPDU, both the Regional Root Identifier and the Designated Bridge Identifier are decoded from the single BPDU field used for the Designated Bridge Parameter (the MST BPDU field in this position encodes the CIST Regional Root Identifier). An STP or RST Bridge is always treated by MSTP as being in an region of its own, so the Internal Root Path Cost is decoded as zero.

The received CIST message priority vector is the same as B's port priority vector if:

$$(R_D == RootID) \&\& (ERC_D == ExtRootPathCost) \&\& (RR_D == RRootID) \&\& (IRC_D == IntRootPathCost) \&\& (D == DesignatedBridgeID) \&\& (P_D == DesignatedPortID)$$

and is better if:

$$\begin{aligned}&((R_D < RootID)) \;||\\ &((R_D == RootID) \&\& (ERC_D < ExtRootPathCost)) \;||\\ &((R_D == RootID) \&\& (ERC_D == ExtRootPathCost) \&\& (RR_D < RRootID)) \;||\\ &((R_D == RootID) \&\& (ERC_D == ExtRootPathCost) \&\& (RR_D == RRootID)\\ &\quad \&\& (IRC_D < IntRootPathCost)) \;||\\ &((R_D == RootID) \&\& (ERC_D == ExtRootPathCost) \&\& (RR_D == RRootID)\\ &\quad \&\& (IRC_D == IntRootPathCost) \&\& (D < DesignatedBridgeID)) \;||\\ &((R_D == RootID) \&\& (ERC_D == ExtRootPathCost) \&\& (RR_D == RRootID)\\ &\quad \&\& (IRC_D == IntRootPathCost) \&\& (D == DesignatedBridgeID)\\ &\quad \&\& (P_D < DesignatedPortID))\end{aligned}$$

A received CIST message priority vector is superior to the port priority vector if, and only if, the message priority vector is better than the port priority vector, or the Designated Bridge Identifier Bridge Address and Designated Port Identifier Port Number components are the same; in which case, the message has been transmitted from the same Designated Port as a previously received superior message, i.e., if:

$$\begin{aligned}&(\{R_D : ERC_D : RR_D : IRC_D : D : P_D : P_B\}\\ &\quad \textit{is better than}\\ &\{RootID : ExtRootPathCost : RRootID : IntRootPathCost :\\ &\quad DesignatedBridgeID : DesignatedPortID : RcvPortID\}\\ &) \;||\; ((D.BridgeAddress == DesignatedBridgeID.BridgeAddress) \&\&\\ &\quad (P_D.PortNumber == DesignatedPortID.PortNumber))\end{aligned}$$

If the message priority vector received in a Configuration Message from a Designated Port is superior, it will replace the current port priority vector.

A *root path priority vector* for a port can be calculated from a port priority vector that contains information from a message priority vector, as follows:

If the port priority vector was received from a Bridge in a different region (13.29.8), the External Port Path Cost EPC_{PB} is added to the External Root Path Cost component, and the Regional Root Identifier is set to the value of the Bridge Identifier for the receiving Bridge. The Internal Root Path Cost component will have been set to zero on reception.

$$root\ path\ priority\ vector = \{R_D : ERC_D + EPC_{PB} : B : 0 : D : P_D : P_B\}$$

If the port priority vector was received from a Bridge in the same region (13.29.8), the Internal Port Path Cost IPC_{PB} is added to the Internal Root Path Cost component.

$$root\ path\ priority\ vector = \{R_D : ERC_D : RR_D : IRC_D + IPC_{PB} : D : P_D : P_B\}$$

The *Bridge priority vector* for a Bridge *B* is the priority vector that would, with the Designated Port Identifier set equal to the transmitting Port Identifier, be used as the message priority vector in Configuration Messages transmitted on Bridge *B*'s Designated Ports if *B* was selected as the Root Bridge of the CIST.

Bridge priority vector = {B : 0 : B : 0 : B : 0 : 0}

The *root priority vector* for Bridge *B* is the best priority vector of the set of priority vectors comprising:

a) The Bridge priority vector; plus
b) All root path priority vectors that:
   1) Have a Designated Bridge Identifier *D* that is not equal to *B*, and
   2) Were received from a Bridge Port attached to a LAN that is not in the same SPT Region as *B*; plus
c) The root path priority vector calculated by ISIS-SPB (if SPB is enabled, and the attached LAN is within the Bridge's SPT Region).

NOTE 2—The BPDUs sent and received by all Bridges attached to a LAN allow MST and SPT Bridges to determine whether each attached LAN is within their region independently of priority vector values. SPT Bridges take advantage of this fact by using ISIS-SPB to communicate the CST priority vector for each of SPT Region's potential Master Ports throughout the region, at the same time as ISIS-SPB calculates the Port Roles for each SPT (see Clause 28).

If the Bridge priority vector is the best of this set of priority vectors, Bridge *B* has been selected as the CIST Root. Otherwise, the root priority vector will only be that calculated by ISIS-SPB if the Root Bridge or Regional Root is within the Bridge's SPT Region.

The *designated priority vector* for a port *Q* on Bridge *B* is the root priority vector with *B*'s Bridge Identifier *B* substituted for the *DesignatedBridgeID* and *Q*'s Port Identifier Q_B substituted for the *DesignatedPortID* and *RcvPortID* components. If *Q* is attached to a LAN that has one or more STP Bridges attached (as determined by the Port Protocol Migration state machine), *B*'s Bridge Identifier *B* is also substituted for the *RRootID* component.

If the designated priority vector is better than the port priority vector and the LAN attached to the port is not within the Bridge's SPT Region (possibly because SPB is not enabled), the port will be the Designated Port for that LAN and the current port priority vector will be updated. If the attached LAN is within the Bridge's SPT Region, then the Port Role is as calculated by ISIS-SPB and the port priority vector will be updated with the designated priority vector if and only if the port is a Designated Port. The message priority vector in Configuration Messages transmitted by a port always comprises the components of the designated priority vector for the port, even if the port is a Root Port.

13.11 MST Priority Vector calculations

The *port priority vector* for a given MSTI is the priority vector held for the port per MSTI when the reception of BPDUs and any pending update of information has been completed:

port priority vector = {RRootID : IntRootPathCost : DesignatedBridgeID : DesignatedPortID : RcvPortID}

The *message priority vector* for a given MSTI is the MSTI priority vector conveyed in a received Configuration Message. For a Bridge with Bridge Identifier *B* receiving a Configuration Message on a Regional Port P_B from a Designated Port P_D on Bridge *D* belonging to the same MST Region and claiming an Internal Root Path Cost of IRC_D:

message priority vector = $\{RR_D : IRC_D : D : P_D : P_B\}$

An MSTI message priority vector received from a Bridge not in the same MST Region is discarded.

An MSTI message priority vector received from a Bridge Port internal to the region is the same as the port priority vector if:

$$((RR_D == RRootID) \&\& (IRC_D == IntRootPathCost) \&\& (D == DesignatedBridgeID) \&\& (P_D == DesignatedPortID))$$

and is better if:

$$((RR_D < RRootID)) \;||\; ((RR_D == RRootID) \&\& (IRC_D < IntRootPathCost)) \;||\; ((RR_D == RRootID) \&\& (IRC_D == IntRootPathCost) \&\& (D < DesignatedBridgeID)) \;||\; ((RR_D == RRootID) \&\& (IRC_D == IntRootPathCost) \&\& (D == DesignatedBridgeID) \&\& (P_D < DesignatedPortID))$$

An MSTI message priority vector is superior to the port priority vector if, and only if, the message priority vector is better than the port priority vector, or the Designated Bridge Identifier Bridge Address and Designated Port Identifier Port Number components are the same; in which case, the message has been transmitted from the same Designated Port as a previously received superior message, i.e., if:

$$(\{RR_D : IRC_D : D : P_D : P_B\} \text{ is better than } \{RRootID : IntRootPathCost : DesignatedBridgeID : DesignatedPortID : RcvPortID\}) \;||\; ((D.BridgeAddress == DesignatedBridgeID.BridgeAddress) \&\& (P_D.PortNumber == DesignatedPortID.PortNumber))$$

If the message priority vector received in a Configuration Message from a Designated Port for the MSTI is superior, it will replace the current port priority vector.

NOTE 1—The agree flag (13.27.3) for the port and this MSTI will be cleared if the CIST Root Identifier, CIST External Root Path Cost, and CIST Regional Root Identifier in the received BPDU are not better than or the same as those for the CIST designated priority vector for the port following processing of the received BPDU.

A *root path priority vector* for a given MSTI can be calculated for a port that has received a port priority vector from a Bridge in the same region by adding the Internal Port Path Cost IPC_{PB} to the Internal Root Path Cost component.

$$root\ path\ priority\ vector = \{RR_D : IRC_D + IPC_{PB} : D : P_D : P_B\}$$

NOTE 2—Internal Port Path Costs are independently manageable for each MSTI, as are the priority components of the Bridge and Port Identifiers. The ability to independently manage the topology of each MSTI without transmitting individual Port Path Costs is a key reason for retaining the use of a Distance Vector protocol for constructing MSTIs. A simple link state protocol requires transmission (or *a priori* sharing) of all Port Costs for all links.

The *Bridge priority vector* for a Bridge *B* for a given MSTI is the priority vector that would, with the Designated Port Identifier set equal to the transmitting Port Identifier, be used as the message priority vector in Configuration Messages transmitted on Bridge *B*'s Designated Ports if *B* was selected as the Root Bridge of a given tree.

$$Bridge\ priority\ vector = \{B : 0 : B : 0\}$$

The *root priority vector* for Bridge *B* is the best priority vector of the set of priority vectors comprising the Bridge priority vector plus all root path priority vectors whose Designated Bridge Identifier *D* is not equal to *B*. If the Bridge priority vector is the best of this set of priority vectors, Bridge *B* has been selected as the Root of the tree.

The *designated priority vector* for a port *Q* on Bridge *B* is the root priority vector with *B*'s Bridge Identifier *B* substituted for the *DesignatedBridgeID* and *Q*'s Port Identifier Q_B substituted for the *DesignatedPortID* and *RcvPortID* components.

If the designated priority vector is better than the port priority vector, the port will be the Designated Port for the attached LAN and the current port priority vector will be updated. The message priority vector in MSTP BPDUs transmitted by a port always comprises the components of the designated priority vector of the port, even if the port is a Root Port.

Figure 13-8 shows the priority vectors and the active topology calculated for an MSTI in a region of the example network of Figure 13-6.

13.12 Port Role assignments

Each Bridge assigns CIST Port Roles (when new information becomes available as specified in this subclause, 13.12) before assigning MSTI or SPT Port Roles. The calculations specified in 13.10 are used to assign a role to each Bridge Port that is enabled as follows:

a) If the Bridge is not the CIST Root, the source of the root priority vector is the Root Port.
b) Each port whose port priority vector is the designated priority vector is a Designated Port.
c) Each port, other than the Root Port, with a port priority vector received from another Bridge is a Alternate Port.
d) Each port with a port priority vector received from another port on this Bridge is a Backup Port.

If the port is not enabled, i.e., its MAC_Operational status is FALSE or its Administrative Bridge Port state is Disabled (8.4), it is assigned the Disabled Port role for the CIST, all MSTIs, and all SPTs, to identify it as having no part in the operation of any of the spanning trees or the active topology of the network.

If the Bridge is an MST or SPT Bridge, the calculations specified in 13.11 are used to assign a role to each enabled Bridge Port for each MSTI as follows:

e) If the port is the CIST Root Port and the CIST port priority vector was received from a Bridge in another MST or SPT Region, the port is the Master Port.
f) If the Bridge is not the MSTI Regional Root, the port that is the source of the MSTI root priority vector is the Root Port.
g) Each port whose port priority vector is the designated priority vector derived from the root priority vector is a Designated Port.
h) Each port, other than the Master Port or the Root Port, with a port priority vector received from another Bridge or a CIST port priority vector from a Bridge in another region, is an Alternate Port.
i) Each port that has a port priority vector that has been received from another port on this Bridge is a Backup Port.

Independently of priority vector values and active topology calculations, each SPT Bridge Port determines from received BPDUs whether all the Bridges attached to its LAN are in the same SPT Region. If not, the port is a Boundary Port, and its role for each SPT is determined by its CIST Port Role as follows:

j) If the port is the CIST Root Port, the port is the Master Port for all SPTs.
k) If the port is not the CIST Root Port, the port's role is the same as that for the CIST.

By excluding Boundary Ports from the physical topology used to calculate SPTs, and adopting CIST connectivity at those ports, ISIS-SPB ensures that the use of SPVIDs (see Clause 27) is not required on shared media LANs attached to Bridges in other regions.

SPT Bridges use ISIS-SPB to assign Port Roles for each SPT to non-Boundary Ports as follows:

l) If the Bridge is not the SPT Root Bridge, the port that ISIS-SPB has calculated as providing the path for frames assigned to the SPT and forwarded to the Bridge from that SPT Root is the Root Port.
m) Each port, other than the Root Port, that ISIS-SPB has calculated as providing a path for frames forwarded from the SPT Root to the attached LAN is a Designated Port.
n) Each port that is attached to the same LAN as another port on that same Bridge that is a Designated Port for the SPT, is a Backup Port.
o) Each port not assigned a Root, Designated, or Backup Port role is an Alternate Port.

13.13 Stable connectivity

This subclause provides an analysis to show that RSTP, MSTP, and ISIS-SPB meet the goal of providing full and simple connectivity for frames assigned to any given VID in a stable network, i.e., where the physical topology has remained constant for long enough that the spanning tree information communicated and processed by Bridges is not changing.

NOTE 1—The FDB can be configured to prevent connectivity, in particular this analysis assumes that every Bridge Port is a member of every VID's Member Set (8.8.10). Spanning tree protocol controls can also be used to prevent new connectivity (to allow for upgrades), or to disallow certain topologies (restricting the location of the CIST Root, for example). This analysis assumes that those controls are not being used, that all the Bridges are using conformant protocol implementations and that the LANs are providing omnidirectional connectivity.

Every LAN provides connectivity for all frames between all attached Bridge Ports. Every Bridge provides connectivity between and only between its CIST Root and Designated Ports for frames assigned to the CIST; between the Root, Designated, and Master Ports for a given MSTI for frames assigned to that MSTI; and between Root and Designated Ports for a given SPT for frames assigned to that SPT. Any given Bridge does not assign frames to more than one tree and has one Root Port per tree, unless it is the Root of that tree.

Every LAN has one and only one CIST Designated Port, and every Bridge apart from the CIST Root has one and only one CIST Root Port. The CIST spanning tree priority vector of the Designated Port attached to the LAN that is connected to a Bridge's Root Port is better than of any Designated Port of that Bridge. The CIST thus connects all Bridges and LANs (is "spanning") and loop-free (is a "tree").

Each MST or SPT Region is bounded by CST Root and Alternate Ports. At the CST Root Ports connectivity for frames assigned to MSTIs or SPTs within the connected regions is the same as that for the CIST. Every region apart from that containing the CIST Root has a single CST Root Port, identified as the Master Port for each MSTI. The CIST spanning tree priority vector of the LAN attached to the region's CST Root Port is better than that of any CST Designated Port of a Bridge in the region attached to a LAN also attached to the CST Root Port of another region. The CST thus provides loop-free connectivity between all regions.

NOTE 2—The term "Common Spanning Tree (CST)" refers to the CIST connectivity between regions, and the term "Internal Spanning Tree (IST)" to the CIST connectivity within each region. An RST Bridge and the LANs for which it is the Designated Bridge are conveniently considered as forming an MST region of limited extent.

Within each region each frame is consistently assigned to the CIST, an MSTI, or an SPT, and each of these spanning trees provides full loop-free connectivity to each of the Bridges within the region, just as the CIST does for the network as a whole, including connectivity between the CST Root Port (Master Port) and the CST Designated Ports. Since each Bridge or LAN is in one and only one region, and it has already been shown that loop-free connectivity is provided between regions, loop-free connectivity is thus provided between all the Bridges and LANs in the network.

Figure 13-9 illustrates the above connectivity with the simple example of Region 1 from the example network of Figure 13-6 and Figure 13-8. Bridge 0.42 has been selected as the CIST Root and Regional Root,

Bridge 0.57 as the Regional Root for MSTI 1, and Bridge 2.83 for MSTI 2 by management of the per MSTI Bridge Identifier priority component. The potential loop through the three Bridges in the region is blocked at different Bridge Ports for the CIST, and each MSTI, but the connectivity across the region and from each LAN and Bridge in the region through the boundaries of the region is the same in all cases.

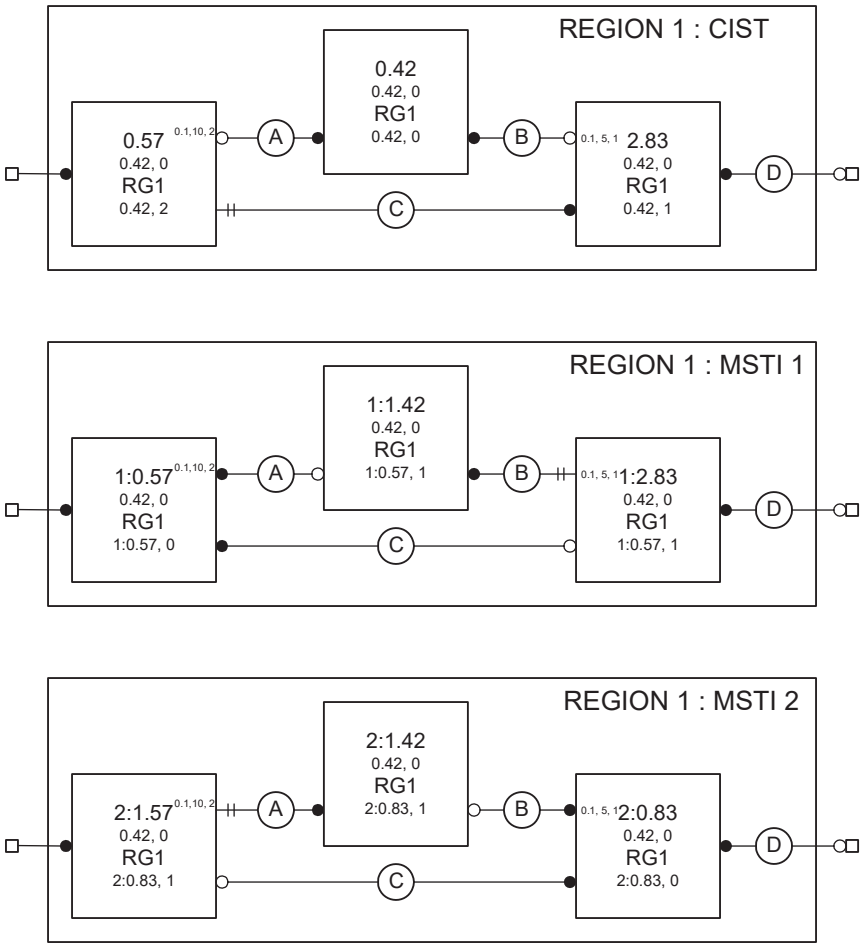


Figure 13-9—CIST and MSTI active topologies in Region 1 of the example network

13.14 Communicating spanning tree information

A Spanning Tree Protocol Entity transmits and receives group addressed BPDUs (Clause 14, 8.13.4) through each of its Bridge Ports to communicate with the Spanning Tree Protocol Entities of the other Bridges attached to the same LAN. The group address used is one of a small number of addresses that identify frames that are not directly forwarded by Bridges (8.6.3), but the information in the BPDU can be used by a Bridge in calculating its own BPDUs to transmit and can stimulate that transmission.

BPDUs are used to convey the following:

a) Configuration Messages
b) Topology Change Notification (TCN) Messages
c) MCIDs
d) Agreement parameters to support SPB

Designated Ports also transmit BPDUs at intervals to guard against loss and to assist in the detection of failed components (LANs, Bridges, or Bridge Ports), so all messages are designed to be idempotent.

A Configuration Message for the CIST can be encoded in an STP Configuration BPDU, an RST BPDU, an MST BPDU, or an SPT BPDU (14.1, 14.5). A TCN Message for the CIST can be encoded in an STP Topology Change Notification BPDU (14.2), or an RST, MST, or SPT BPDU with the TC flag set. Configuration and TCN Messages for the CIST and for all MSTIs in an MST Region are encoded in a single MST or SPT BPDU, as is the MCID. No more than 64 MSTI Configuration Messages shall be encoded in an MST BPDU, and no more than 64 MSTIs shall be supported by an MST Bridge.

When SPB is enabled, ISIS-SPB is used to communicate CST priority vectors, IST topology information, and CST topology change information to and from the other Bridges in the SPT Region and to calculate IST and SPT Port Roles and designated priority vectors. However, the full CIST priority information is still conveyed in SPT BPDUs, partly to encode agreement information for the IST, but principally to support interoperability at the boundaries of each region without having to assess whether the transmitting port is at a boundary before deciding what to encode in each BPDU.

Configuration and Topology Change Notification BPDUs are distinguished from each other and from RST and MST BPDUs by their BPDU Type (Clause 14). RST and MST BPDUs share the same BPDU Type and are distinguished by their version identifiers.

Bridges implementing STP (Clause 8 of IEEE Std 802.1D, 1998 Edition [B11]) transmit and decode Configuration and Topology Change Notification BPDUs, and ignore RST and MST BPDUs on receipt. This ensures that connection of a Bridge Port of such a Bridge to a LAN that is also attached to a Bridge implementing RSTP or MSTP is detected, as transmission of RSTP or MSTP BPDUs does not suppress regular transmissions by the STP Bridge. This functionality is provided by the Port Protocol Migration state machine for RSTP (13.32). The Port Protocol Migration state machines select the BPDU types used to encode spanning tree messages so that all Bridges attached to the same LAN participate in a spanning tree protocol, while maximizing the available functionality. If one or more attached Bridges only implement STP, only Configuration and Topology Change Notification BPDUs will be used and the functionality provided by the protocol will be constrained.

13.15 Changing spanning tree information

Addition, removal, failure, or management of the parameters of Bridges and LAN connectivity can change spanning tree information and require Port Role changes in all or part of the network (for the CIST) or all or part of an MST or SPT Region (for an MSTI or SPT Set). A CIST or MSTI configuration message received in a BPDU is considered superior to, and will replace, that recorded in the reception Port’s port priority vector if its message priority vector is better, or if it was transmitted by the same Designated Bridge and Designated Port and the message priority vector, timer, or hop count information differ from those recorded.

RSTP and MSTP propagate new information rapidly from Bridge to Bridge, superseding prior information and stimulating further transmissions until it reaches either Designated Ports that have already received the new information through redundant paths in the network or the leaves of the spanning tree, as defined by the new configuration. Configuration Message transmissions will then once more occur at regular intervals from ports selected as Designated Ports.

To ensure that old information does not endlessly circulate through redundant paths in the network, preventing the effective propagation of the new information, MSTP associates a hop count with the information for each spanning tree. The hop count is assigned by the CIST Regional Root or the MSTI Regional Root and decremented by each reception Port. Received information is discarded and the port made a Designated Port if the hop count reaches zero.

RSTP and MSTP's CST processing do not use an explicit hop count (for reasons of STP compatibility), but detect circulating aged information by treating the BPDU Message Age parameter as an incrementing hop count with Max Age as its maximum value. MSTP increments Message Age for information received at the boundary of an MST Region, discarding the information if necessary.

If a Bridge Port's MAC_Operational parameter becomes FALSE, the port becomes a Disabled Port and received information is discarded. Spanning tree information for the tree can be recomputed, the Bridge's Port Roles changed, and new spanning tree information transmitted if necessary. Not all component failure conditions can be detected in this way, so each Designated Port transmits BPDUs at regular intervals and a reception Port will discard information and become a Designated Port if two transmissions are missed.

NOTE—Use of a separate hop count and message loss detection timer provides superior reconfiguration performance compared with the original use of Message Age and Max Age by STP. Connectivity loss detection is not compromised by the need to allow for the overall diameter of the network, nor does the time allowed extend the number of hops permitted to aged recirculating information. Management calculation of the necessary parameters for custom topologies is also facilitated, as no allowance needs to be made for relative timer jitter and accuracy in different Bridges.

ISIS-SPB communicates CST, IST, and SPT information throughout an SPT Region using link state procedures specified in Clause 28. In addition to the normal hop-by-hop distribution of this information, which is essential to guarantee its dissemination, each link state PDU (LSP) is also broadcast on the SPT rooted at the originating Bridge, so new information can reach Bridges in the region with the same delay as data.

13.16 Changing Port States with RSTP or MSTP

The Port State for the CIST and each MSTI for each Bridge Port is controlled by state machines whose goal is to maximize connectivity without introducing temporary loops in each of these active topologies. Root Ports, Master Ports, and Designated Ports are transitioned to the Forwarding Port State, and Alternate Ports and Backup Ports to the Discarding Port State, as rapidly as possible. Transitions to the Discarding Port State can be simply effected without the risk of data loops. This subclause (13.16) describes the conditions that RSTP and MSTP use to transition a Port State for a given spanning tree to Forwarding.

Starting with the assumption that any connected fragment of a network is composed of Bridges, Bridge Ports, and connected LANs that form a subtree of a spanning tree, ports with Root Port, Master Port, or Designated Port roles are transitioned using conditions that ensure that the newly enlarged fragment continues to form either a subtree or the whole of the spanning tree. Since the conditions are used every time a fragment is enlarged, it is possible to trace the growth of a fragment from a single Bridge—a consistent, if small, subtree of a spanning tree—to any sized fragment, thus justifying the initial assumption.

Port States in two subtrees, each bounded by ports that are not forwarding or are attached to LANs not attached to any other Bridge, can be made consistent by waiting for any changes in the priority vector information used to assign Port Roles to reach all Bridges in the network, thus ensuring that the subtrees are not, and are not about to be, joined by other Forwarding Ports. However, it can be shown that a newly selected Root Port can forward frames as soon as prior recent root ports on the same Bridge cease to do so, without further communication from other Bridges. Rapid transitions of Designated Ports and Master Ports do require an explicit Agreement from the Bridges in the subtrees to be connected. The Agreement mechanism is described, together with a Proposal mechanism that forces satisfaction of the conditions if they have not already been met by blocking Designated Ports connecting lower subtrees that are not yet in agreement. The same Agreement mechanism is then used to transition the newly blocked ports back to forwarding, advancing any temporary cut in the active topology toward the edge of the network.

13.16.1 Subtree connectivity and priority vectors

Any given Bridge *B*, the LANs connected through its Forwarding Designated Ports, the further Bridges connected to those LANs through their Root Ports, the LANs connected to their Forwarding Designated Ports, and so on, recursively, constitute a subtree S_B. Any LAN *L* that is part of S_B will be connected to *B* through a Forwarding Designated Port P_{CL} on a Bridge *C* also in S_B. *L* cannot be directly connected to any port P_B on Bridge *B* unless *B* and *C* are one and the same, since the message priority vector for P_B is better than that of any port of any other Bridge in S_B, and prior to Forwarding P_{CL} will have advertised its spanning port priority vector for long enough for it to receive any better message priority vector (within the design probabilities of protocol failure due to repeated BPDU loss) or will have engaged in an explicit confirmed exchange (see below) with all other Bridge Ports attached to that LAN.

NOTE—The analysis for the distance vector-based RSTP and MSTP differs from that for the link state-based ISIS-SPB (see 13.17). In the latter C's priority vector can become better than B's while C remains in S_B, without B being aware of the improvement first.

13.16.2 Root Port transition to Forwarding

It follows from the above that *B*'s Root Port can be transitioned to Forwarding immediately whether it is attached to a LAN in S_B or in the rest of the network, provided that all prior recent Root Ports on *B* (that might be similarly arbitrarily attached) have been transitioned to Discarding and the Root Port was not a Backup Port recently (*B* and *C* the same as above).

13.16.3 Designated Port transition to Forwarding

On any given Bridge *A*, the Designated Port P_{AM} connected to a LAN *M* can be transitioned to Forwarding provided that the message priority advertised by the Designated Port P_{CL} on any LAN *L* in any subtree S_{M1}, S_{M2}, etc. connected to *M* is worse than that advertised by P_{AM}; that any Bridge *D* attached to *L* has agreed that P_{CL} is the Designated Port; and that only the Root Port and Designated Ports on *D* are Forwarding. A sufficient condition for P_{AM} to transition to Forwarding is that *M* is a point-to-point link attached to the Root Port P_{BM} of a Bridge *B*, that the port priority of P_{BM} is the same as or worse than that of P_{AM}, and any port P_{BN} on B is Discarding or similarly attached to a Bridge *C*. P_{BM} signals this condition to P_{AM} by setting the Agreement flag in a Configuration Message carrying P_{BM}'s designated priority and Port Role.

NOTE 1—RSTP and MSTP use adminPointToPointMAC and operPointToPointMAC (IEEE Std 802.1AC) to allow the point-to-point status of LANs to be managed and used by the Port Role Transition state machines for Designated Ports. A newly selected Root Port can be transitioned to Forwarding rapidly, even if attached to a shared media LAN.

Figure 13-10 illustrates the generation of an Agreement at a Bridge's Root Port from an Agreement received or a Port State of Discarding at each of its Designated Ports, and a Port State of Discarding at each of its Alternate and Backup Ports. A Bridge receiving a Proposal transitions any Designated Port not already synchronized to Discarding so it can send the Agreement, and that port solicits an Agreement by sending a Proposal in its turn.

NOTE 2—Agreements can be generated without prior receipt of a Proposal as soon as the necessary conditions are met. Subsequent receipt of a Proposal serves to elicit a further Agreement. If all other ports have already been synchronized (allSynced in Figure 13-10) and the Proposal's priority vector does not convey worse information, synchronization is maintained and there is no need to transition Designated Ports to Discarding once more, or to transmit further Proposals.

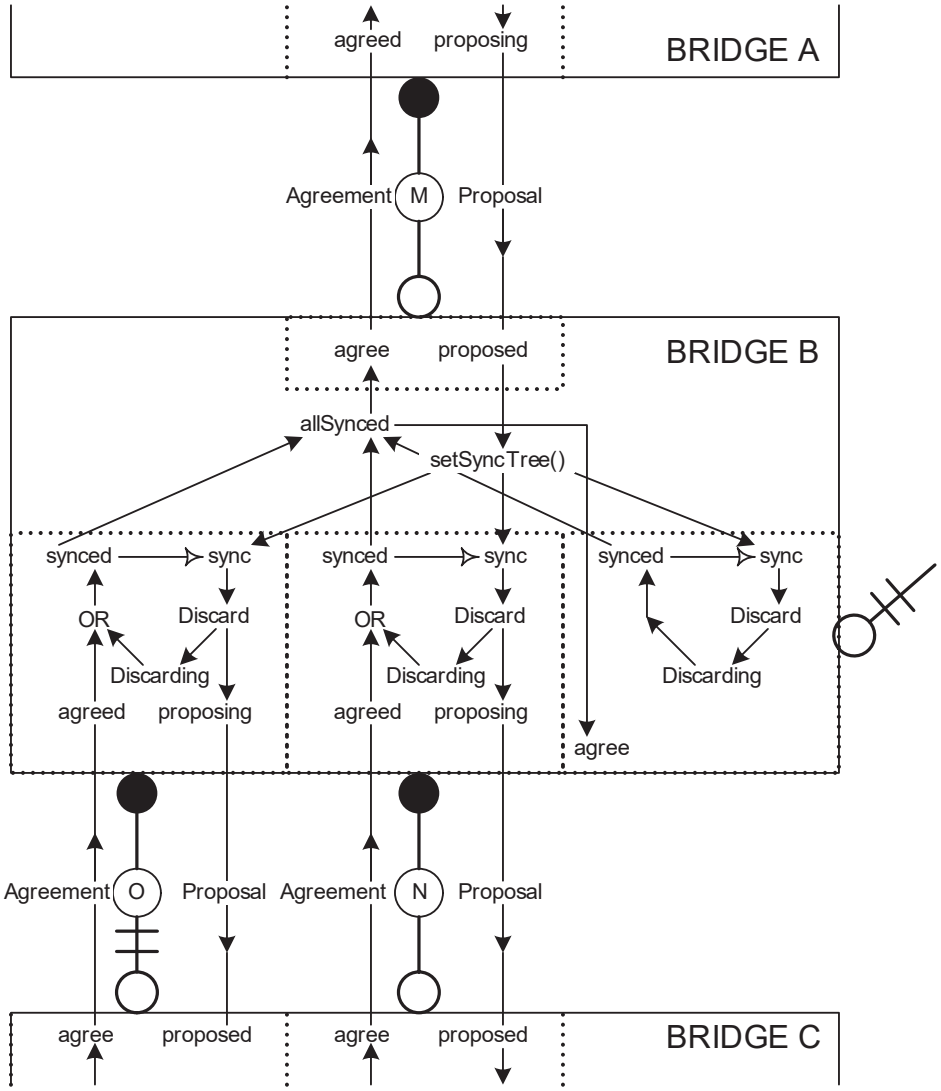


Figure 13-10—Agreements and Proposals

13.16.4 Master Port transition to Forwarding

While the connectivity of the CIST from the CIST Regional Root through an MST Region to the rest of the CST comprises a subtree rooted in the CIST Regional Root, the connectivity of the MSTI from the Master Port includes both a subtree below the CIST Regional Root and a subtree rooted in the MSTI Regional Root and connected to the CIST Regional Root by an MSTI Root Port. In the example network of Figure 13-6, this latter subtree continues CST connectivity, from the Master Port on Bridge 86 through to LAN N, for frames allocated to the MSTI within Region 2 (see Figure 13-11). In general either MSTI subtree could be providing CST connectivity through a prior Master Port: the connectivity of both subtrees has to agree with the new CIST Regional Root, before a new Master Port transitions to Forwarding.

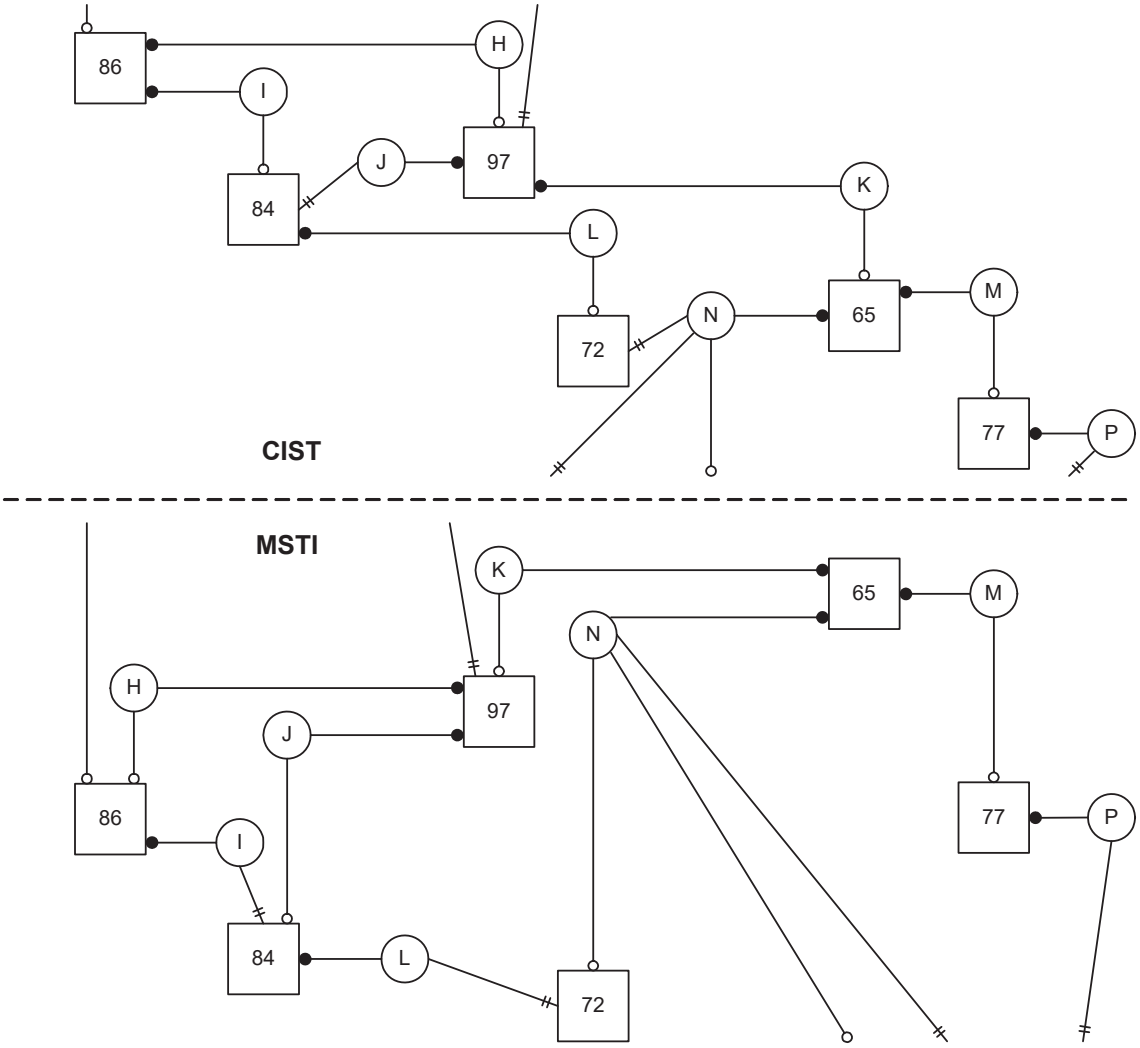


Figure 13-11—CIST and MSTI Active Topologies in Region 2 of Figure 13-6

NOTE 1—The physical layout shown in the two halves of Figure 13-11 differs in order to reflect the different priorities and logical topologies for the two spanning tree instances. The layout convention is that Designated Ports are shown as horizontal lines, Root Ports as vertical lines, and Alternate Ports as diagonal lines.

Figure 13-12 illustrates the extension of the Agreement mechanism to signal from Designated Ports to Root Ports as well as vice versa. To ensure that an MSTI does not connect alternate Master Ports, an Agreement is

only recognized at an MSTI Port when the associated CIST Regional Root information matches that selected by the reception Port. Proposals, eliciting Agreements, necessarily flow from Designated Ports to Root Ports with the propagation of spanning tree information, so a new CIST Regional Root cannot transmit a Proposal directly on its MSTI Root Ports. However, updating a CIST Designated Port's port priority vector with a new Regional Root Identifier forces the port to discard frames for all MSTIs, thus initiating the Proposal from the first Bridge nearer the MSTI Regional Root that learns of the new Regional Root.

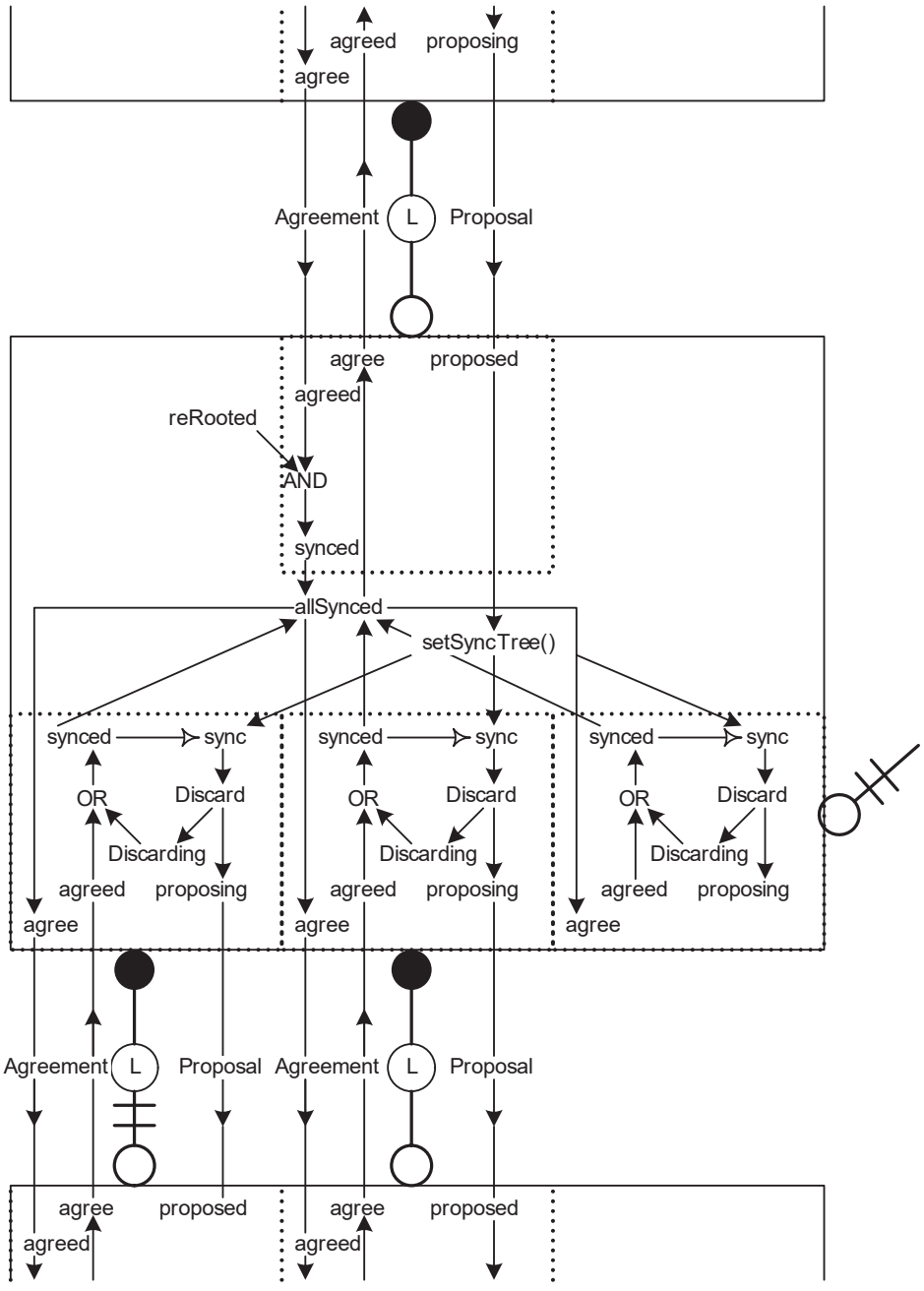


Figure 13-12—Enhanced Agreements

When an Agreement A_{MR} is sent by a Root Port P_{MR} on a Regional Root *M,* it attests that the CIST Root Identifier and External Root Path Cost components of the message priority advertised on all LANs connected to the CIST by P_{MR} through *M* are the same as or worse than those accompanying A_{MR}. The connectivity provided by each MSTI can be independent of that provided by the CIST within the MST Region and can therefore connect P_{MR} and one or more CIST Root Ports external to but attached at the boundary of the region even as CIST connectivity within the region is interrupted in order to satisfy the conditions for generating A_{MR}. The Agreement cannot therefore be generated unless all MSTI subtrees as well as the CIST subtree internal to the region are in Agreement. To ensure that an MSTI does not connect to a CIST subtree external to the region that does not meet the constraints on the CST priority vector components, an Agreement received at an MSTI Designated Port from a Bridge Port not internal to the region is only recognized if the CIST Root Identifier and External Root Path Cost of the CIST root priority vector selected by the transmitting Bridge Port are equal to or worse than those selected by the receiver. Updating of a CIST Designated Port's port priority vector with a worse CIST Root Identifier and External Root Path Cost forces the port to discard frames for all MSTIs, thus initiating a Proposal that will elicit agreement.

NOTE 2—MSTI Designated Ports are prompted to discard frames, as required above, as follows. The CIST Port Information state machine sets sync for all MSTIs on a transition into the UPDATE state if updating the port priority with the designated priority changes the Regional Root Identifier or replaces the CIST Root Identifier or External Path Cost with a worse tuple. The MSTI's Port Role Transition machine acts on the sync, instructing the port to discard frames, and setting synced and canceling sync when the port is discarding or an agreement is received.

NOTE 3—A "cut" in an MSTI can be transferred to the CST, either at a Designated Port attached to the same LAN as an STP Bridge or at the Root Port of a Bridge in an adjacent region. If the CST priority components have already been synced, as is likely if the original cut was caused by changes in physical topology within the region, the cut will terminate there. Otherwise, the transferred cut precedes a cut in the CIST, and the synced port may terminate the latter. In that way, cuts in the CST will proceed through an MST Region by the quickest tree that will carry them.

NOTE 4—In the important topology where the CIST Root Bridge is within an MST Region, cuts are not transferred from the region's IST to any MSTI. CIST cuts propagating in the region will not disrupt MSTI connectivity.

13.17 Changing Port States with SPB

While the link state routing protocols are less likely to create temporary loops than distance vector-based protocols, loops are still possible if (for example) two (or more) links fail about the same time. Any potential loop is a serious problem for bridged networks, as a frame that is multicast or whose destination has not been learned and is traveling around a loop is copied to each of the connected subtrees on every circuit, consuming bandwidth throughout the network. Each SPT Bridge Port uses SPT BPDUs and/or SPB Hello PDUs (28.2) to ensure that additions to each active topology do not occur unless there is sufficient agreement between neighboring Bridges (with some ports temporarily transitioned to Discarding if necessary) to ensure that a temporary loop will not be created.

Like RSTP and MSTP, agreements (see 13.16, Figure 13-12) are used to ensure that ports that transition to forwarding do not create loops. However, IS-IS distributes information in parallel with computation, rather than computing a new active topology hop-by-hop as priority vector information is passed from the Root Bridge to members of a potential subtree. Moreover the distribution path is not restricted to the potential subtree. Arbitrary distribution and parallel computation means that different Bridges can complete topology calculations at quite different times, with two major consequences as follows.

First, each Bridge is not necessarily aware of priority vector changes passed to any subtree connected through one of its Designated Ports before any other Bridge in that subtree. A forwarding Designated Port on a given Bridge can only provide connectivity to another Bridge through the latter's Root Port; and new connectivity is only allowed if the Designated Port has received an agreement showing that the Root Port's designated priority is worse than its own. When RSTP (or MSTP) is used priority vectors propagate down the tree: so each Bridge knows that its forwarding parents (connected through its Root Port) either have a better *designated priority* or have discarded any agreement previously received. None of those parents can

therefore provide an agreement allowing connectivity through their Root Port to one of the given Bridge's Designated Ports (potentially creating a loop), unless one of the Designated Ports between the parent and the given Bridge becomes Discarding—allowing an agreement to be sent but interrupting the potential loop. When the CIST or an SPT is supported by ISIS-SPB, a Bridge Port needs to receive an explicit message from its neighbors discarding any outstanding agreement before it can start forwarding as a Designated Port or (if it is the Root Port) before the Bridge's Designated Ports can use an improved designated priority to transition to forwarding. A given port cannot discard outstanding agreements until all the other ports of the Bridge have either received suitable agreements or stopped forwarding, or until the given port itself is Discarding.

The second major consequence of arbitrary distribution and parallel computation is that received Agreements that appear to contradict the results of the last local link state computation can become useful after a future computation completes. Agreements received after the last computation can be retained until they prove useful (following a further link state update) or are superseded by the receipt of a further agreement or a changed Port Role. The Bridge transmitting the agreement will not create any connectivity that is inconsistent with the agreement until it has been explicitly discarded. For example, two Designated Ports attached to the same LAN cannot both transition to forwarding, each using an old Agreement with a Root Port role from the other. To minimize the number of messages needed to create new connectivity, unsatisfactory received Agreements are voluntarily discarded when a link state topology calculation completes. In addition to the Agreement Digest, the Agreement Protocol (13.16, 13.17) uses a two-bit Agreement Number and a Discarded Agreement Number (in SPT BPDUs and SPB Hello PDUs) to allow for message delay, loss, duplication, and misordering. Once an Agreement has been sent it is considered outstanding until the Agreement Protocol declares a new topology match.

Agreements for the IST use CIST information present in MST and SPT BPDUs. This minimizes active topology disruption while allowing parallel adoption of a new topology since neighboring Bridges can communicate IST priority vectors, propagate agreements, and signal the need for temporary cuts to speed transitions to forwarding: even while those neighbors' views of the entire active topology differ as a consequence of differences in their knowledge of the latest physical topology. A single BPDU or SPB Hello PDU cannot convey the same per-tree state for all possible SPTs, so the input to their link state calculation is summarized in a Agreement Digest (28.4). If a received digest matches the Bridge's own digest, the Bridge can compute the implied received Agreements. Using a digest means neighboring Bridges cannot synchronize their local views of any SPT's active topology until they have synchronized their views of the physical topology of the entire SPT Region, but reducing the number of messages is worthwhile.

NOTE 1—Management VLANs with modest bandwidth needs should be allocated to the IST in SPT Regions.

The per-port per-tree state machine variable agreed (see Figure 13-12) is recomputed after ISIS-SPB completes a link state calculation, including the calculation of each port's designated priority vector, and after each BPDU is received: agreed is TRUE if and only if the port is a Root or Alternate Port with no outstanding agreements worse than its designated priority vector, or a Designated Port with no outstanding agreements and a received agreement that is worse than its designated priority vector and any outstanding agreement for the Bridge's Root Port. As in Figure 13-12 each port is synced if it is either agreed or Discarding for the tree, and agree is TRUE for a given port when all other ports are synced. Unused outstanding agreements are discarded, by their recipient, only when agree is TRUE, since any continued connectivity has to be supported by continued agreement if loops are to be prevented.

To avoid delays that might otherwise occur waiting for Agreements to percolate up the tree, sync is set for all Designated Ports to force those that are not agreed to Discarding, so that the Root Port can transmit an Agreement to its neighbor. However, it is an implementation issue about how long sync requires to take effect: the likelihood of receiving an Agreement for the CIST from the Designated Port's neighbor before the port can be transitioned to Discarding and then to Forwarding again can be taken into account. Each BPDU's CIST Proposal flag should be set when a Designated Port is Discarding, thus providing a prompt for the return of an Agreement just as described above (13.16) for RSTP and MSTP.

The Agreement Digest conveys fresh Agreements for all SPTs (all identified by the same Agreement Number used for the CIST) and discards those received for prior topologies (identified by the Discarded Agreement Number). Since different trees will have different Root Ports (in the same Bridge), if all Bridges waited for agreed to be set for all other ports for all other trees before transmitting a fresh digest the protocol would deadlock. If the Root Port is not agreed but all other ports are synced, then agree is also set for any port that is Discarding, thus avoiding the potential deadlock. When a link state computation completes, each Bridge transitions any Designated Port that is not agreed for an SPT to Discarding as rapidly as possible so that it can send the fresh digest to its neighbors, and does not attempt to optimize Port State transitions by waiting to receive a matching digest.

NOTE 2—In all comparisons between SPT priority vectors, the specified comparisons take place within the CST context, and agreed is only set if the CST Root and External Path Cost match exactly. This allow the Port Role Transition state machine for the Master Port at the SPT Region boundary, where the IST and each SPT are connected into the CST, to function just as for MSTP.

The considerations and state machine conditions detailed in this subclause (13.17) can be summarized (for an SPT Bridge with all ports providing connectivity within an SPT Region) as follows:

A Root Port satisfies the conditions for Forwarding if and only if:

a) The Agreement Protocol has declared a topology match; and
b) Since (and including) that topology match, no outstanding Agreement Digest sent through the port is for a topology where:
    1) This Bridge is or was farther from the SPT's Root Bridge than in the current topology; or
    2) The port was a Designated Port or Backup Port.

A Designated Port satisfies the conditions for Forwarding if and only if:

c) The Agreement Protocol has declared a topology match; and
d) Since (and including) that topology match, no outstanding Agreement Digest sent through the port is for a topology where:
    1) Any other Bridge attached to the same LAN is or was as close or closer to the SPT's Root Bridge than this Bridge is in the current topology; or
    2) The port was a Root Port or Alternate Port.

Note that a Root Port can only become Forwarding following receipt of a fresh Agreement Digest if all Designated Ports either satisfy the conditions for Forwarding or are made Discarding. A Designated Port can only become Forwarding if the Root Port also satisfies the conditions for Forwarding, or is made Discarding.

An Agreement Digest is sent on all ports as soon as possible after ISIS-SPB completes a link state calculation, but is only sent if (for every SPT)

e) The port sending the Agreement Digest is Discarding; or
f) The port is a Root Port or a Designated Port, that satisfies the necessary conditions for Forwarding [item a) to item d) above], and every other port of the Bridge is either Discarding or is a Root or Designated Port that also satisfies those conditions.

13.17.1 Agreement Digest

The Agreement Digest is calculated as specified in 28.4.

The purpose of the Agreement Digest is to prevent temporary loops and its use as an input to the Port Role Transition and Port State Transition state machines is specified in 13.29, 13.37, and 13.38. Successful operation of ISIS-SPB relies on the fact that SPT Bridges attached to the same LAN will, in the absence of continual physical topology changes in the network or continual loss of ISIS-SPB frames, advertise the same Agreement Digest in transmitted BPDUs and SPB Hello PDUs. Conditions that would result in permanent disagreement, and consequent failure to provide SPB, are captured in the MCID (13.8). Differences in the MCID result in both MST and SPT Bridge Ports attached to the LAN being identified as bounding a region, so connectivity can be provided using the CST.

13.18 Managing spanning tree topologies

The active topology of the CIST, and the topologies that can result after the failure or addition of network components, may be managed by assigning values to some or all of the following:

— The Bridge Priority component of the CIST Bridge Identifier for one or more Bridges
— The External Port Path Cost (also referred to as the Port Path Cost for RSTP) for some Bridge Ports
— Components of the MCID for Bridges with the same Configuration Digest
— The CIST Internal Port Path Cost Port (for MSTP and ISIS-SPB) for some Bridge Ports
— The Port Priority component of the Port Identifier for some Bridge Ports

Within an MST Region, the active topology of each MSTI may be managed by assigning values to some or all of the following:

— The Bridge Priority component of the MSTI Regional Root Identifier
— The Internal Port Path Cost for the MSTI for some Bridge Ports
— The Port Priority component of the MSTI's Port Identifier for some Bridge Ports

In general topology management objectives can be met by modifying only a few parameter values in a few Bridges in the network. Table 13-3 specifies default values and ranges for Bridge Priorities and Port Priorities. If these parameters can be updated by management, the Bridge shall have the capability to use the full range of values with the granularity specified.

Table 13-3—Bridge and Port Priority values

Parameter	Recommended or default value	Range
Bridge Priority	32 768	0–61 440 in steps of 4096
Port Priority	128	0–240 in steps of 16

NOTE 1—The stated ranges and granularities for Bridge Priority and Port Priority differ from those in IEEE Std 802.1D, 1998 Edition [B11], and earlier revisions of that standard. Expressing these values in steps of 4096 and 16 allows consistent management of old and new implementations of this standard; the steps chosen ensure that bits that have been re-assigned are not modified, but priority values can be directly compared.

Table 13-4 recommends defaults and ranges for Port Path Cost and Internal Port Path Cost values, chosen according to the speed of the attached LAN, to minimize the administrative effort required to provide reasonable active topologies. If these values can be set by management, the Bridge shall be able to use the full range of values in the parameter ranges specified, with a granularity of 1.

Table 13-4—Port Path Cost values

Link Speed	Recommended value	Recommended range	Range
<=100 kb/s	200 000 000	20 000 000–200 000 000	1–200 000 000
1 Mb/s	20 000 000	2 000 000–200 000 000	1–200 000 000
10 Mb/s	2 000 000	200 000–20 000 000	1–200 000 000
100 Mb/s	200 000	20 000–2 000 000	1–200 000 000
1 Gb/s	20 000	2000–200 000	1–200 000 000
10 Gb/s	2000	200–20 000	1–200 000 000
100 Gb/s	200	20–2000	1–200 000 000
1 Tb/s	20	2–200	1–200 000 000
10 Tb/s	2	1–20	1–200 000 000

When two or more links are aggregated (see IEEE Std 802.1AX), Port Path Cost and Internal Port Path Cost values can be modified to reflect the actual throughput. However, as the primary purpose of Path Cost is to select active topologies, it can be inappropriate to track throughput too closely, as the resultant active topology could fluctuate or differ from that intended by the network administrator. For example, if the network administrator had chosen aggregated links for resilience (rather than for increased data rate), it would be inappropriate to change topology as a result of one of the links in an aggregation failing. Similarly, with links that can autonegotiate their data rate, reflecting such changes of data rate in changes to Path Cost is not necessarily appropriate. As a default behavior, dynamic changes of data rate should not automatically cause changes in Port Path Cost.

NOTE 2—BPDUs are capable of carrying 32 bits of Root Path Cost information, though IEEE Std 802.1D, 1998 Edition [B11], and its earlier revisions limited the range of the Port Path Cost parameter to a 16-bit unsigned integer value. Table 13-4 uses the full 32-bit range to extend the range of supported link speeds. Additional recommended values can be calculated as 20 000 000 000/(Link Speed in kb/s). Limiting the range of the Path Cost parameter to 1–200 000 000 ensures that the accumulated Path Cost cannot exceed 32 bits over a concatenation of 20 hops. Where Bridges using the IEEE Std 802.1D, 1998 Edition [B11], recommendations and others using Table 13-4 are mixed in the same Bridged Network, explicit configuration is likely to be necessary to obtain reasonable CST topologies.

There exist media for which it is difficult to define a Link Speed. This includes, for example, Ethernet-over-packet-network technologies, where the frames are carried over a layer 3 best-effort network. Another example is IEEE 802.11 wireless media, where the effective bandwidth is shared among stations operating at different speeds, all varying on short timescales. Individual media specifications provide values for Link Speed suitable for use with Table 13-4 to determine a Port Path Cost.

13.19 Updating learned station location information

In normal stable operation, learned station location information held in the FDB need only change as a consequence of the physical relocation of stations. It is therefore desirable to employ a long ageing time for Dynamic Filtering Entries (8.8.3), especially as many end stations transmit frames following power-up causing the information to be relearned.

However, when the active topology reconfigures, stations can appear to move from the point of view of any given Bridge even if that Bridge's Port States have not changed. If a Bridge Port is no longer part of an active topology, stations are no longer reachable through that port, and its Dynamic Filtering Entries are

removed from that Bridge's FDB. Conversely, stations formerly reachable through other ports might be reachable through a newly active port. Dynamic Filtering Entries for the other ports are removed, and RSTP and MSTP transmit Topology Change Notification Messages both through the newly active Port and through the other active Ports on that Bridge. TCNs signal additional connectivity, not just changes in connectivity, as relearning a station's location is only possible if it can be reached, and if that is possible when a port is removed from the active topology another port will be added. A TCN is sent when a Bridge Port joins the active topology, and not before, so that Bridges can relearn removed station location information and minimize unnecessary flooding of frames. A Bridge that receives a TCN on an active port removes Dynamic Filtering Entries for their other active ports and propagates the TCN through those ports.

NOTE 1—STP allowed for the presence of LAN repeaters that could partition a shared media LAN, thus causing stations to appear to move when the partition was repaired later—with the only Bridge Port changing Port Role or Port State transitioning to Discarding at that time. This scenario does not occur with current technology, and its future likelihood does not justify the use of TCNs to signal connectivity loss. Bridge Ports that participate in the MAC status propagation protocol (Clause 23) should be capable of originating TCNs when that protocol signals additional connectivity.

The Topology Change state machine (13.39) avoids removing learned information when ports temporarily revert to Discarding to suppress loops. It treats a port as joining the active topology when it becomes forwarding, and no longer active when it becomes an Alternate, Backup, or Disabled Port and stops forwarding and learning. TCNs are not generated following Edge Port (operEdge, 13.27.44) Port State changes, as these do not affect connectivity or station location information in the rest of the network, nor are Dynamic Filtering Entries for Edge Ports removed when TCNs are received.

Dynamic Filtering Entries for MAC addresses previously learned on a Root Port may be modified to move those addresses to an Alternate Port that becomes the new Root Port and a TCN sent only through the new Root Port (and not through other active ports), reducing the need to flood frames. This optimization is possible because a retiring Root Port that becomes Discarding temporarily partitions the active topology into two subtrees, one including all Bridges and LANs hitherto reachable through the retiring Root Port, and the other including all the others. If the new Root Port simply provides a new path to the first of these subtrees, its stations will not appear to move from the point of view of Bridges in the other subtree. Alternatively if a the tree reconfiguration is more complex one or more newly Designated Port will become active and will transmit the necessary TCNs.

NOTE 2—The rules described require removal of potentially invalid learned information for a minimum set of ports on each Bridge. A Bridge implementation can flush information from more ports than strictly necessary, removing (for example) all Dynamic Filtering Entries rather than just those for the specified ports. This does not result in incorrect operation, but will result in more flooding of frames with unknown destination addresses.

Changes in the active topology of any given MSTI or SPT do not change Dynamic Filtering Entries for the CIST or any other MSTI or SPT, unless the underlying changes in the physical topology that gave rise to the reconfiguration also cause those trees to reconfigure. Changes to the CST, i.e., the connectivity provided between regions, can cause end station location changes for all trees. Changes to an IST can cause CST end station location changes but do not affect MSTIs in that region unless those trees also reconfigure.

On receipt of a CIST TCN Message from a Bridge Port not internal to the region, or on a change in Port Role for a Bridge Port at the region boundary, TCN Messages are transmitted through each of the other ports of the receiving Bridge for each MSTI and the Dynamic Filtering Entries for those ports are removed.

NOTE 3—The port receiving the CIST TCN Message can be a Master Port, a Designated Port attached to the same LAN as an STP Bridge, or a Designated Port attached to the same LAN as the Root Ports of Bridges in other regions.

TCN Messages for the CIST are always encoded in the same way, irrespective of whether they are perceived to have originated from topology changes internal to the region or outside it. This allows RST Bridges whose Root Ports attach to a LAN within an MST Region to receive these TCN Messages correctly.

Since each SPT is rooted at the source of the frames assigned to that SPT, or at the point where those frames enter the SPT Region, entries are only learned for the Root Port of an SPT. Any apparent changes in station location due to changes in an SPT's active topology only occur when a Bridge changes the Root Port for that SPT, and are accommodated by removing the Dynamic Filtering Entries for the prior Root Port and FID associated with the SPT Set. If the same new Root Port is chosen for all SPTs, in the SPT set, with that prior Root Port, the entries can be moved to the new Root Port rather than simply being deleted.

NOTE 4—Dynamic Filtering Entries created by ISIS-SPB as a result of that protocol's direct knowledge of the location of some stations are not removed when a TCN is received, but can be changed by ISIS-SPB as result of its calculations.

NOTE 5—Topology changes for the IST are always propagated by TCNs received and transmitted in BPDUs, and are not injected as a result of ISIS-SPB calculations as the latter complete prior to new connectivity being established.

13.20 Managing reconfiguration

The priority component of the Bridge Identifier can be managed for the CIST, and independently for each MSTI, to allow preferential selection of the first choice Root Bridge and of alternate Roots that will be used if the better choices have failed or lack connectivity. The Port Path Cost of each Bridge Port can also be managed to allow preferential selection of the path from each Bridge to the Root, with the priority component of each Bridge's Bridge Identifier providing a manageable tie-breaker between equal cost paths.

In the event of LAN or Bridge failure, fastest reconfiguration (and thus highest service availability) can usually be provided by a Bridge that can substitute a prior Alternate Port for a Root Port that now lacks or provides inferior connectivity to the Root. Figure 13-2 illustrates a simple topology where most failures can be handled in this way. Configuration to place a backup Root Bridge adjacent to the primary (Bridges 222 and 111 in the figure, respectively) enables Alternate Port to Root Port failover in the other Bridges. If the original Root Port and its replacement Alternate Port have the same Root Port Path Cost, Bridges further from the Root will not see a topology change. Figure 13-5 illustrates a ring topology, where simple failover copes with few failures. However, locating a backup Root Bridge adjacent to the preferred Root remains effective in reducing the effect of any change.

RSTP and MSTP are distance vector protocols: following the failure of a Root Bridge (or selection of a costlier path to the Root) spanning tree priority vectors conveying the prior Root can circulate in the network until that information ages out (i.e., until Message Age exceeds Max Age, or the remainingHops parameter is decremented to zero). To accommodate a wide range of networks, the default setting of these parameters permit 20 hops. However, if the preferred and alternate Roots are located at the center of the network, many networks can be configured with minimal values (6 hops, Table 13-5) so each message can only be received by any node at most twice. In larger networks, for example ring backbones with other Bridges redundantly attached to adjacent Bridges in the ring, the unwanted effects of recirculating information can be prevented by configuring the restrictedRole parameter (13.27.64). This parameter prevents information from being propagated through ports that should never provide connectivity toward the Root. In Figure 13-3, for example, restrictedRole could be configured for any or all of the Designated Ports.

Other potentially disruptive effects of reconfiguration can be prevented or mitigated by setting the restrictedTcn parameter (13.27.65) for a port.

The configuration of a subtree of a spanning tree defined by the connectivity provided by a given Bridge *B* (say) can be made independent of the rest of the tree by configuring *B*'s Root Port as a Layer 2 Gateway Port (L2GP). An L2GP Port behaves as if it is in continual receipt of a fixed, manageable, spanning tree priority vector. Provided that this fixed priority vector is worse than the actual priority vector transmitted by the Designated Port for the LAN attached to *B*'s Root Port, there is no potential for a loop. Each port in the subtree will transmit a worse priority vector. If a received message priority vector is worse than the fixed value the disputed flag is set, causing the L2GP port to transition to Discarding. Thus stability of the spanning tree priority vector information in the subtree is maintained, at the possible expense of the

connectivity between the subtree and the rest of the tree. Alternatively, if another Bridge within *B*'s subtree becomes the source of better priority information, causing *B*'s L2GP port to assume a Designated Port Role, a dispute will exist between the newly propagated spanning tree information and the fixed information for the L2GP port, and will also cause that port to become Discarding.

The L2GP capability is optional, and is primarily intended to be used for service access protection (25.9) when a single customer's Bridged Network is connected to a PBBN or a PBN. Two or more Bridge Ports on one or more of the Bridges within the customer's network, are connected to a single service instance supported by the provider's network, and are configured as L2GP ports. The L2GP ports' fixed priority vectors are each defined by a different, configured pseudoRootId (13.27.51). Only the L2GP port with the best pseudoRootId can provide connectivity to the provider's network. Spanning tree information from that port will be disseminated throughout the customer's network and will be disputed by the other L2GP port, causing the latter to become Discarding. If all the customer network's ports that are bridged to other networks (such as PBNs or PBBNs) are configured as L2GP ports, those ports neither have to transmit or receive BPDUs to prevent loops—though connectivity through providers' networks to other networks will not be protected. Enabling BPDU reception for each L2GP port prevents loops that might otherwise be caused by attaching another of the customer's network's ports to the provider network.

13.21 Partial and disputed connectivity

It is possible for the connectivity between Bridge Ports attached to the same LAN to fail, in system or media access method-dependent ways, so that BPDUs and data frames are transmitted in one direction only. As a result it is possible for more than one port attached to the same LAN to believe itself to be the Designated Port. To ensure that the active topology remains loop-free, a Designated Port will recognize that a dispute is in progress and stop learning from or forwarding frames, if it receives a BPDU with a worse message priority and the Learning flag set from another port that claims to be Designated.

If two (Designated) ports attached to the same shared media LAN cannot communicate with each other at all, but can each communicate with a third (Root) port, a potential loop exists if one of the Designated Ports has a priority vector that is worse than that of the Root Port. To ensure that such loop does not occur, a Root Port that receives an inferior message from a Designated Port detects a dispute if the Learning flag is set, and transitions to Discarding.

13.22 In-service upgrades

It can be desirable to upgrade the control plane software of a bridging system, without interrupting existing data connectivity, while the Spanning Tree Protocol Entity is not operating. This can be done, without the risk of creating data loops, providing that the other Bridges in the network are suitably configured. However, the failure of a network component (Bridge or LAN) while the upgrade is in progress can result in a loss of connectivity, as the ways in which the network can reconfigure are restricted. This subclause (13.22) describes the necessary configuration of the other Bridges in the network; the behavior of the upgrading system is assumed to be system dependent and is not specified in detail, except as follows:

a) Frames can be received from and transmitted to ports that were forwarding prior to beginning the upgrade, and are not forwarded to or from any other port.
b) Frames received on ports that were learning prior to beginning the upgrade can be submitted to the Learning Process, while frames received on other ports are not.
c) BPDUs are not transmitted, and received BPDUs are discarded, while the upgrade is in progress.
d) If there is to be no interruption in connectivity when the upgrade is complete, the parameters of BPDUs received prior to beginning the upgrade are retained, or recovered using ISIS-SPB.

NOTE 1—If received BPDU information is not retained, the spanning tree protocol variables and state machines are reinitialized by asserting BEGIN, and there will be a brief interruption in connectivity.

The need for a control plane software upgrade can result from the need to change any component of that software, and rarely from upgrades to the Spanning Tree Protocol Entity itself. The in-service upgrade procedures described here depend on the operation of specifically identified features of the RSTP, MSTP, and ISIS-SPB specified in this standard (Clause 13), and do not ensure loop-free operation if the necessary criteria are not met by all Bridges in the network. In particular, safe upgrades are not supported in networks including Bridges operating STP as specified in the IEEE Std 802.1D, 1998 Edition [B11], and earlier revisions. It is essential for the network administrator to base-line the network, i.e., verify its configuration and the configuration of its components, prior to attempting an in-service upgrade. It is recommended that a single system be upgraded at a time, and its subsequent correct operation verified prior to making further changes.

If all the LANs that connect the Bridges in the network provide point-to-point connectivity, connecting at most two Bridges, and each Bridge Port thus connecting to another Bridge meets the following conditions:

e) operPointToPointMAC (13.28.16) is TRUE and
f) operEdge (13.27.44) is FALSE,

NOTE 2—Apart from the requirement for a point-to-point physical topology, these conditions can be ensured by setting adminPointToPointMAC (IEEE Std 802.1AC) TRUE, and both AdminEdge and AutoEdge FALSE.

then a Designated Port will not transition from Discarding to Learning or Forwarding without receiving an Agreement from its immediate neighbor (see 13.37). This prevents the introduction of data loops while one or more Bridges are being upgraded, even if other Bridges or LANs fail or are added to the network. To prevent existing connectivity being disrupted (provided no other network additions or failures occur) the following are also necessary:

g) Prior to the upgrade, each of the upgrading Bridge's immediately neighboring ports that is a Root Port (for a given tree) has to be configured as an Layer 2 Gateway Port (13.20) (for that tree), with the same information that it was previously receiving from the upgrading Bridge.
h) After the upgrade, each of the ports thus temporarily configured as an Layer 2 Gateway Port needs to have its normal configuration restored.

NOTE 3—If the upgrading Bridge is capable of sending periodic 'canned BPDUs' containing the same information as immediately prior to the upgrade, there is no requirement for neighbor L2GP configuration, or for the point-to-point and operEdge conditions. Attempts by neighboring Bridges to operate outside the parameters dictated by the 'canned BPDUs' will result in disputes, preventing new connectivity.

On the SPB ports within an SPT Region, the functions of the Layer 2 Gateway Port described in item g) and item h) above are replaced by those of "Restart Signaling for IS-IS" (IETF RFC 5306 [B37]), which allows the forwarding state across an adjacency to be maintained while an IS-IS element is restarted. When the neighbor (running) shortest path Bridge receives a restart request, it performs the procedures of IETF RFC 5306, and for as long as it maintains the state of the IS-IS adjacency as "UP" it also maintains its received Agreement Digest at the last value received from the restarting Bridge before it requested restart. If the adjacency is successfully reacquired by the procedures of IETF RFC 5306, as signaled by the restarting Bridge clearing the Restart Request bit in an SPB Hello PDU, its running neighbor shall include its current Agreement Digest value in its SPB Hello response [and update it as required thereafter according to the Agreement Protocol (13.17)].

Once the restarting Bridge has achieved LSP Database Synchronization according to the procedures of IETF RFC 5306 [B37], it shall compute its local value of the Agreement Digest prior to making any changes to its FDB. On ports for which a Digest match is achieved with a neighbor, full installation of unicast and multicast state may be performed immediately. On ports that do not have a Digest match (caused for example by a propagating topology change), the restarting Bridge shall assume when computing allowed forwarding entries that Digest Agreement has never been achieved on the affected adjacency (where "allowed" is determined by the value of the Agreement Digest Convention Identifier; see 28.4.3). In either

event, a Digest Agreement shall be sent to the neighbor as soon as possible, as specified by the Agreement Protocol.

SPB ports on the boundary of an SPT Region use the procedures of a) to h) unaltered.

13.23 Fragile Bridges

Some, nonconformant, bridging systems are known to be “fragile,” i.e., they can suffer from unpredictable interruptions to Spanning Tree Protocol Entity operation and will forward data frames while no longer sending or receiving BPDUs, on some or all ports. If the spanning tree protocol implementations of the other Bridges in the network conform to prior revisions of this standard and IEEE Std 802.1D-2004 [B12], these interruptions can result data loops even in networks of point-to-point LANs. This revision of this standard allows a Bridge Port attached to point-to-point LAN to ensure that its neighbor remains capable of receiving and transmitting BPDUs, even if that neighbor’s RSTP or MSTP implementation conforms to a prior revision of this standard, and to block connectivity (by transitioning to Discarding) otherwise. The CIST Proposal flag is set in all BPDUs transmitted by a Designated Port, and used to solicit an Agreement from the neighbor (which might otherwise not transmit). This capability is controlled by the AutoIsolate (13.27.19) variable, is disabled by default to allow for in-service upgrades, and is only effective if the neighboring Bridge is capable of RSTP or MSTP operation.

13.24 Spanning tree protocol state machines

Each Spanning Tree Protocol Entity’s operation of the protocols specified in this clause (Clause 13) is specified by the following state machines:

a) Port Role Selection (PRS, 13.36)

for the CIST and for each MSTI, with the following state machines for each Bridge Port:

b) Port Timers (PTI, 13.30)
c) Port Protocol Migration (PPM, 13.32)
d) Port Receive (PRX, 13.31)
e) Port Transmit (PRT, 13.34)
f) Bridge Detection (BDM, 13.33)

and the following optional state machine for each Bridge Port:

g) Layer 2 Gateway Port Receive (L2GPRX, 13.40)

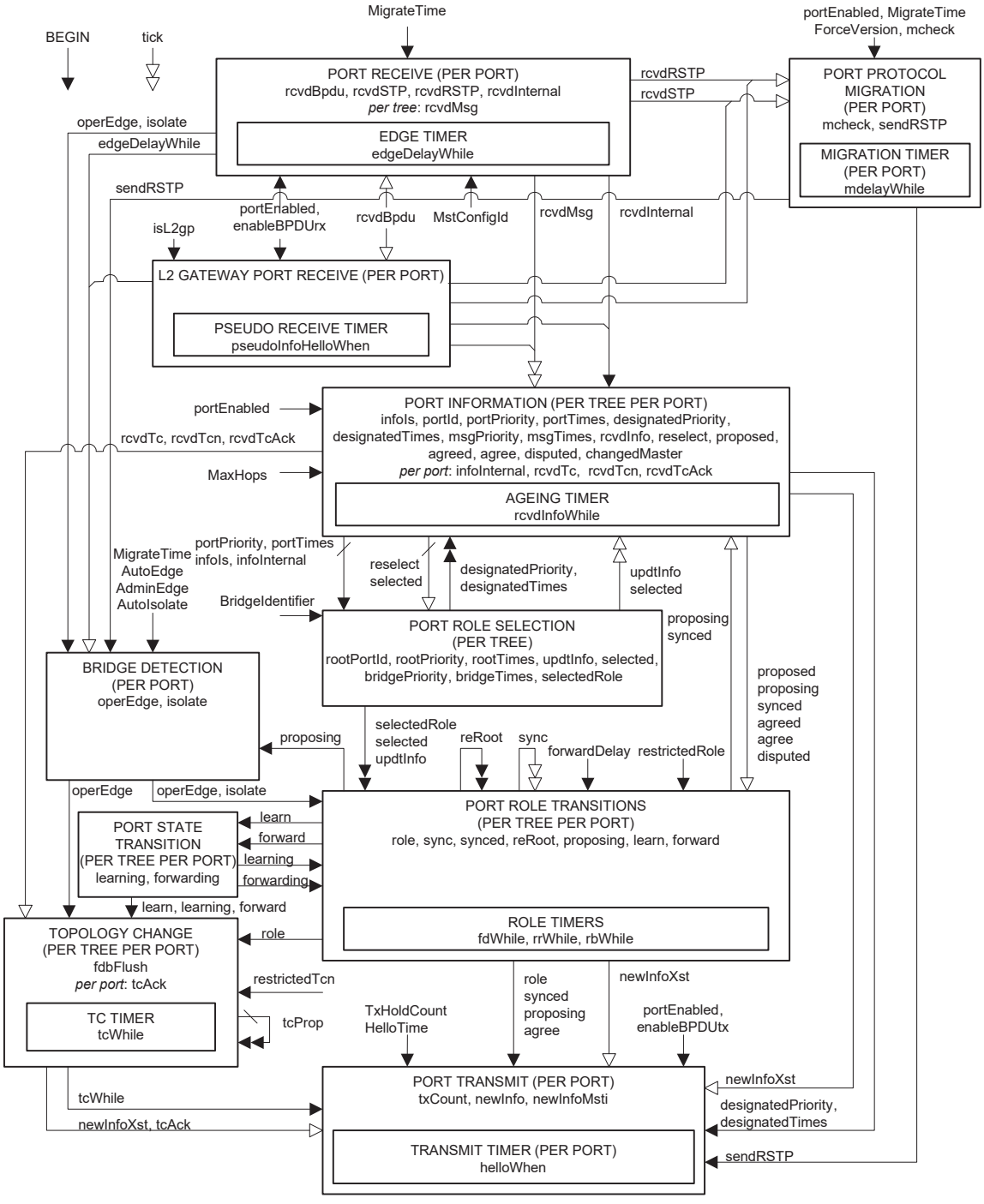
and the following state machines for each Bridge Port for the CIST and for each MSTI:

h) Port Information (PIM, 13.35)
i) Topology Change (TCM, 13.39)

and the following state machines for each Bridge Port for the CIST, for each MSTI, and for each SPT:

j) Port Role Transitions (PRT, 13.37)
k) Port State Transition (PST, 13.38)

Each state machine and its associated variable and procedural definitions are specified in detail in 13.25 through 13.40. The state machine notation is specified in Annex E. Figure 13-13 is not itself a state machine but provides an overview of the state machines, their state variables, and communication between machines. Figure 13-14 describes its notation.



NOTE: For convenience all timers are collected together into one state machine.

Figure 13-13—Spanning tree protocol state machines—overview and relationships

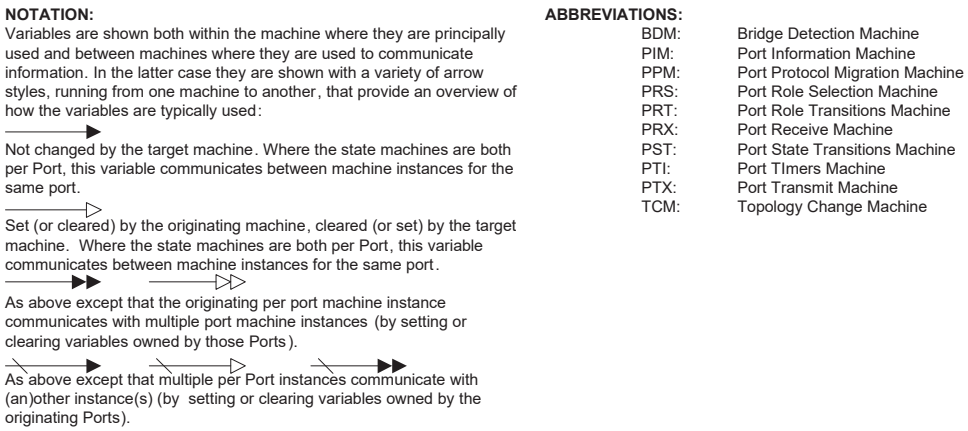


Figure 13-14—MSTP overview notation

13.25 State machine timers

The timer variables declared in this subclause are part of the specification. The accompanying descriptions are provided to aid in the comprehension of the protocol only, and are not part of the specification. Each timer variable represents an integral number of seconds before timer expiry.

One instance of the following shall be implemented per port:

a) edgeDelayWhile (13.25.1)
b) helloWhen (13.25.3)
c) mdelayWhile (13.25.4)

One instance of the following shall be implemented per port when L2GP functionality is provided:

d) pseudoInfoHelloWhen (13.25.10)

One instance per port of the following shall be implemented for the CIST and one per port for each MSTI:

e) fdWhile (13.25.2)
f) rrWhile (13.25.7)
g) rbWhile (13.25.5)
h) tcWhile (13.25.9)
i) rcvdInfoWhile (13.25.6)
j) tcDetected (13.25.8)

Table 13-5 specifies values and ranges for the initial values of timers and for transmission rate limiting performance parameters. Default values are specified to avoid the need to set values prior to operation in most cases, and are widely applicable to networks using the spanning tree protocols specified in this standard. The table recommends Bridge Hello Time, Bridge Max Age, and Bridge Forward Delay values that maximize interoperability in networks that include Bridges using STP as specified in IEEE Std 802.1D, 1998 Edition [B11]. Ranges are specified to ensure that the protocols operate correctly.

NOTE—Changes to Bridge Forward Delay do not affect reconfiguration times, unless the network includes Bridges that do not conform to this revision of this standard. Changes to Bridge Max Age can have an effect, as it is possible for old information to persist in loops in the physical topology for a number of “hops” equal to the value of Max Age in seconds, and thus exhaust the Transmit Hold Count in small loops.

Table 13-5—Timer and related parameter values

Parameter	Default	Permitted range	Interoperability recommendations
Migrate Time	3.0	—[a]	—[a]
(Bridge) Hello Time	2.0	—[a]	—[a]
Bridge Max Age	20.0	6.0–40.0	20.0
Bridge Forward Delay	15.0	4.0–30.0	15.0
Transmit Hold Count	6	1–10	6
Max Hops	20	6–40	—

All times are in seconds. —[a] Not applicable, value is fixed.

Bridge Max Age, Bridge Forward Delay, and Transmit Hold Count may be set by management, if this capability is provided the Bridge shall have the capability to use the full range of values in the parameter ranges specified in the "Permitted range" column of Table 13-5, with a timer resolution of *r* seconds, where $0 < r <= 1$. To support interoperability with previous revisions of this standard and IEEE Std 802.1D-2004 [B12], a Bridge shall enforce the following relationships:

$$2 \times (Bridge\_Forward\_Delay - 1.0\ seconds) >= Bridge\_Max\_Age$$

$$Bridge\_Max\_Age >= 2 \times (Bridge\_Hello\_Time + 1.0\ seconds)$$

13.25.1 edgeDelayWhile

The Edge Delay timer. The time remaining, in the absence of a received BPDU, before this port is identified as an operEdge Port.

13.25.2 fdWhile

The Forward Delay timer. Used to delay Port State transitions until other Bridges have received spanning tree information.

13.25.3 helloWhen

The Hello timer. Used to ensure that at least one BPDU is transmitted by a Designated Port in each HelloTime period.

13.25.4 mdelayWhile

The Migration Delay timer. Used by the Port Protocol Migration state machine to allow time for another RST Bridge on the same LAN to synchronize its migration state with this port before the receipt of a BPDU can cause this port to change the BPDU types it transmits. Initialized to MigrateTime (13.26.6).

13.25.5 rbWhile

The Recent Backup timer. Maintained at its initial value, twice HelloTime, while the port is a Backup Port.

13.25.6 rcvdInfoWhile

The Received Info timer. The time remaining before information, i.e., portPriority (13.27.47) and portTimes (13.27.48), received in a Configuration Message is aged out if a further message is not received.

13.25.7 rrWhile

The Recent Root timer.

13.25.8 tcDetected

The Topology Change timer for MRP application usage. ‘New’ messages are sent while this timer is running (see 10.2).

13.25.9 tcWhile

The Topology Change timer. TCN Messages are sent while this timer is running.

13.25.10 pseudoInfoHelloWhen

The Pseudo Info Hello When timer. Used by the Layer 2 Gateway Port Receive (L2GPRX, 13.40) state machine to prompt the simulated reception at HelloTime intervals of a BPDU (see 13.29.11).

13.26 Per Bridge variables

The variables declared in this subclause (13.26) are part of the specification. The accompanying descriptions are provided to aid in the comprehension of the protocol only, and are not part of the specification.

There is one instance per Bridge component of the following variable(s):

a) ForceProtocolVersion (13.26.5)
b) TxHoldCount (13.26.12)
c) MigrateTime (13.26.6)

One instance of the following shall be implemented per Bridge component if MSTP or ISIS-SPB is implemented:

d) MstConfigId (13.26.7)

The above parameters [item a) through item d)] are not modified by the operation of the spanning tree protocols, but are treated as constants by the state machines. If ForceProtocolVersion or MSTConfigId are modified by management, BEGIN shall be asserted for all state machines.

There is one instance per Bridge of each of the following for the CIST and one for each MSTI.

e) BridgeIdentifier (13.26.2)
f) BridgePriority (13.26.3)
g) BridgeTimes (13.26.4)
h) rootPortId (13.26.9)
i) rootPriority (13.26.10)
j) rootTimes (13.26.11)

BridgeIdentifier, BridgePriority, and BridgeTimes are not modified by the operation of the spanning tree protocols but are treated as constants by the state machines. If they are modified by management, spanning tree priority vectors and Port Role assignments for all trees shall be recomputed, as specified by the operation of the Port Role Selection state machine (13.36) by clearing selected (13.27.67) and setting reselect (13.27.62) for all Bridge Ports for the relevant MSTI and for all trees if the CIST parameter is changed.

If the ISIS-SPB is implemented there is one instance per Bridge component, of the following variable(s), with that single instance supporting all SPTs:

k) agreementDigest (13.26.1)
l) AuxMstConfigId (13.26.8)

13.26.1 agreementDigest

The Agreement Digest calculated by ISIS-SPB (28.4), and updated with other calculated parameters (see 13.36).

13.26.2 BridgeIdentifier

The unique Bridge Identifier assigned to this Bridge for this tree (CIST or MSTI).

The 12-bit system ID extension component of a Bridge Identifier (14.2.5) shall be set to zero for the CIST and to the value of the MSTID for an MSTI, thus allocating distinct Bridge Identifiers to the CIST and each MSTI—all based on the use of a single Bridge Address component value for the MST Bridge as a whole.

NOTE—This convention is used to convey the MSTID for each MSTI Configuration Message in an MST BPDU.

The most significant 4 bits of the Bridge Identifier (the settable Priority component) for the CIST and for each MSTI can be modified independently of the setting of those bits for all other trees, as a part of allowing full and independent configuration control to be exerted over each spanning tree instance.

13.26.3 BridgePriority

For the CIST, the value of the CIST Bridge priority vector, as defined in 13.10. The CIST Root Identifier, CIST Regional Root Identifier, and Designated Bridge Identifier components are all equal to the value of the CIST Bridge Identifier. The remaining components (External Root Path Cost, Internal Root Path Cost, and Designated Port Identifier) are set to zero.

For a given MSTI, the value of the MSTI Bridge priority vector, as defined in 13.11. The MSTI Regional Root Identifier and Designated Bridge Identifier components are equal to the value of the MSTI Bridge Identifier (13.26.2). The remaining components (MSTI Internal Root Path Cost, Designated Port Identifier) are set to zero.

BridgePriority is used by updtRolesTree() in determining the value of the rootPriority variable (see 13.26.10).

13.26.4 BridgeTimes

For the CIST, BridgeTimes comprises:

a) The current values of Bridge Forward Delay and Bridge Max Age (13.25, Table 13-5).
b) A Message Age value of zero.
c) The current value of Max Hops (13.25, Table 13-5). This parameter value is determined only by management.

For a given MSTI, BridgeTimes comprises:

d) The current value of MaxHops (Max Hops in Table 13-5), the initial value of remainingHops for MSTI information generated at the boundary of an MSTI region (see 13.26.11).

BridgeTimes is used by updtRolesTree() in determining the value of the rootTimes variable (13.26.11).

13.26.5 ForceProtocolVersion

The Force Protocol Version parameter for the Bridge (13.7.2).

13.26.6 MigrateTime

The value of the Migrate Time parameter as specified in Table 13-5. This value shall not be changed.

13.26.7 MstConfigId

The current value of the Bridge's MCID (13.8). Changes in this parameter cause BEGIN to be asserted for the state machines for the Bridge, for all trees, and for each port.

13.26.8 AuxMstConfigId

The previous value of the Bridge's MCID (13.8). This value is saved in nonvolatile memory when certain non-critical configuration is made if the Bridge supports the ISIS-SPB non critical changes (27.4.1).

13.26.9 rootPortId

For the CIST, the Port Identifier of the Root Port, and a component of the CIST root priority vector (13.10).

For a given MSTI, the Port Identifier of the Root Port, and a component of the MSTI root priority vector (13.11).

13.26.10 rootPriority

For the CIST: the Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Bridge's CIST root priority vector (13.10).

For a given MSTI: the MSTI Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the Bridge's MSTI root priority vector (13.11).

13.26.11 rootTimes

For the CIST, the Bridge's timer parameter values (Message Age, Max Age, Forward Delay, and remainingHops). The values of these timers are derived (see 13.29.34) from the values stored in the CIST's portTimes parameter (13.27.48) for the Root Port or from BridgeTimes (13.26.4).

For a given MSTI, the value of remainingHops derived (13.29.34) from the value stored in the MSTI's portTimes parameter (13.27.48) for the Root Port or from BridgeTimes (13.26.4).

13.26.12 TxHoldCount

The value of Transmit Hold Count (Table 13-5) for the Bridge. If this is modified, the value of txCount (13.27) for all ports shall be set to zero.

13.27 Per port variables

The variables declared in this subclause (13.27) are part of the specification. The accompanying descriptions are provided to aid in the comprehension of the protocol only, and are not part of the specification.

There is one instance per port of each of the following variables:

a) AdminEdge (13.27.1)
b) agingTime (13.27.2)
c) AutoEdge (13.27.18)
d) AutoIsolate (13.27.19)
e) enableBPDUrx (13.27.23)
f) enableBPDUtx (13.27.24)
g) ExternalPortPathCost (13.27.25)
h) isL2gp (13.27.26)
i) isolate (13.27.27)
j) mcheck (13.27.38)
k) newInfo (13.27.42)
l) operEdge (13.27.44)
m) portEnabled (13.27.45)
n) rcvdBpdu (13.27.52)
o) rcvdRSTP (13.27.56)
p) rcvdSTP (13.27.57)
q) rcvdTcAck (13.27.59)
r) rcvdTcn (13.27.60)
s) restrictedRole (13.27.64)
t) restrictedTcn (13.27.65)
u) sendRSTP (13.27.69)
v) tcAck (13.27.72)
w) tick (13.27.74)
x) txCount (13.27.75)

If MSTP or the ISIS-SPB is implemented, there is one instance per port, applicable to the CIST and to all MSTIs and SPTs, of the following variable(s):

y) rcvdInternal (13.27.54)
z) restrictedDomainRole (13.27.63)

If MSTP or the ISIS-SPB is implemented, there is one instance per port of each of the following variables for the CIST:

aa) infoInternal (13.27.31)
ab) master (13.27.36)
ac) mastered (13.27.37)

A single per port instance of the following variable(s) applies to all MSTIs:

ad) newInfoMsti (13.27.43)

If the Layer 2 Gateway Port Receive state machine (13.20, 13.40) is implemented for a port, there is one instance for the CIST, and one instance for each MSTI, for that port of the following variable:

ae) pseudoRootId (13.27.51)

If the ISIS-SPB is implemented, there is one instance per port of the following variable(s):

af) agreedMisorder (13.27.10)
ag) agreedN (13.27.11)
ah) agreedND (13.27.12)

ai) agreeN (13.27.16)
aj) agreeND (13.27.17)

If the ISIS-SPB is implemented, there is one instance per port of the following variable(s), with that single instance supporting all SPTs:

ak) agreedDigest (13.27.6)
al) agreedDigestValid (13.27.7)
am) agreeDigest (13.27.8)
an) agreeDigestValid (13.27.9)
ao) agreedTopology (13.27.14)

There is one instance per port of each of the following variables for the CIST, one per port for each MSTI and one per port for each SPT:

ap) agree (13.27.3)
aq) agreed (13.27.4)
ar) designatedPriority (13.27.20)
as) designatedTimes (13.27.21)
at) disputed (13.27.22)
au) fdbFlush (13.27.28)
av) forward (13.27.29)
aw) forwarding (13.27.30)
ax) infoIs (13.27.32)
ay) InternalPortPathCost (13.27.33)
az) learn (13.27.34)
ba) learning (13.27.35)
bb) msgPriority (13.27.39)
bc) msgTimes (13.27.40)
bd) portId (13.27.46)
be) portPriority (13.27.47)
bf) portTimes (13.27.48)
bg) proposed (13.27.49)
bh) proposing (13.27.50)
bi) rcvdInfo (13.27.53)
bj) rcvdMsg (13.27.55)
bk) rcvdTc (13.27.58)
bl) reRoot (13.27.61)
bm) reselect (13.27.62)
bn) role (13.27.66)
bo) selected (13.27.67)
bp) selectedRole (13.27.68)
bq) sync (13.27.70)
br) synced (13.27.71)
bs) tcProp (13.27.73)
bt) updtInfo (13.27.76)

If the ISIS-SPB is implemented, there is one instance per port of the following variable(s) for the CIST and one per port for each SPT:

bu) agreedPriority (13.27.13)
bv) agreementOutstanding (13.27.15)

If the ISIS-SPB is implemented, there is one instance per port of the following variables for each SPT:

bw) agreedAbove (13.27.5)
bx) neighbourPriority (13.27.41)

13.27.1 AdminEdge

A Boolean. Set by management if the port is to be identified as operEdge immediately on initialization, without a delay to detect other Bridges attached to the LAN. The recommended default value is FALSE.

13.27.2 ageingTime

FDB entries for this port are aged out after ageingTime has elapsed since they were first created or refreshed by the Learning Process. The value of this parameter is normally Ageing Time (8.8.3, Table 8-9), and is changed to FwdDelay (13.28.10) for a period of FwdDelay after fdbFlush (13.27.28) is set by the topology change state machine if stpVersion (13.28.23) is TRUE.

13.27.3 agree

A Boolean. See 13.16 and Figure 13-12.

13.27.4 agreed

A Boolean. Set, for the CIST or an MSTI, if an Agreement has been received indicating that the Port States and transmitted priority vectors for the other Bridge attached to this LAN are (and, in the absence of further communication with this Bridge and within the design probabilities of protocol failure due to repeated BPDU loss, will remain) compatible with a loop-free active topology determined by this port's priority vectors (13.16, 13.24).

13.27.5 agreedAbove

A Boolean controlled by the updtAgreement() procedure to indicate agreement on the neighbor(s) superior priority vector.

13.27.6 agreedDigest

The Agreement Digest conveyed in the last BPDU received, if the port is internal to an SPT Region.

13.27.7 agreedDigestValid

A Boolean. TRUE if the Agreement Valid flag was set in the last BPDU or SPB Hello PDU that conveyed an Agreement Digest.

13.27.8 agreeDigest

The Agreement Digest currently encoded in SPT BPDUs transmitted from the port.

13.27.9 agreeDigestValid

A Boolean. TRUE if the Agreement Valid flag is to be set in transmitted SPT BPDUs and SPB Hello PDUs.

13.27.10 agreedMisorder

A Boolean. TRUE if the Agreement Protocol (13.16, 13.17) has received an out of order message as indicated by the received Agreement Number (13.27.16), reset when an in order message is received.

13.27.11 agreedN

The Agreement Number associated with the last BPDU received, if the port is within an SPT Region. It takes values 0, 1, 2, or 3, and all arithmetic using this variable is modulo 4, e.g., 1 + 1 = 2, 3 + 1 = 0, 0 – 1 = 3.

13.27.12 agreedND

The Discarded Agreement Number (see 13.17) to be included in SPT BPDUs transmitted from the port. The variable values 0, 1, 2, or 3, are encoded in a two-bit field and all arithmetic using this variable is modulo 4.

13.27.13 agreedPriority

The priority vector associated with the worst priority received by a CIST or SPT Designated Port from an SPT Region in SPT BPDUs that are sent by Root Ports, zero if there is no such agreement.

13.27.14 agreedTopology

A Boolean. TRUE if the Agreement Protocol has declared a topology match for agreeDigest (13.27.8), and agreeDigest has the same value as the last calculated agreementDigest (13.26.1). Reset to FALSE whenever agreementDigest is recalculated by ISIS-SPB, and set TRUE by updtDigest().

13.27.15 agreementOutstanding

The priority vector for the worst priority associated with outstanding Agreements made by a CIST or SPT Root Port, Alternate Port, or Backup Port within an SPT Region. in SPT BPDUs. When an SPT BPDU, from the same SPT Region, is received with a Discarded Agreement Number that is the immediate precursor of the current agreeN (13.27.16), the CIST's agreementOutstanding is set to the port's designatedPriority. On reception of a BPDU that is either not an SPT BPDU or is from a different SPT Region, the agreeND (13.27.17) is set to the value of the agreeN (13.27.16), so there is no outstanding Agreement.

13.27.16 agreeN

The Agreement Number (see 13.17) transmitted in SPT BPDUs. The variable values 0, 1, 2, or 3, are encoded in a two-bit field and arithmetic using this variable is modulo 4.

13.27.17 agreeND

The last Discarded Agreement Number (see 13.17) received in an SPT BPDU. It takes values 0, 1, 2, or 3, and arithmetic using this variable is modulo 4. If agreeND matches agreeN, there is no outstanding agreement.

13.27.18 AutoEdge

A Boolean. Set by management if the Bridge detection state machine (BDM, 13.33) is to detect other Bridges attached to the LAN, and set operEdge automatically. The recommended default is TRUE.

13.27.19 AutoIsolate

A Boolean. Set by management if isolate (13.27.27) is to be set, causing a Designated Port to transition to Discarding if both AdminEdge (13.27.1) and AutoEdge (13.27.18) are FALSE and the other Bridge presumed to be attached to the same point-to-point LAN does not transmit periodic BPDUs—either as a Designated Port or in response to BPDUs with the Proposal flag set (see 13.23). The recommended default of this parameter is FALSE. AdminEdge and AutoEdge are both reset only on ports that are known to connect to other Bridges.

13.27.20 designatedPriority

For the CIST and a given port, the CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the port's CIST designated priority vector, as defined in 13.10.

For a given MSTI and port, the Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the designated priority vector, as defined in 13.11.

13.27.21 designatedTimes

For the CIST and a given port, the set of timer parameter values (Message Age, Max Age, Forward Delay, and remainingHops) that are used to update Port Times when updtInfo is set. These timer parameter values are used in BPDUs transmitted from the port. The value of designatedTimes is copied from the CIST rootTimes Parameter (13.26.11) by the operation of the updtRolesTree() procedure.

For a given MSTI and port, the value of remainingHops used to update this MSTI's portTimes parameter when updtInfo is set. This timer parameter value is used in BPDUs transmitted from the port. The updtRolesTree() procedure (13.29.34) copies designatedTimes from the MSTI's rootTimes (13.26.11).

13.27.22 disputed

A Boolean. See 13.21, 13.20, Figure 13-20, 13.29.16, Figure 13-24, and Figure 13-25.

13.27.23 enableBPDUrx

A Boolean. This per port management parameter is set by default, and should not be clear unless the port is configured as a Layer Two Gateway Port (i.e., isL2gp is set). When clear it can allow loops to be created, or can result in no connectivity. When cleared, BPDUs received on the port are discarded and not processed.

13.27.24 enableBPDUtx

A Boolean. This per port management parameter is set by default, and should not be clear unless the port is configured as a Layer Two Gateway Port (i.e., isL2gp is set). When clear it can allow loops to be created, or can result in no connectivity. When cleared, no BPDUs are transmitted by this port.

13.27.25 ExternalPortPathCost

The port's contribution, when it is the CIST Master Port (for MSTP and ISIS-SPB) or the CST Root Port (for RSTP and MSTP), to the External Root Path Cost (13.9) for the Bridge.

13.27.26 isL2gp

A Boolean. Set by management to identify a port configured to be a Layer Two Gateway Port. This parameter is set to FALSE by default. When set, enableBPDUtx should be cleared.

13.27.27 isolate

A Boolean. Set by the Bridge detection state machine (BDM, 13.33) when the Spanning Tree Protocol Entity of a neighboring Bridge has apparently failed (see 13.23, 13.27.19).

13.27.28 fdbFlush

A Boolean. Set by the topology change state machine to instruct the FDB to remove entries for this port, immediately if rstpVersion (13.28.21) is TRUE, or by rapid ageing (13.27.2) if stpVersion (13.28.23) is TRUE. Reset by the FDB once the entries are removed if rstpVersion is TRUE, and immediately if stpVersion is TRUE. Setting the fdbFlush variable does not result in removal of FDB entries in the case that the port is an Edge Port (i.e., operEdge is TRUE). The FDB removes entries only for those VIDs that have a fixed registration (see 10.7.2) on any port of the Bridge that is not an Edge Port.

NOTE—If MVRP or MIRP is in use, the topology change notification and flushing mechanisms defined in MRP (Clause 10) and MVRP (11.2.5) are responsible for filtering entries in the FDB for VIDs that are dynamically registered using MVRP or MIRP (i.e., for which there is no fixed registration in the Bridge on non-Edge Ports).

13.27.29 forward

A Boolean. Set or cleared by the Port Role Transitions state machine (13.37) to instruct the Port State Transitions state machine (13.38) to enable or disable forwarding.

13.27.30 forwarding

A Boolean. Set or cleared by the Port State Transitions state machine (13.38) to indicate that forwarding has been enabled or disabled.

13.27.31 infoInternal

If infoIs is Received, indicating that the port has received current information from the Designated Bridge for the attached LAN, infoInternal is set if that Designated Bridge is in the same MST Region as the receiving Bridge and reset otherwise.

13.27.32 infoIs

A variable that takes the values Mine, Aged, Received, or Disabled, to indicate the origin/state of the port's Spanning Tree information (portInfo) held for the port, as follows:

a) If infoIs is Received, the port has received current (not aged out) information from the Designated Bridge for the attached LAN (a point-to-point Bridge link being a special case of a LAN).
b) If infoIs is Mine, information for the port has been derived from the Root Port for the Bridge (with the addition of root port cost information). This includes the possibility that the Root Port is "Port 0," i.e., the Bridge is the Root Bridge for the Bridged Network.
c) If infoIs is Aged, information from the Root Bridge has been aged out. Just as for reselect (13.27.62), the state machine does not formally allow the Aged state to persist. However, if there is a delay in recomputing the new root port, correct processing of a received BPDU is specified.
d) Finally if the port is disabled, infoIs is Disabled.

13.27.33 InternalPortPathCost

The port's contribution, when it is an IST or SPT Root Port (for MSTP and ISIS-SPB) to the Internal Root Path Cost (13.9) for the Bridge.

13.27.34 learn

A Boolean. Set or cleared by the Port Role Transitions state machine (13.37) to instruct the Port State Transitions state machine (13.38) to enable or disable learning.

13.27.35 learning

A Boolean. Set or cleared by the Port State Transitions state machine (13.38) to indicate that learning has been enabled or disabled.

13.27.36 master

A Boolean. Used to determine the value of the Master flag for a given MSTI and port in transmitted MST BPDUs.

Set TRUE if the Port Role for the MSTI and Port is Root Port or Designated Port, and the Bridge has selected one of its ports as the Master Port for this MSTI or the mastered flag is set for this MSTI for any other Bridge Port with a Root Port or Designated Port Role. Set FALSE otherwise.

13.27.37 mastered

A Boolean. Used to record the value of the Master flag for a given MSTI and port in MST BPDUs received from the attached LAN.

NOTE—master and mastered signal the connection of the MSTI to the CST via the Master Port throughout the MSTI. These variables and their supporting procedures do not affect the connectivity provided by this standard but permit future enhancements to MSTP providing increased flexibility in the choice of Master Port without abandoning plug-and-play network migration. They are therefore omitted from the overviews of protocol operation, including Figure 13-13.

13.27.38 mcheck

A Boolean. May be set by management to force the Port Protocol Migration state machine to transmit RST (or MST or SPT) BPDUs for a MigrateTime (13.26.6, Table 13-5) period, to test whether all STP Bridges on the attached LAN have been removed and the port can continue to transmit RST BPDUs. Setting mcheck has no effect if stpVersion (13.28.23) is TRUE.

13.27.39 msgPriority

For the CIST and a given port, the CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the CIST message priority vector conveyed in a received BPDU, as defined in 13.10.

For a given MSTI and port, the Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the MSTI message priority vector, as defined in 13.11 and conveyed in a received BPDU for this MSTI.

13.27.40 msgTimes

For the CIST and a given port, the timer parameter values (Message Age, Max Age, Forward Delay, Hello Time, and remainingHops) conveyed in a received BPDU. If the BPDU is an STP or RST BPDU without MSTP parameters, remainingHops is set to the value of the MaxHops component of BridgeTimes (13.26.4).

For a given MSTI and port, the value of remainingHops received in the same BPDU as the message priority components of this MSTI's msgPriority parameter.

13.27.41 neighbourPriority

For a port attached to a point-to-point LAN within the same SPT Region, the designated priority of the other Bridge attached to that LAN as calculated by ISIS-SPB for a given SPT. Receipt of an Agreement Digest matching the Bridge component's agreementDigest implies receipt of an Agreement, with agreedPriority == neighbourPriority, for each SPT for which the port's selectedRole is DesignatedPort.

If the port is attached to a shared media LAN that is within the same SPT Region, i.e., all Bridges attached to that LAN are within the Region, then neighbourPriority is the best (13.9) of all the neighbor's calculated designated priority vectors, and an SPT BPDU with a matching digest has to be received from all the neighbors before agreedPriority is updated.

13.27.42 newInfo

A Boolean. Set TRUE if a BPDU conveying changed CIST information is to be transmitted. It is set FALSE by the Port Transmit state machine.

13.27.43 newInfoMsti

A Boolean. Set TRUE if a BPDU conveying changed MSTI information is to be transmitted. It is set FALSE by the Port Transmit state machine.

13.27.44 operEdge

A Boolean. The value of the operEdgePort parameter [item l) in 12.18.2.1.3], as determined by the operation of the Bridge Detection state machine (13.33).

13.27.45 portEnabled

A Boolean. Set if the Bridge's MAC Relay Entity and Spanning Tree Protocol Entity can use the MAC Service provided by the Bridge Port's MAC entity to transmit and receive frames to and from the attached LAN, i.e., portEnabled is TRUE if and only if:

a) MAC_Operational (IEEE Std 802.1AC) is TRUE; and
b) Administrative Bridge Port State (8.4, 13.12) for the port is Enabled.

13.27.46 portId

The Port Identifier for this port. This variable forms a component of the port priority and designated priority vectors (13.10, 13.11).

The most significant 4 bits of the Port Identifier (the settable Priority component) for the CIST and for each MSTI can be modified independently of the setting of those bits for all other trees, as a part of allowing full and independent configuration control to be exerted over each spanning tree instance.

13.27.47 portPriority

For the CIST and a given port, the CIST Root Identifier, External Root Path Cost, Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the port's port priority vector (13.10).

For a given MSTI and port, the Regional Root Identifier, Internal Root Path Cost, Designated Bridge Identifier, and Designated Port Identifier components of the port's MSTI port priority vector (13.11).

13.27.48 portTimes

For the CIST and a given port, the port's timer parameter values (Message Age, Max Age, Forward Delay, Hello Time, and remainingHops). The Hello Time timer parameter value is used in transmitted BPDUs.

For a given MSTI and port, the value of remainingHops for this MSTI in transmitted BPDUs.

13.27.49 proposed

A Boolean. See 13.16, Figure 13-10, Figure 13-12, 13.29.14, 13.29.19, 13.37, and Figure 13-24.

13.27.50 proposing

A Boolean. See 13.16, Figure 13-10, Figure 13-12, 13.29.14, 13.29.15, 13.33, and Figure 13-25.

13.27.51 pseudoRootId

A Bridge Identifier configured by management for L2GP operation. By default, it is set to the BridgeIdentifier (13.26.2).

13.27.52 rcvdBPDU

A Boolean. Set by system-dependent processes, this variable notifies the Port Receive state machine (13.31) when a valid (Clause 14) Configuration, TCN, RST, MST, or SPT BPDU (14.3) is received on the port. Reset by the Port Receive state machine.

13.27.53 rcvdInfo

Set to the result of the rcvInfo() procedure (13.29.12).

13.27.54 rcvdInternal

A Boolean. Set TRUE by the Receive Machine if the BPDU received was transmitted by a Bridge in the same MST Region as the receiving Bridge.

13.27.55 rcvdMsg

A Boolean. See 13.29.13 and 13.31.

13.27.56 rcvdRSTP

A Boolean. See 13.31, 13.29.31, and 13.32.

13.27.57 rcvdSTP

A Boolean. See 13.31, 13.29.31, and 13.32.

13.27.58 rcvdTc

A Boolean. See 13.29.13, 13.29.24, and 13.39.

13.27.59 rcvdTcAck

A Boolean. See 13.29.24 and 13.39.

13.27.60 rcvdTcn

A Boolean. See 13.29.13, 13.29.24, and 13.39.

13.27.61 reRoot

A Boolean. Set by a newly selected Root Port to force prior Root Ports to Discarding, before it becomes forwarding. See Figure 13-24, 13.29.21, Figure 13-23, Figure 13-25, and Figure 13-26.

13.27.62 reselect

A Boolean. Set to prompt recomputation of the CIST or an MSTI. See 13.35 and 13.36.

13.27.63 restrictedDomainRole

A Boolean. Set by management. If TRUE, causes a port that is a Boundary Port of an SPT Region not to be selected as Root Port for the CIST, any MSTI, or any SPT, even it has the best spanning tree priority vector. See 13.20, 27.7, and restrictedRole (13.27.64).

13.27.64 restrictedRole

A Boolean. Set by management. If TRUE causes the port not to be selected as Root Port for the CIST or any MSTI, even it has the best spanning tree priority vector. Such a port will be selected as an Alternate Port after the Root Port has been selected. This parameter should be FALSE by default. If set, it can cause lack of spanning tree connectivity. It is set by a network administrator to prevent Bridges external to a core region of the network influencing the spanning tree active topology, possibly because those Bridges are not under the full control of the administrator.

13.27.65 restrictedTcn

A Boolean. Set by management. If TRUE causes the port not to propagate received topology change notifications and topology changes to other ports. This parameter should be FALSE by default. If set it can cause temporary loss of connectivity after changes in a spanning trees active topology as a result of persistent incorrectly learned station location information. It is set by a network administrator to prevent Bridges external to a core region of the network, causing address flushing in that region, possibly because those Bridges are not under the full control of the administrator or MAC_Operational for the attached LANs transitions frequently.

13.27.66 role

The current Port Role. DisabledPort, RootPort, DesignatedPort, AlternatePort, BackupPort, or MasterPort.

NOTE—The MasterPort role applies to each MSTI when the CIST Port Role is RootPort and connects to another MST Region. An MSTI Master Port is part of the stable active topology for frames assigned to that MSTI, just as the CIST Root Port forwards frames for the IST. The Port State for each MSTI may differ as required to suppress temporary loops.

13.27.67 selected

A Boolean. See 13.36 and 13.29.22.

13.27.68 selectedRole

A newly computed role for the port.

13.27.69 sendRSTP

A Boolean. See 13.32 and 13.34.

13.27.70 sync

A Boolean. Set to force the Port State to be compatible with the loop-free active topology determined by the priority vectors held by this Bridge (13.16, 13.24) for this tree (CIST or MSTI), transitioning the Port State to Discarding, and soliciting an Agreement if possible, if the port is not already synchronized (13.27.71).

13.27.71 synced

A Boolean. TRUE only if the Port State is compatible with the loop-free active topology determined by the priority vectors held by this Bridge for this tree (13.16, 13.24).

13.27.72 tcAck

A Boolean. Set to transmit a Configuration Message with a topology change acknowledge flag set.

13.27.73 tcProp

A Boolean. Set by the Topology Change state machine of any other port, to indicate that a topology change should be propagated through this port.

13.27.74 tick

A Boolean. See the Port Timers state machine (13.30).

13.27.75 txCount

A counter. Incremented by the Port Transmission (13.34) state machine on every BPDU transmission, and decremented used by the Port Timers state machine (13.30) once a second. Transmissions are delayed if txCount reaches TxHoldCount (13.26.12).

13.27.76 updtInfo

A Boolean. Set by the Port Role Selection state machine (13.36, 13.29.34) to tell the Port Information state machine that it should copy designatedPriority to portPriority and designatedTimes to portTimes.

13.28 State machine conditions and parameters

The following variable evaluations are defined for notational convenience in the state machines:

a) allSptAgree (13.28.1)
b) allSynced (13.28.2)
c) allTransmitReady (13.28.3)
d) BestAgreementPriority (13.28.4)
e) cist (13.28.5)
f) cistRootPort (13.28.6)
g) cistDesignatedPort (13.28.7)
h) EdgeDelay (13.28.8)
i) forwardDelay (13.28.9)
j) FwdDelay (13.28.10)

k) HelloTime (13.28.11)
l) MaxAge (13.28.12)
m) msti (13.28.13)
n) mstiDesignatedOrTCpropagatingRootPort (13.28.14)
o) mstiMasterPort (13.28.15)
p) operPointToPointMAC (13.28.16)
q) rcvdAnyMsg (13.28.17)
r) rcvdCistMsg (13.28.18)
s) rcvdMstiMsg (13.28.19)
t) reRooted (13.28.20)
u) rstpVersion (13.28.21)
v) spt (13.28.22)
w) stpVersion (13.28.23)
x) updtCistInfo (13.28.24)
y) updtMstiInfo (13.28.25)

13.28.1 allSptAgree

TRUE, if and only if, agree is TRUE for the given port for all SPTs.

13.28.2 allSynced

The condition allSynced is TRUE for a given port, for a given tree, if and only if:

a) For all ports for the given tree, selected is TRUE, the port's role is the same as its selectedRole, and updtInfo is FALSE; and
b) The role of the given port is:
    1) Root Port or Alternate Port and synced is TRUE for all ports for the given tree other than the Root Port; or
    2) Designated Port and synced is TRUE for all ports for the given tree other than the given port; or
    3) Designated Port, and the tree is an SPT or the IST, and the Root Port of the tree and the given port are both within the Bridge's SPT Region, and both learning and forwarding are FALSE for the given port; or
    4) Master Port and synced is TRUE for all ports for the given tree other than the given port.

13.28.3 allTransmitReady

TRUE, if and only if, for the given port for all trees:

a) selected is TRUE; and
b) updtInfo is FALSE.

13.28.4 BestAgreementPriority

The best of all possible priority vectors, i.e., numerically the lowest.

13.28.5 cist

TRUE only for CIST state machines; i.e., FALSE for MSTI or SPT state machine instances.

13.28.6 cistRootPort

TRUE if the CIST role for the given port is RootPort.

13.28.7 cistDesignatedPort

TRUE if the CIST role for the given port is DesignatedPort.

13.28.8 EdgeDelay

Returns the value of MigrateTime if operPointToPointMAC is TRUE, and the value of MaxAge otherwise.

13.28.9 forwardDelay

Returns the value of HelloTime if sendRSTP is TRUE, and the value of FwdDelay otherwise.

13.28.10 FwdDelay

The Forward Delay component of the CIST's designatedTimes parameter (13.27.21).

13.28.11 HelloTime

The Hello Time component of the CIST's portTimes parameter (13.27.48) with the recommended default value given in Table 13-5.

13.28.12 MaxAge

The Max Age component of the CIST's designatedTimes parameter (13.27.21).

13.28.13 msti

TRUE only for MSTI state machines; i.e., FALSE for CIST or SPT state machine instances.

13.28.14 mstiDesignatedOrTCpropagatingRootPort

TRUE if the role for any MSTI for the given port is either:

a) DesignatedPort or
b) RootPort, and the instance for the given MSTI and port of the tcWhile timer is not zero.

13.28.15 mstiMasterPort

TRUE if the role for any MSTI for the given port is MasterPort.

13.28.16 operPointToPoint

TRUE if operPointToPointMAC (IEEE Std 802.1AC) is TRUE for the Bridge Port.

13.28.17 rcvdAnyMsg

TRUE for a given port if rcvdMsg is TRUE for the CIST or any MSTI for that port.

13.28.18 rcvdCistMsg

TRUE for a given port if and only if rcvdMsg is TRUE for the CIST for that port.

13.28.19 rcvdMstiMsg

TRUE for a given port and MSTI if and only if rcvdMsg is FALSE for the CIST for that port and rcvdMsg is TRUE for the MSTI for that port.

13.28.20 reRooted

TRUE if the rrWhile timer is clear (zero) for all Ports for the given tree other than the given Port.

13.28.21 rstpVersion

TRUE if ForceProtocolVersion (13.7.2) is greater than or equal to 2.

13.28.22 spt

TRUE only for SPT state machines, in an SPT Bridge; i.e., FALSE for CIST and MSTI state machine instances.

13.28.23 stpVersion

TRUE if Force Protocol Version (13.7.2) is less than 2.

13.28.24 updtCistInfo

TRUE for a given port if and only if updtInfo is TRUE for the CIST for that port.

13.28.25 updtMstiInfo

TRUE for a given port and MSTI if and only if updtInfo is TRUE for the MSTI for that port or updtInfo is TRUE for the CIST for that port.

NOTE—The dependency of rcvdMstiMsg and updtMstiInfo on CIST variables for the port reflects the fact that MSTIs exist in a context of CST parameters. The state machines ensure that the CIST parameters from received BPDUs are processed and updated prior to processing MSTI information.

13.29 State machine procedures

The following procedures perform the functions specified for both the state machines for all trees, or specifically for the CIST, a given MSTI, or a given SPT:

a) betterorsameInfo(newInfoIs) (13.29.1)
b) clearAllRcvdMsgs() (13.29.2)
c) clearReselectTree() (13.29.3)
d) disableForwarding() (13.29.4)
e) disableLearning() (13.29.5)
f) enableForwarding() (13.29.6)
g) enableLearning() (13.29.7)
h) fromSameRegion() (13.29.8)
i) newTcDetected() (13.29.9)
j) newTcWhile() (13.29.10)
k) pseudoRcvMsgs() (13.29.11)
l) rcvInfo() (13.29.12)
m) rcvMsgs() (13.29.13)
n) recordAgreement() (13.29.15)

o) recordDispute() (13.29.16)
p) recordMastered() (13.29.17)
q) recordPriority() (13.29.18)
r) recordProposal() (13.29.19)
s) recordTimes() (13.29.20)
t) setReRootTree() (13.29.21)
u) setSelectedTree() (13.29.22)
v) setSyncTree() (13.29.23)
w) setTcFlags() (13.29.24)
x) setTcPropTree() (13.29.25)
y) syncMaster() (13.29.26)
z) txConfig() (13.29.27)
aa) txRstp() (13.29.28)
ab) txTcn() (13.29.29)
ac) updtBPDUVersion() (13.29.31)
ad) updtRcvdInfoWhile() (13.29.33)
ae) updtRolesTree() (13.29.34)
af) updtRolesDisabledTree() (13.29.35)

The following procedures perform the functions specified for all SPTs, or for a given SPT or the CIST when ISIS-SPB is implemented:

ag) rcvAgreements() (13.29.14)
ah) updtAgreement() (13.29.30)
ai) updtDigest() (13.29.32)

All references to named variables in the specification of procedures are to instances of the variables corresponding to the instance of the state machine using the function, i.e., to the CIST or the given MSTI or the given SPT as appropriate. References to forwarding and learning apply to frames assigned to the specified tree.

13.29.1 betterorsameInfo(newInfoIs)

Returns TRUE if, for a given port and tree (CIST or MSTI), either:

a) The procedure's parameter newInfoIs is Received, and infoIs is Received and the msgPriority vector is better than or the same as (13.10) the portPriority vector; or
b) The procedure's parameter newInfoIs is Mine, and infoIs is Mine and the designatedPriority vector is better than or the same as (13.10) the portPriority vector.

Returns False otherwise.

NOTE—This procedure is not invoked (in the case of a MSTI) if the received BPDU carrying the MSTI information was received from another MST Region. In that event, the Port Receive Machine (using rcvMsgs()) does not set rcvdMsg for any MSTI, and the Port Information Machine's SUPERIOR_DESIGNATED state is not entered.

13.29.2 clearAllRcvdMsgs()

Clears rcvdMsg for the CIST and all MSTIs, for this port.

13.29.3 clearReselectTree()

Clears reselect for the tree (the CIST or a given MSTI) for all ports of the Bridge.

13.29.4 disableForwarding()

An implementation-dependent procedure that causes the Forwarding Process (8.6) to stop forwarding frames through the port. The procedure does not complete until forwarding has stopped.

13.29.5 disableLearning()

An implementation-dependent procedure that causes the Learning Process (8.7) to stop learning from the source address of frames received on the port. The procedure does not complete until learning has stopped.

13.29.6 enableForwarding()

An implementation-dependent procedure that causes the Forwarding Process (8.6) to start forwarding frames through the port. The procedure does not complete until forwarding has been enabled.

13.29.7 enableLearning()

An implementation-dependent procedure that causes the Learning Process (8.7) to start learning from frames received on the port. The procedure does not complete until learning has been enabled.

13.29.8 fromSameRegion()

Returns TRUE if rcvdRSTP is TRUE, and the received BPDU conveys a MCID that matches that held for the Bridge. Returns FALSE otherwise. If SPB protocols are implemented, fromSameRegion() returns TRUE if the Bridge detects that either its MCID (13.26.7) or its Auxiliary MCID (13.26.8) match either the MCID or Auxiliary MCID carried by the received SPT BPDU.

13.29.9 newTcDetected()

If the value of tcDetected is zero and sendRSTP is TRUE, this procedure sets the value of tcDetected to HelloTime plus one second. The value of HelloTime is taken from the CIST's portTimes parameter (13.27.48) for this port.

If the value of tcDetected is zero and sendRSTP is FALSE, this procedure sets the value of tcDetected to the sum of the Max Age and Forward Delay components of rootTimes.

Otherwise, the procedure takes no action.

13.29.10 newTcWhile()

If the value of tcWhile is zero and sendRSTP is TRUE, this procedure sets the value of tcWhile to HelloTime plus one second and sets either newInfo TRUE for the CIST or newInfoMsti TRUE for a given MSTI. The value of HelloTime is taken from the CIST's portTimes parameter (13.27.48) for this port.

If the value of tcWhile is zero and sendRSTP is FALSE, this procedure sets the value of tcWhile to the sum of the Max Age and Forward Delay components of rootTimes and does not change the value of either newInfo or newInfoMsti.

Otherwise, the procedure takes no action.

13.29.11 pseudoRcvMsgs()

Using local parameters, this procedure simulates the processing that would be applied by rcvInfo() and rcvMsgs() to a BPDU received on the port, from the same region and with the following parameters:

a) Message Age, Max Age, Hello Time, and Forward Delay are derived from BridgeTimes (13.26.4).
b) The CIST information carries the message priority vector (13.10) with a value of {pseudoRootId, 0, pseudoRootId, 0, 0, 0}.
c) A CIST Port Role of Designated Port, with the Learning and Forwarding flags set.
d) The Version 1 Length is 0 and Version 3 Length calculated appropriately.
e) For each MSTI configured on the Bridge, the corresponding MSTI Configuration Message carries the following:
    1) A message priority vector with a value of {pseudoRootId, 0, 0, 0}
    2) A Port Role of Designated Port, with the Learning and Forwarding flags set
    3) MSTI Remaining Hops set to the value of the MaxHops component of BridgeTimes (13.26.4)

NOTE—If two L2GP ports are configured with the same CIST pseudoRootId then the IST may partition within the MST Region, but either of the L2GP ports can be selected to provide connectivity from the Region/customer network to a provider's network on an MSTI by MSTI basis.

13.29.12 rcvInfo()

Returns SuperiorDesignatedInfo if, for a given port and tree (CIST or MSTI),

a) The received CIST or MSTI message conveys a Designated Port Role and
    1) The message priority (msgPriority—13.27.39) is superior (13.10 or 13.11) to the port's port priority vector; or
    2) The message priority is the same as the port's port priority vector, and any of the received timer parameter values (msgTimes—13.27.40) differ from those already held for the port (portTimes—13.27.48).

Otherwise, returns RepeatedDesignatedInfo if, for a given port and tree (CIST or MSTI),

b) The received CIST or MSTI message conveys a Designated Port Role and
    1) A message priority vector and timer parameters that are the same as the port's port priority vector and timer values and
    2) infoIs is Received.

Otherwise, returns InferiorDesignatedInfo if, for a given port and tree (CIST or MSTI),

c) The received CIST or MSTI message conveys a Designated Port Role.

Otherwise, returns InferiorRootAlternateInfo if, for a given port and tree (CIST or MSTI),

d) The received CIST or MSTI message conveys a Root Port, Alternate Port, or Backup Port Role and a CIST or MSTI message priority that is the same as or worse than the CIST or MSTI port priority vector.

Otherwise, returns OtherInfo.

NOTE—A Configuration BPDU implicitly conveys a Designated Port Role.

13.29.13 rcvMsgs()

This procedure is invoked by the Port Receive state machine (13.31) to decode a received BPDU. Sets rcvdTcn and rcvdTc for each and every MSTI if a TCN BPDU has been received, and extracts the message priority and timer values from the received BPDU storing them in the msgPriority and msgTimes variables.

If ISIS-SPB is implemented, ForceProtocolVersion is 4 (or greater), the BPDU is an SPT BPDU, and has been received on a Bridge Port that is internal to the SPT Region (i.e., is not a Boundary Port, see 13.12), then the rcvAgreements() procedure processes the CIST and SPT information conveyed by the BPDU.

Otherwise (i.e., if rcvAgreements() is not used), this procedure sets rcvdMsg for the CIST and makes the received CST or CIST message available to the CIST Port Information state machines.

If and only if rcvdInternal is set, this procedure sets rcvdMsg for each and every MSTI for which a MSTI message is conveyed in the BPDU, and makes available each MSTI message and the common parts of the CIST message priority (the CIST Root Identifier, External Root Path Cost, and Regional Root Identifier) to the Port Information state machine for that MSTI.

13.29.14 rcvAgreements()

This procedure is used to process agreements received in SPT BPDUs and in SPB Hello PDUs. The same variables are used in both cases. In the case of SPT BPDUs, this procedure is invoked by the rcvMsgs() procedure that decodes received BPDUs.

If the received Agreement Number is equal to the value of agreedN plus three, agreedMisorder is set TRUE.

The variables agreedN and agreeND are set to the values of the received Agreement Number and Discard Agreement Number, respectively. The variables agreedDigest and agreedDigestValid are updated with the values of the received Agreement Digest and Agreement Digest flag, respectively.

The CIST proposed flag is set to the value of the Proposal flag for the CIST in the received BPDU.

The updtDigest() procedure is invoked. The updtAgreement() procedure is invoked for the port, for the CIST and for each SPT.

13.29.15 recordAgreement()

For the CIST and a given port, if rstpVersion is TRUE, operPointToPointMAC (IEEE Std 802.1AC) is TRUE, and the received CIST Message has the Agreement flag set, then the CIST agreed flag is set and the CIST proposing flag is cleared. Otherwise, the CIST agreed flag is cleared. Additionally, if the CIST message was received from a Bridge in a different MST Region, i.e., the rcvdInternal flag is clear, the agreed and proposing flags for this port for all MSTIs are set or cleared to the same value as the CIST agreed and proposing flags. If the CIST message was received from a Bridge in the same MST Region, the MSTI agreed and proposing flags are not changed.

For a given MSTI and port, if operPointToPointMAC (IEEE Std 802.1AC) is TRUE, and:

a) The message priority vector of the CIST Message accompanying the received MSTI Message (i.e., received in the same BPDU) has the same CIST Root Identifier, CIST External Root Path Cost, and Regional Root Identifier as the CIST port priority vector, and
b) The received MSTI Message has the Agreement flag set,

the MSTI agreed flag is set and the MSTI proposing flag is cleared. Otherwise, the MSTI agreed flag is cleared.

NOTE—MSTI Messages received from Bridges external to the MST Region are discarded and not processed by recordAgreeement() or recordProposal().

13.29.16 recordDispute()

For the CIST and a given port, if the CIST message has the learning flag set:

a) The disputed variable is set, and
b) The agreed variable is cleared.

Additionally, if the CIST message was received from a Bridge in a different MST region (i.e., if the rcvdInternal flag is clear), then for all the MSTIs:

c) The disputed variable is set, and
d) The agreed variable is cleared.

For a given MSTI and port, if the received MSTI message has the learning flag set:

e) The disputed variable is set, and
f) The agreed variable is cleared.

13.29.17 recordMastered()

For the CIST and a given port, if the CIST message was received from a Bridge in a different MST Region, i.e., the rcvdInternal flag is clear, the mastered variable for this port is cleared for all MSTIs.

For a given MSTI and port, if the MSTI message was received on a point-to-point link and the MSTI Message has the Master flag set, set the mastered variable for this MSTI. Otherwise, reset the mastered variable.

13.29.18 recordPriority()

Sets the components of the portPriority variable to the values of the corresponding msgPriority components.

13.29.19 recordProposal()

For the CIST and a given port, if the received CIST Message conveys a Designated Port Role, and has the Proposal flag set, the CIST proposed flag is set. Otherwise, the CIST proposed flag is not changed. Additionally, if the CIST Message was received from a Bridge in a different MST Region, i.e., the rcvdInternal flag is clear, the proposed flags for this port for all MSTIs are set or cleared to the same value as the CIST proposed flag. If the CIST message was received from a Bridge in the same MST Region, the MSTI proposed flags are not changed.

For a given MSTI and port, if the received MSTI Message conveys a Designated Port Role, and has the Proposal flag set, the MSTI proposed flag is set. Otherwise, the MSTI proposed flag is not changed.

13.29.20 recordTimes()

For the CIST and a given port, sets portTimes' Message Age, Max Age, Forward Delay, and remainingHops to the received values held in msgTimes and portTimes' Hello Time to the default specified in Table 13-5.

For a given MSTI and port, sets portTime's remainingHops to the received value held in msgTimes.

13.29.21 setReRootTree()

Sets reRoot TRUE for this tree (the CIST or a given MSTI) for all ports of the Bridge.

13.29.22 setSelectedTree()

Sets selected TRUE for this tree (the CIST or a given MSTI) for all ports of the Bridge if reselect is FALSE for all ports in this tree. If reselect is TRUE for any port in this tree, this procedure takes no action.

13.29.23 setSyncTree()

Sets sync TRUE for this tree (the CIST or a given MSTI) for all ports of the Bridge.

13.29.24 setTcFlags()

For the CIST and a given port:

a) If the Topology Change Acknowledgment flag is set for the CIST in the received BPDU, sets rcvdTcAck TRUE.
b) If rcvdInternal is clear and the Topology Change flag is set for the CIST in the received BPDU, sets rcvdTc TRUE for the CIST and for each and every MSTI.
c) If rcvdInternal is set, sets rcvdTc for the CIST if the Topology Change flag is set for the CIST in the received BPDU.

For a given MSTI and port, sets rcvdTc for this MSTI if the Topology Change flag is set in the corresponding MSTI message.

13.29.25 setTcPropTree()

If and only if restrictedTcn is FALSE for the port that invoked the procedure, sets tcProp TRUE for the given tree (the CIST or a given MSTI) for all other ports.

13.29.26 syncMaster()

For all MSTIs, for each port that has infoInternal set:

a) Clears the agree, agreed, and synced variables; and
b) Sets the sync variable.

13.29.27 txConfig()

Transmits a Configuration BPDU. The first four components of the message priority vector (13.27.39) conveyed in the BPDU are set to the value of the CIST Root Identifier, External Root Path Cost, Bridge Identifier, and Port Identifier components of the CIST's designatedPriority parameter (13.27.20) for this port. The topology change flag is set if (tcWhile != 0) for the port. The topology change acknowledgment flag is set to the value of tcAck for the port. The remaining flags are set to zero. The value of the Message Age, Max Age, and Fwd Delay parameters conveyed in the BPDU are set to the values held in the CIST's designatedTimes parameter (13.27.21) for the port. The value of the Hello Time parameter conveyed in the BPDU is set to the value held in the CIST's portTimes parameter (13.27.48) for the port.

13.29.28 txRstp()

Transmits a RST BPDU, MST BPDU, or SPT BPDU as determined by the value of ForceProtocolVersion (13.7.2), and encoded as specified by Clause 14. All per port variables referenced in this subclause (13.29.28) are those for the transmitting port.

The first six components of the CIST message priority vector (13.27.39) conveyed in the BPDU are set to the value of the CIST's designatedPriority parameter (13.27.20). The Port Role in the BPDU (14.2.9) is set to the current value of the CIST's role (13.27.66). The Agreement and Proposal flags in the BPDU are set to the values of agree (13.27.3) and proposing (13.27.50), respectively. The CIST topology change flag is set if (tcWhile != 0) for the port. The topology change acknowledge flag in the BPDU is never used and is set to zero. The Learning and Forwarding flags in the BPDU are set to the values of learning (13.27.35) and forwarding (13.27.30) for the CIST, respectively. The value of the Message Age, Max Age, and Fwd Delay parameters conveyed in the BPDU are set to the values held in the CIST's designatedTimes parameter (13.27.21). The value of the Hello Time parameter conveyed in the BPDU is set to the value held in the CIST's portTimes parameter (13.27.48).

If the value of the Force Protocol Version parameter is less than 3, no further parameters are encoded in the BPDU and the protocol version parameter is set to 2 (denoting a RST BPDU). Otherwise, MST BPDU parameters are encoded as follows:

a) The version 3 length.
b) The MST Configuration Identifier parameter of the BPDU is the value of MstConfigId (13.26.7).
c) The CIST Internal Root Path Cost (13.27.20).
d) The CIST Bridge Identifier (CIST Designated Bridge Identifier—13.27.20).
e) The CIST Remaining Hops (13.27.21).
f) The parameters of each MSTI message, encoded in MSTID order.

NOTE—No more than 64 MSTIs may be supported. The parameter sets for all of these can be encoded in a standard-sized Ethernet frame. The number of MSTIs supported can be zero: an SPT Bridge, for example, is not obliged to have MSTIs configured in order to support SPB.

If the value of the Force Protocol Version parameter is less than 3, no further parameters are encoded in the BPDU and the protocol version parameter is set to 3 (denoting a MST BPDU). Otherwise, SPT BPDU parameters are encoded, and the protocol version parameter is set to 4 (denoting an SPT BPDU):

g) agreeN (13.27.16) is encoded in the Agreement Number field.
h) agreedND (13.27.17) is encoded in the Discarded Agreement Number field.
i) agreeDigest (13.27.8) is encoded in the Agreement Digest field.

13.29.29 txTcn()

Transmits a TCN BPDU.

13.29.30 updtAgreement()

If ISIS-SPB is implemented, this procedure is invoked for a given port, for the CIST or a given SPT, by the updtRolesTree() procedure used by the Port Role Selection machine (13.36), and by the rcvAgreements() procedure. The Port Role Selection machine itself could have been invoked following receipt of a BPDU on a port that is at the boundary of the SPT Region, possibly changing the context for the link state calculation, or following a link state update computed by ISIS-SPB following receipt of an IS-IS PDU.

If the procedure has been invoked for the CIST:

a) If the port's selectedRole is DesignatedPort, agreed is TRUE if and only if:

1) agreedTopology is TRUE; and
2) designatedPriority is the same or better (13.9) than agreedPriority.

b) If the port's selectedRole is not DesignatedPort, agreed is TRUE if and only if:
1) agreementOutstanding is the same or better than designatedPriority.

If the procedure has been invoked for an SPT, and the port's selectedRole is DesignatedPort:

c) agreedAbove is reset to FALSE;
d) if agreedTopology is TRUE:
1) agreementOutstanding (13.27.15) is set to BestAgreementPriority (13.28.4); and
2) agreedPriority (13.27.13) is set to the sum of neighbourPriority (13.27.41) and InternalPortPathCost.
e) if agreedTopology is FALSE and agreedPriority is less than the sum of neighbourPriority and InternalPortPathCost:
1) agreedPriority (13.27.13) is set to the sum of neighbourPriority (13.27.41) and InternalPortPathCost.
f) agreed (13.27.4) is TRUE if and only if:
1) designatedPriority is better than agreedPriority.

If the procedure has been invoked for an SPT and the port's selectedRole is not DesignatedPort:

g) agreedPriority is set to BestAgreementPriority;
h) if agreedTopology is TRUE:
1) agreedAbove is set TRUE, and
2) agreementOutstanding (13.27.15) is set is set to the sum of neighbourPriority (13.27.41) and InternalPortPathCost.
i) if agreedTopology is FALSE and agreementOutstanding is better than the sum of neighbourPriority and InternalPortPathCost:
1) agreementOutstanding is set to the sum of neighbourPriority (13.27.41) and InternalPortPathCost.
j) agreed is TRUE if and only if:
1) agreedAbove is TRUE, and
2) agreementOutstanding is the same as or better than designatedPriority.

Independently of whether the procedure was invoked for the CIST or an SPT:

k) if agreed is FALSE, then the sync variable is set TRUE.

13.29.31 updtBPDUVersion()

Sets rcvdSTP TRUE if the BPDU received is a version 0 or version 1 TCN or a Config BPDU. Sets rcvdRSTP TRUE if the received BPDU is a RST BPDU or a MST BPDU.

13.29.32 updtDigest()

Updates agreeDigest and agreeN, following calculation of a new topology or topologies by ISIS-SPB, and checks for a topology match with the updated values of those variables, as follows.

If agreeDigest is not equal to agreementDigest and:

a) agreeN is equal to agreeND, or
b) agreeN plus one is equal to agreeND:

then

c) agreeDigest is set equal to agreementDigest, and
d) agreeDigestValid is reset to FALSE, and
e) agreeN is set equal to agreeN plus one.

Additionally, if agreeDigest is now equal to agreementDigest and:

f) agreeDigest equals agreedDigest, and
g) agreedDigestValid is TRUE:

then

h) if agreedND is not equal to agreedN plus one, then
    1) agreedND is set equal to agreedN plus one, and
    2) newInfoMsti is set.

and

i) if agreeND is equal to agreeN and agreedMisorder is FALSE, or
j) if agreeND is set equal to agreeN plus one, then
    1) agreedTopology is set TRUE, and
    2) agreedMisorder is set FALSE;

otherwise, i.e., if (f) and (g) above are not both TRUE:

k) if agreedND is not equal to agreedN, then:
    1) agreedND is set equal to agreedN, and
    2) newInfoMsti is set.

The agreeDigest, agreeN, and agreedND variables determine the values of the Agreement Digest, Agreement Number (AN), and Discarded Agreement Number (DAN), transmitted in SPT BPDU and SPB Hello PDUs. This procedure is used by updtRolesTree() before using updtAgreement() for each SPT, and also by rcvAgreements(), since the latter can rotate the AN sequence window number and thus allow agreeDigest to be updated with agreementDigest.

Wherever newInfoMsti is set in this procedure, transmission of an SPB Hello PDU to convey the updated digest and sequence number information is also requested. SPT BPDUs and SPB Hello PDUs perform additional functions and are subject to different rate limiters, but both convey the Agreement Digest and related information.

13.29.33 updtRcvdInfoWhile()

Updates rcvdInfoWhile (13.25). The value assigned to rcvdInfoWhile is three times the Hello Time, if either:

a) Message Age, incremented by 1 second and rounded to the nearest whole second, does not exceed Max Age and the information was received from a Bridge external to the MST Region (rcvdInternal FALSE); or
b) remainingHops, decremented by one, is greater than zero and the information was received from a Bridge internal to the MST Region (rcvdInternal TRUE);

and is zero otherwise.

The values of Message Age, Max Age, remainingHops, and Hello Time used in these calculations are taken from the CIST's portTimes parameter (13.27.48) and are not changed by this procedure.

13.29.34 updtRolesTree()

This procedure calculates the following priority vectors (13.9, 13.10 for the CIST, 13.11 for a MSTI) and timer values, for the CIST or a given MSTI:

a) The *root path priority* vector for each Bridge Port that is not Disabled and has a *port priority* vector (portPriority plus portId—see 13.27.47 and 13.27.46) that has been recorded from a received message and not aged out (infoIs == Received).
b) The *root path priority* vector propagated and calculated by ISIS-SPB (if ISIS-SPB is implemented and ForceProtocolVersion is 4).
c) The Bridge's *root priority vector* (rootPortId, rootPriority—13.26.9, 13.26.10), chosen as the best of the set of priority vectors comprising the Bridge's own *Bridge priority vector* (BridgePriority—13.26.3) plus all calculated root path priority vectors whose:
    1) DesignatedBridgeID Bridge Address component is not equal to that component of the Bridge's own Bridge priority vector (13.10) and
    2) Port's restrictedRole parameter is FALSE and
    3) Port's restrictedDomainRole parameter is FALSE or the port is not a Boundary Port of the SPT Region (13.12).

NOTE 1—If ISIS-SPB is being used but did not provide the selected *root priority vector* for the CIST, that priority vector will be associated with the Master Port of the SPT Region (a Boundary Port of, and not internal to, the Region) and will be used by ISIS-SPB to propagate the CST component of the priority vector throughout the Region.

d) The Bridge's *root times*, (rootTimes—13.26.11), set equal to:
    1) BridgeTimes (13.26.4), if the chosen root priority vector is the Bridge priority vector, or was calculated by ISIS-SPB; otherwise,
    2) portTimes (13.27.48) for the port associated with the selected root priority vector, with the Message Age component incremented by 1 second and rounded to the nearest whole second if the information was received from a Bridge external to the MST Region (rcvdInternal FALSE), and with remainingHops decremented by one if the information was received from a Bridge internal to the MST Region (rcvdInternal TRUE).
e) The *designated priority vector* (designatedPriority—13.27.20) for each port that is not internal an SPT Region.
f) The *designated times* (designatedTimes—13.27.21) for each port set equal to the value of *root times*.

If the root priority vector for the CIST is recalculated, and has a different Regional Root Identifier than that previously selected, and has or had a nonzero CIST External Root Path Cost, the syncMaster() procedure (13.29.26) is invoked.

NOTE 2—Changes in Regional Root Identifier will not cause loops if the Regional Root is within an MST Region, as is the case if and only if the MST Region is the Root of the CST. This important optimization allows the MSTIs to be fully independent of each other in the case where they compose the core of a network.

The CIST, MSTI, or SPT Port Role for each port is assigned, and its port priority vector and timer information are updated as specified in the remainder of this subclause (13.41.2).

If the port is Disabled (infoIs == Disabled), selectedRole is set to DisabledPort.

Otherwise, if this procedure was invoked for an MSTI or an SPT, for a port that is not Disabled, and that has CIST port priority information that was received from a Bridge external to its Bridge's Region (infoIs == Received and infoInternal == FALSE), then:

g) If the selected CIST Port Role (calculated for the CIST prior to invoking this procedure for an MSTI or SPT) is RootPort, selectedRole is set to MasterPort.
h) If selected CIST Port Role is AlternatePort, selectedRole is set to AlternatePort.

i) Additionally, updtInfo is set if the port priority vector differs from the designated priority vector or the port's associated timer parameter differs from the one for the Root Port.

Otherwise, for the CIST for a port that is not Disabled and not internal to an SPT Region, or for an MSTI for a port of that is not Disabled and whose CIST port priority information was not received from a Bridge external to the Region (infoIs != Received or infoInternal == TRUE), the CIST or MSTI port role is assigned, and the port priority vector and timer information updated as follows:

j) If the port priority vector information was aged (infoIs = Aged), updtInfo is set and selectedRole is set to DesignatedPort.
k) If the port priority vector was derived from another port on the Bridge or from the Bridge itself as the Root Bridge (infoIs = Mine), selectedRole is set to DesignatedPort. Additionally, updtInfo is set if the port priority vector differs from the designated priority vector or the port's associated timer parameter(s) differ(s) from the Root Port's associated timer parameters.
l) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), and the root priority vector is now derived from it, selectedRole is set to RootPort, and updtInfo is reset.
m) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated Bridge and designated port components of the port priority vector do not reflect another port on this Bridge, selectedRole is set to AlternatePort, and updtInfo is reset.
n) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is not better than the port priority vector, and the designated Bridge and designated port components of the port priority vector reflect another port on this Bridge, selectedRole is set to BackupPort, and updtInfo is reset.
o) If the port priority vector was received in a Configuration Message and is not aged (infoIs == Received), the root priority vector is not now derived from it, the designated priority vector is better than the port priority vector, selectedRole is set to DesignatedPort, and updtInfo is set.

Otherwise, for the CIST or an SPT, for a port that is not Disabled and is internal to an SPT Region, ISIS-SPB determines the selectedRole (and other parameters, see 13.36), and uses updtAgreement() (13.29.30).

13.29.35 uptRolesDisabledTree()

This procedure sets selectedRole to DisabledPort for all ports of the Bridge for a given tree (CIST, or MSTI, or SPT).

13.30 The Port Timers state machine

The Port Timers state machine shall implement the function specified by the state diagram in Figure 13-15 and the attendant definitions in 13.25 through 13.29.

The state machine uses tick (13.27), a signal set by an implementation-specific system clock function at one second intervals, to decrement the timer variables for the CIST and all MSTIs for the port. The state machine that uses a given timer variable is responsible for setting its initial value.

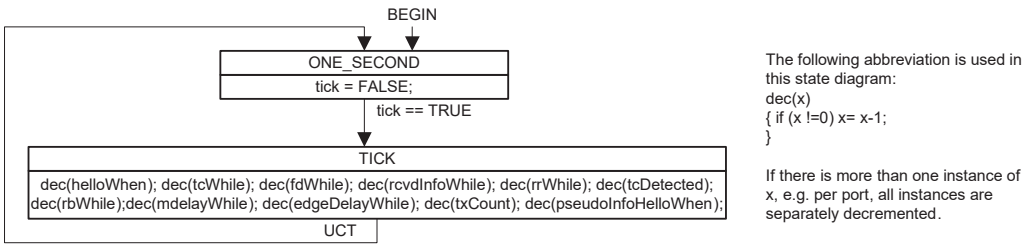


Figure 13-15—Port Timers state machine

13.31 Port Receive state machine

The Port Receive state machine shall implement the function specified by the state diagram in Figure 13-16 and the attendant definitions in 13.25 through 13.29.

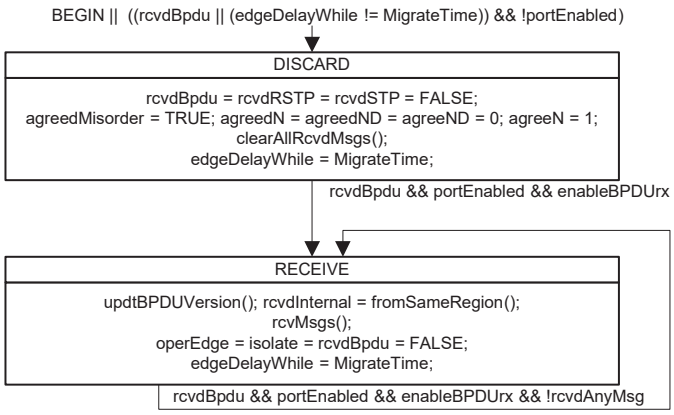


Figure 13-16—Port Receive state machine

This state machine receives and decodes validated BPDUs. The rcvdMsg flag is set for the CIST and for each MSTI supported by the receiving Bridge if the received BPDU is from the same MST or SPT Region. The next BPDU is not processed until all rcvdMsg flags have been cleared by the per-tree state machines.

NOTE—This standard does not specify or constrain the means used by the rcvMsgs() procedure to identify or extract per-tree information from a BPDU for processing by rcvInfo() in the Port Information Machine RECEIVE state.

13.32 Port Protocol Migration state machine

The Port Protocol Migration state machine shall implement the function specified by the state diagram in Figure 13-17 and the attendant definitions in 13.25 through 13.29.

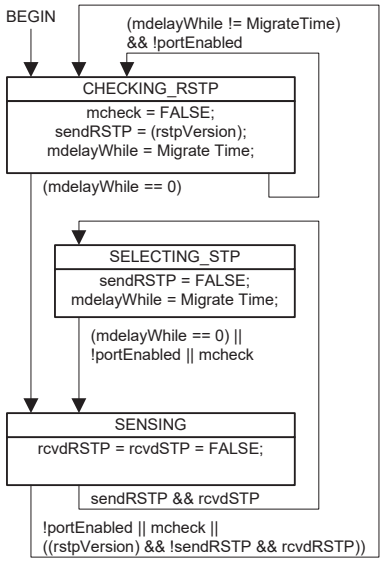


Figure 13-17—Port Protocol Migration state machine

13.33 Bridge Detection state machine

The Bridge Detection state machine shall implement the function specified by the state diagram in Figure 13-18 and the attendant definitions in 13.25 through 13.29.

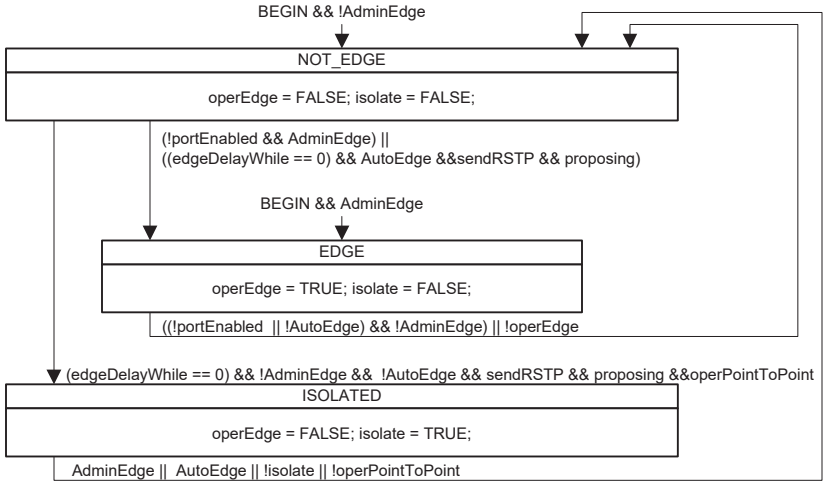


Figure 13-18—Bridge Detection state machine

13.34 Port Transmit state machine

The Port Transmit state machine shall implement the function specified by the state diagram in Figure 13-19 and the attendant definitions in 13.25 through 13.29.

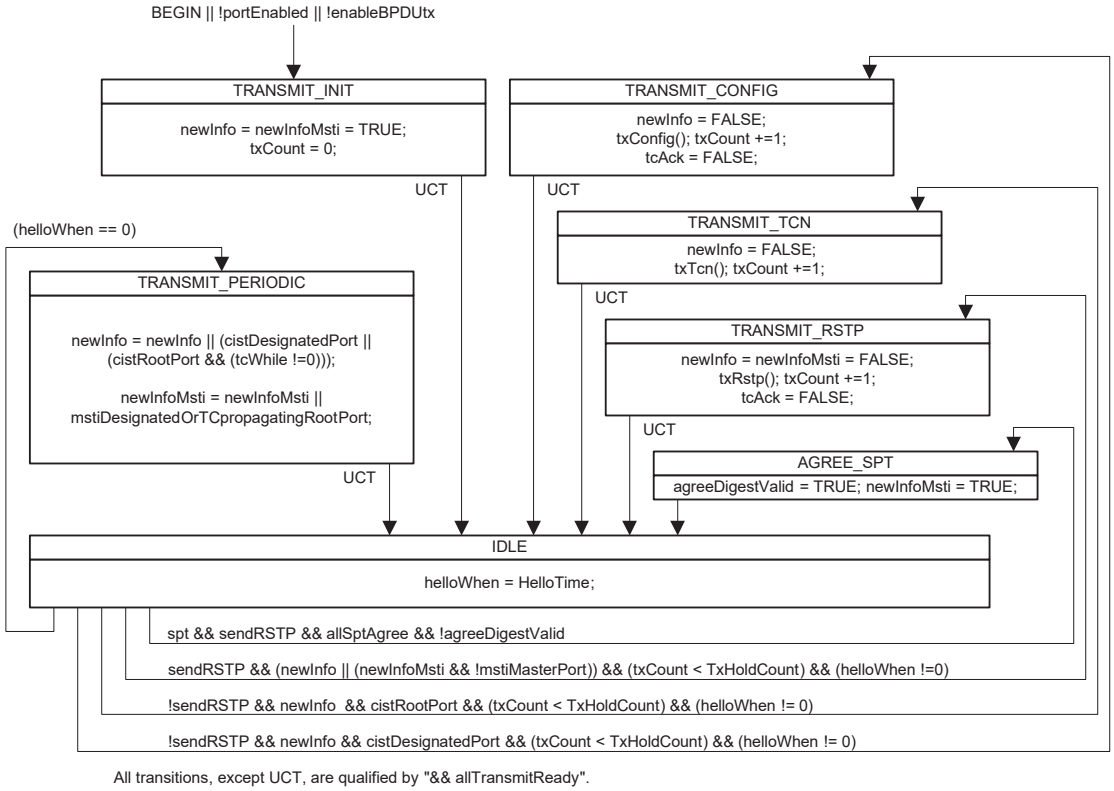


Figure 13-19—Port Transmit state machine

This state machine is responsible for transmitting BPDUs. It also determines when the Agreement Digest in SPT BPDUs can be updated, and prompts transmission when that has been done.

NOTE 1—Any single received BPDU that changes the CIST Root Identifier, CIST External Root Path Cost, or CIST Regional Root associated with MSTIs should be processed entirely, or not at all, before encoding BPDUs for transmission.This recommendation minimizes the number of BPDUs to be transmitted following receipt of a BPDU with new information. It is not required for correctness and has not therefore been incorporated into the state machines.

NOTE 2—If a CIST state machine sets newInfo, this machine will ensure that a BPDU is transmitted conveying the new CIST information. If MST BPDUs can be transmitted through the port, this BPDU will also convey new MSTI information for all MSTIs. If a MSTI state machine sets newInfoMsti, and MST BPDUs can be transmitted through the port, this machine will ensure that a BPDU is transmitted conveying information for the CIST and all MSTIs. Separate newInfo and newInfoMsti variables are provided to avoid requiring useless transmission of a BPDU through a port that can only transmit STP BPDUs (as required by the Force Protocol Version parameter or Port Protocol Migration machine) following a change in MSTI information without any change to the CIST.

13.35 Port Information state machine

The Port Information state machine for each tree shall implement the function specified by the state diagram in Figure 13-20 and the attendant definitions in 13.25 through 13.29.

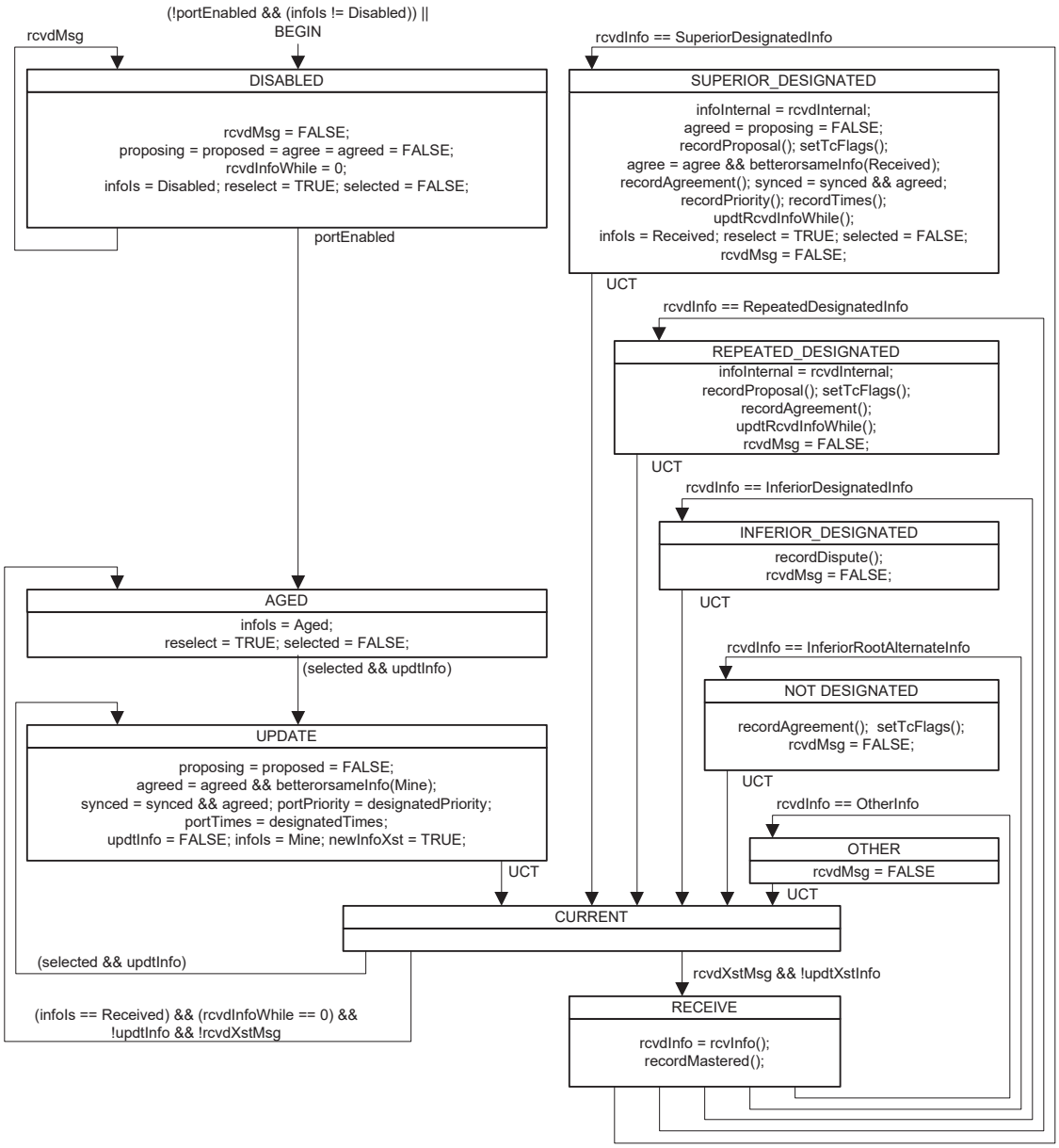


Figure 13-20—Port Information state machine

This state machine is responsible for recording the spanning tree information currently in use by the CIST or a given MSTI for a given port, ageing that information out if it was derived from an incoming BPDU, and recording the origin of the information in the infoIs variable. The selected variable is cleared and reselect set to signal to the Port Role Selection machine that port roles need to be recomputed. The infoIs and portPriority variables from all ports are used in that computation and, together with portTimes, determine new values of designatedPriority and designatedTimes. The selected variable is set by the Port Role Selection machine once the computation is complete.

13.36 Port Role Selection state machine

The Port Role Selection state machine shall implement the function specified by the state diagram in Figure 13-21 and the attendant definitions in 13.25 through 13.29.

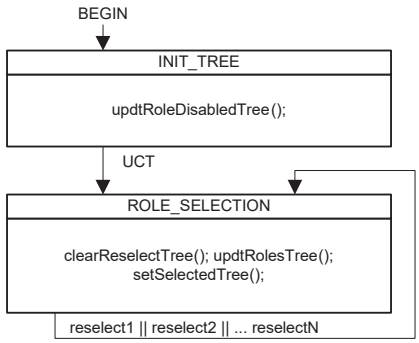


Figure 13-21—Port Role Selection state machine

When ISIS-SPB finishes a link state calculation, it clears the selected variable for each port for each SPT before updating agreementDigest (13.26.1) for the Bridge component, the root priority vector (rootPortId, rootPriority—13.26.9, 13.26.10) for each SPT and the selectedRole (13.12, 13.27.68), designated priority vector (designatedPriority—13.27.20), and neighbourPriority for each port for each SPT. ISIS-SPB then sets reselect for each SPT.

13.37 Port Role Transitions state machine

The Port Role Transitions state machine shall implement the function specified by the state diagram in the following figures:

a) Part 1: Figure 13-22 for both the initialization of this state machine and the states associated with the DisabledPort role
b) Part 2: Figure 13-23 for the states associated with the MasterPort role
c) Part 3: Figure 13-24 for the states associated with the RootPort role
d) Part 4: Figure 13-25 for the states associated with the DesignatedPort role
e) Part 5: Figure 13-26 for the states associated with the AlternatePort and BackupPort roles

and the attendant definitions in 13.25 through 13.29.

As Figure 13-22, Figure 13-23, Figure 13-24, Figure 13-25, and Figure 13-26 are component parts of the same state machine, the global transitions associated with these diagrams are possible exit transitions from the states shown in any of the diagrams.

Figure 13-22 and Figure 13-26 show the Port Roles for ports that do not form part of the active topology of the given tree.

Figure 13-23, Figure 13-24, and Figure 13-25 show the Port Roles that form part of the active topology.

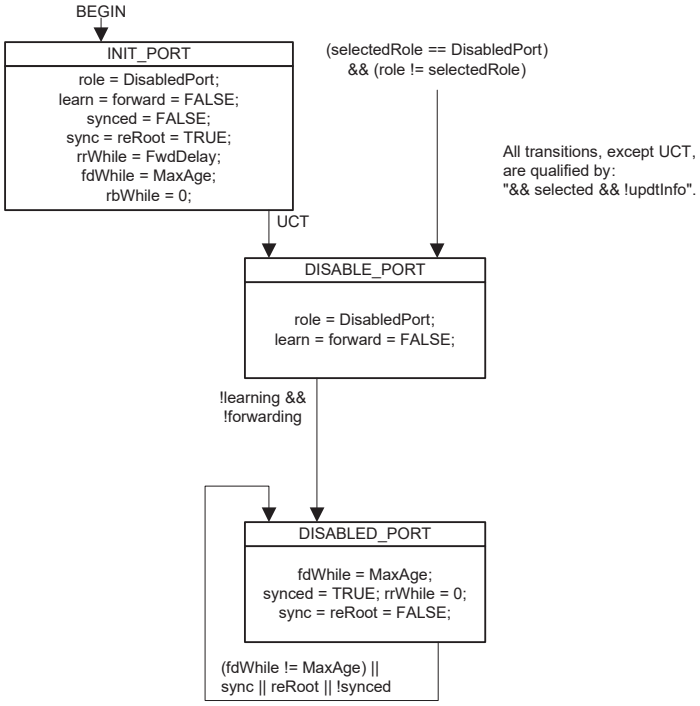


Figure 13-22—Disabled Port role transitions

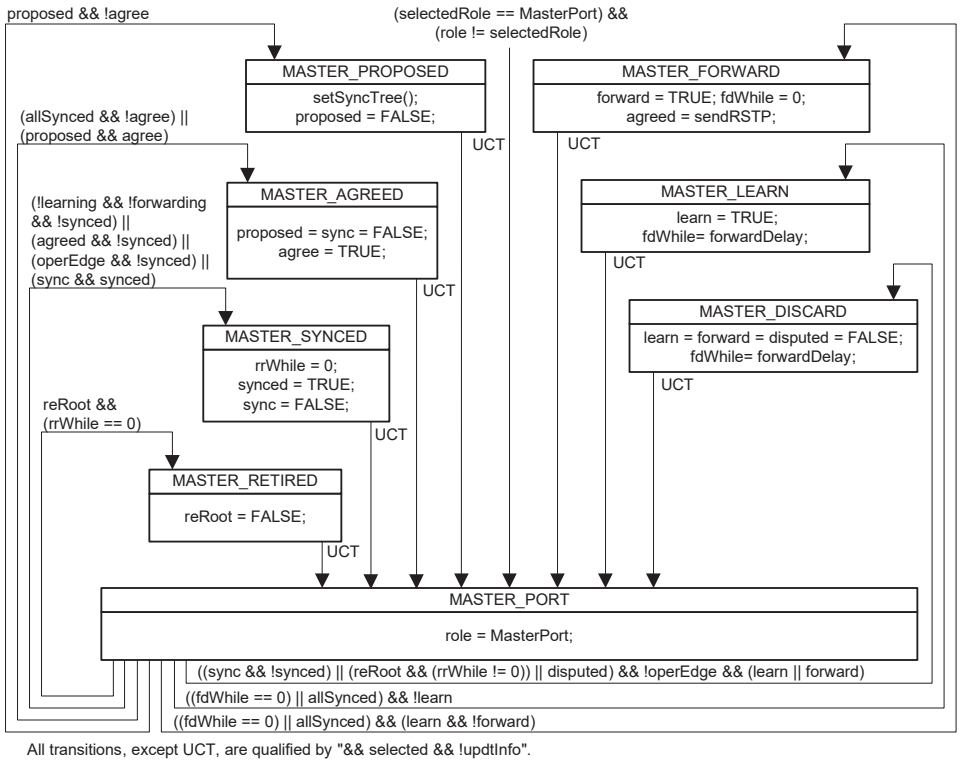


Figure 13-23—Port Role Transitions state machine—MasterPort

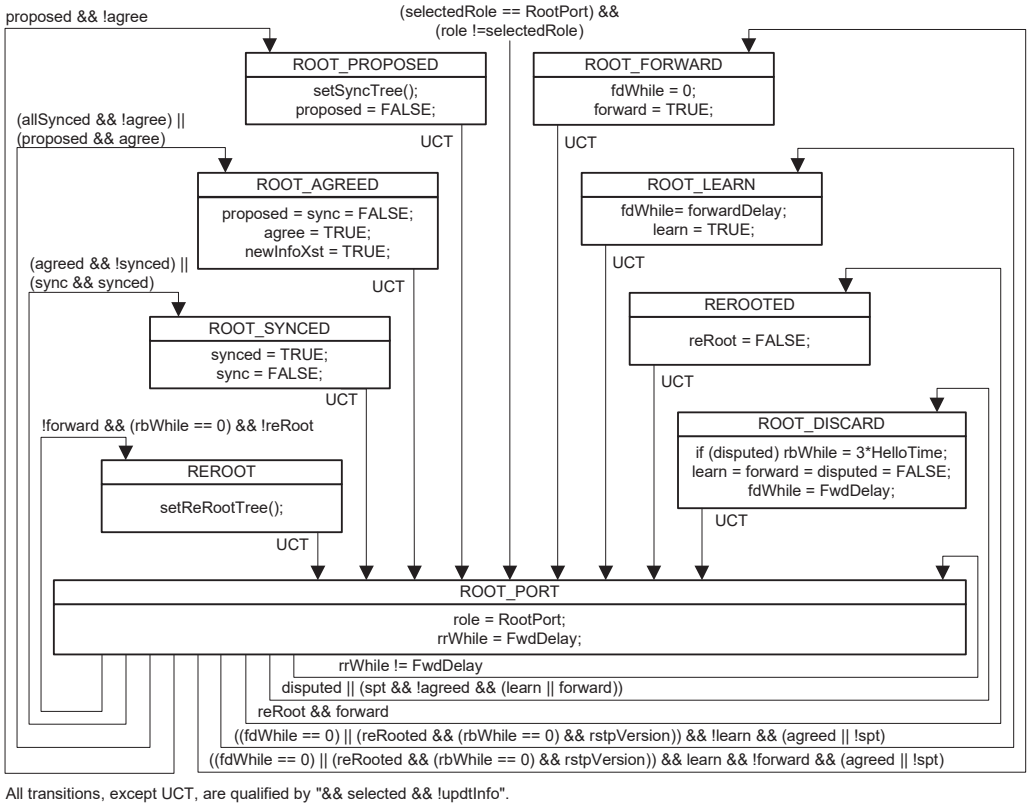
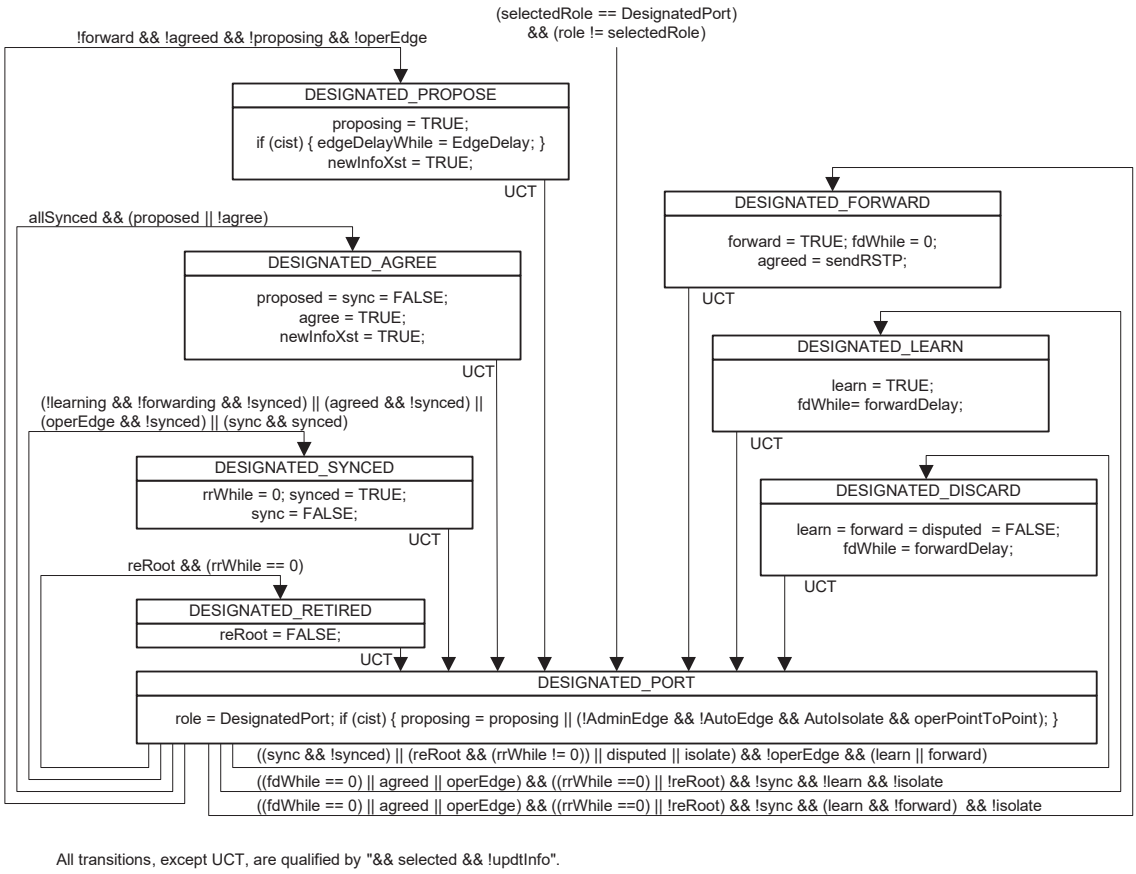


Figure 13-24—Port Role Transitions state machine—RootPort



All transitions, except UCT, are qualified by "&& selected && !updtInfo".

Figure 13-25—Port Role Transitions state machine—DesignatedPort

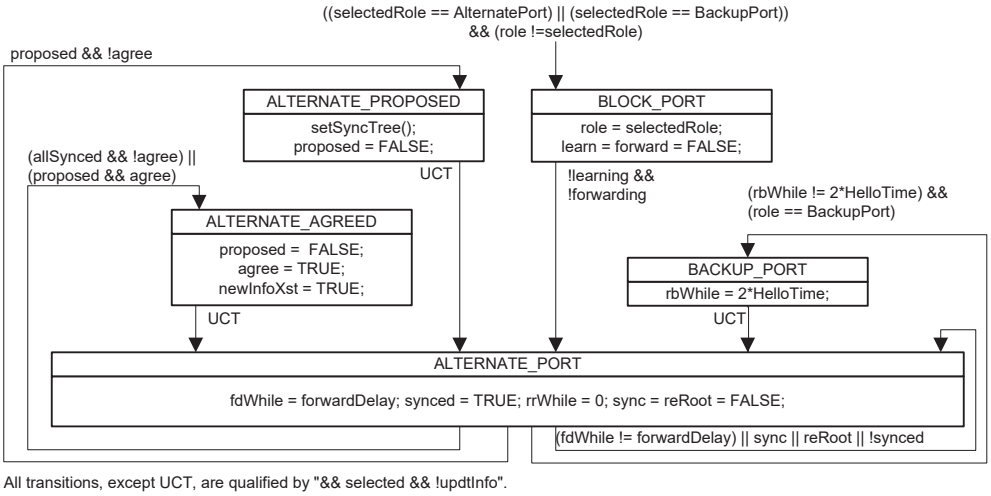


Figure 13-26—Port Role Transitions state machine—AlternatePort and BackupPort

13.38 Port State Transition state machine

The Port State Transition state machine shall implement the function specified by the state diagram in Figure 13-27 and the attendant definitions in 13.25 through 13.29.

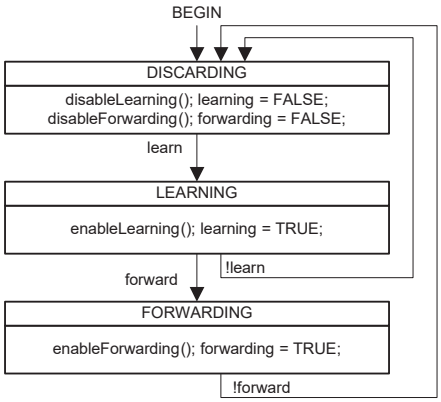


Figure 13-27—Port State Transition state machine

NOTE—A small system-dependent delay may occur on each of the transitions shown in the referenced state machine.

This state machine operates independently of the type of tree (CIST, MSTI, or SPT) and whether backbone bridging is being supported. However, the way in which the Bridge supports the learn and forward variables and the disableForwarding(), disableLearning(), enableForwarding(), and enableLearning() procedures are supported does vary (see 8.4, 8.6, 8.6.1). The forwarding and learning variables provide implementation-independent reporting of the current state.

13.38.1 Port State transitions for the CIST and MSTIs

The CIST and each MSTI are always supported by an explicit Port State, enforced by Bridge's implementation of the Forwarding Process, and the procedures prompt that implementation to take the necessary action to forward and/or learn from received frames (as requested).

13.38.2 Port State transitions for SPTs

The enableLearning() and disableLearning() procedures return without taking an action: for SPBV mode learning does not occur until forwarding is enabled (8.6.1); for SPBM mode the Learning Process (8.7) neither creates or deletes Dynamic Filtering Entries.

When a VLAN is supported by an SPT Bridge using SPBV mode, a Dynamic VLAN Registration Entry is created for each SPVID and Enable Ingress Filtering (8.6.2) enabled on each port. Connectivity is provided, and loops prevented, by adding and removing ports from the Dynamic VLAN Registration Entry (27.13).

The enableForwarding() procedure adds the port to the Dynamic VLAN Registration Entry for each SPVID that is associated with the SPT (provided the VLAN topology extends through the port, see 27.13). Similarly disableForwarding() removes the port from the registration entry.

When frames with a given VID are supported by SPBM mode, MAC address-based ingress filtering is used to discard a received frame if there is no corresponding Dynamic Filtering Entry (8.8, 8.6.1, 27.14) for that VID and the frame's source MAC address with the receiving port in the Port Map.

ISIS-SPB identifies the port that provides the shortest path to a given Bridge: this is the Root Port for the SPT rooted at that Bridge. The individual MAC addresses (there can be more than one) known to ISIS-SPB as identifying sources for which that given Bridge first transmits frames within the SPT Region (entering the region from an attached Bridge or station, or from a protocol entity within the Bridge) or as identifying destinations for which that Bridge is the last recipient within the region (delivering frames to an attached Bridge or station, or to a protocol entity within the Bridge) are associated with that Root Port. If loop mitigation (6.5.4.2) is used for unicast frames, a Dynamic Filtering Entry is created for those addresses and VID, permitting forwarding through that port and no others, without reference to the state machines specified in this clause (Clause 13), and the setting or clearing of the forward variable for any port. The enableForwarding() procedure creates or modifies these Dynamic Filtering Entries, so that forwarding to and from a given port is permitted, if and only if loop prevention (6.5.4.1) is used for both unicast and multicast frames and the port's role is RootPort, and has no effect otherwise. Similarly if loop prevention is being used, disableForwarding() modifies or removes any existing Dynamic Filtering Entry so that forwarding to or from the port is not permitted.

NOTE—The Port Role Transition machine allows an SPT to transition a Root Port to Discarding in support of enableForwarding() and disableForwarding() as specified in this subclause (13.38.2). The need to specify that transition could have been avoided by specifying that the Dynamic Filtering Entry would only permit forwarding through a given port if forward was TRUE for the port for every other SPT for which it was a Designated Port. While equivalent, such a specification approach would have been obscure and many implementors would have failed to spot the way to avoid checking variables for all SPTs when processing a change for a single tree.

An SPT Bridge using SPBM mode uses source-specific multicast addresses, so that the destination address alone can be used to identify the SPT (Clause 27) on egress, and a Static Filtering Entry (8.8.1) is created for that multicast address and the B-VIDs supported by the SPT. If enableForwarding() is invoked for a Designated Port, the Static Filtering Entry's control element for that port is updated to specify that frames should be Forwarded through the port. The control element is modified to specify Filtered if enableForwarding() is invoked and the port's role is not Designated Port, or if disabledForwarding() is used.

13.39 Topology Change state machine

The Topology Change state machine for each tree shall implement the function specified by the state diagram in Figure 13-28 and the attendant definitions in 13.25 through 13.29.

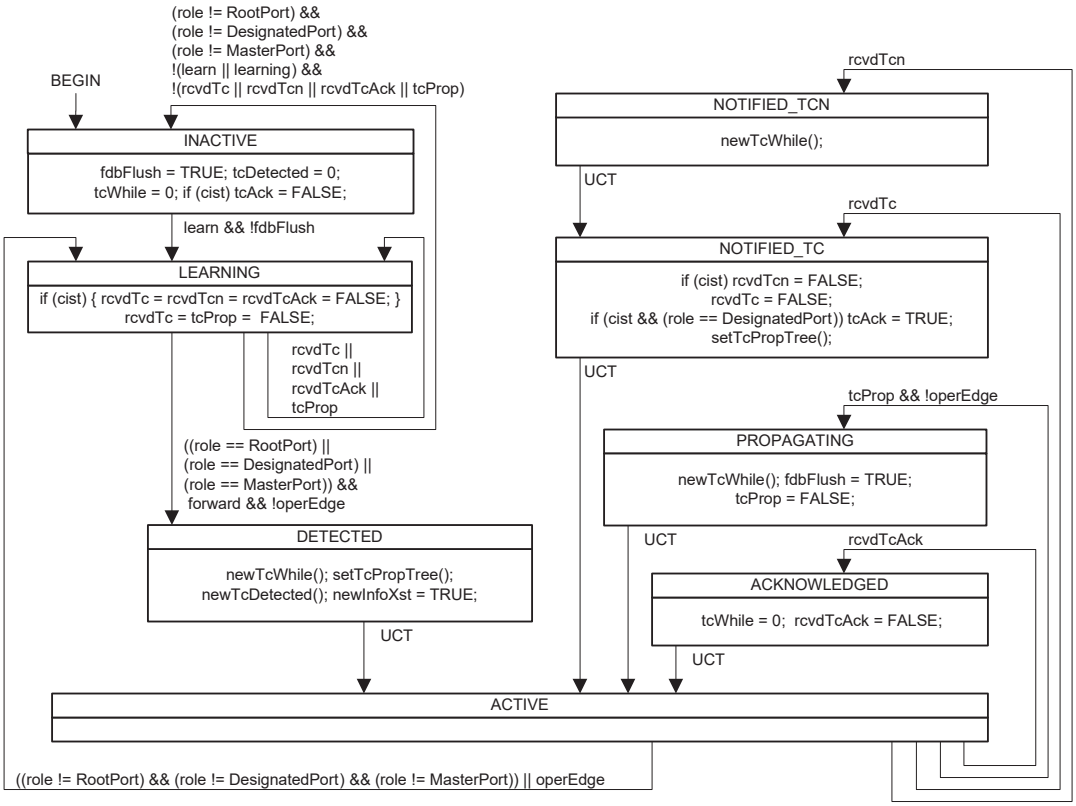


Figure 13-28—Topology Change state machine

NOTE—MRP (Clause 10) uses the tcDetected variable maintained by this state machine.

13.40 Layer 2 Gateway Port Receive state machine

If implemented, the Layer 2 Gateway Port state machine for each port shall implement the function specified by the state diagram in Figure 13-29 and the attendant definitions in 13.25 through 13.29.

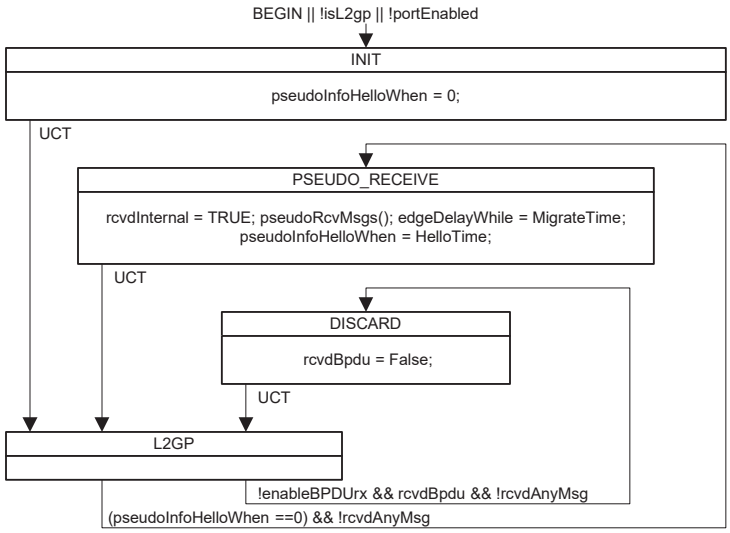


Figure 13-29—L2 Gateway Port Receive state machine

NOTE—The functionality provided by this state machine is discussed in 13.20, 25.9.2, 26.4.3, and 13.29.11.

13.41 CEP spanning tree operation

This subclause specifies the operation of the Spanning Tree Protocol Entity within a C-VLAN component that supports a CEP (Figure 15-4) of a Provider Edge Bridge. The CEP and each PEP are treated as separate Bridge Ports by the spanning tree protocol.

If the C-VLAN component connects to the S-VLAN component with a single PEP, and the associated service instance supports no more than two customer interfaces, then all frames (including ST BPDUs) addressed to the Bridge Group Address may be relayed between the two ports of the C-VLAN component without modification. Otherwise, the Spanning Tree Protocol Entity shall execute RSTP, as modified by the provisions of this subclause (13.41).

The RSTP enhancements specified do not reduce PBN connectivity between CEPs to a single spanning tree of service instances but ensure that connectivity for frames assigned to any given C-VLAN is loop-free. In this respect, the C-VLAN component's spanning tree protocol operation is equivalent to, but simpler to manage than, the operation of MSTP.

13.41.1 PEP operPointToPointMAC and operEdge

The value of the adminPointToPointMAC parameter for a PEP is always Auto, and no management control over its setting is provided. The value of the operPointToPointMAC parameter, used by the RSTP state machines, shall be TRUE if the service instance corresponding to the PEP connects at most two customer interfaces, and FALSE otherwise.

The value of the AdminEdge, AutoEdge, and operEdge parameters for a PEP are always FALSE, TRUE, and FALSE, respectively. No management control over their setting is provided.

13.41.2 updtRolesTree()

The spanning tree priority vectors timer values are calculated, and the port role for each port, its port priority vector, and timer information updated as specified in 13.29.34, with one exception. If selectedRole was to be set to AlternatePort, the port is a PEP, and the root priority vector was derived from another PEP, then the selectedRole shall be set to RootPort.

NOTE—The effect of this enhancement is to allow the C-VLAN component to have multiple Root Ports (just as if separate per S-VLAN trees were being provided), if they are all PEPs. As the C-VLAN component assigns each frame to a single C-VLAN and maps any given C-VLAN to and from at most one PEP, no loop is created.

13.41.3 setReRootTree(), setSyncTree(), setTcPropTree()

The setReRootTree() and setSyncTree() procedures specified in 13.29.21 and 13.29.23 set the reRoot and sync variables for all ports of the Bridge, and the setTcPropTree() as specified in 13.29.25 sets the tcProp variable for all ports other than the port that invoked the procedure. If the port invoking the procedure is a CEP, then this behavior is unchanged; if it is a PEP, then the behavior of each procedure shall be as follows:

— The setReRootTree() procedure sets reRoot for the port invoking the procedure and for the CEP.
— The setSyncTree() procedure sets sync for the port invoking the procedure and for the CEP.
— The setTcPropTree() procedure sets tcProp for the CEP.

13.41.4 allSynced, reRooted

RSTP specifies a single value of the allSynced and reRooted state machine conditions for all Bridge Ports. This specification requires an independent value of each of these conditions for each port of the C-VLAN component. If that port is the CEP, then allSynced shall be TRUE if and only if synced is TRUE for all PEPs, and reRooted shall be TRUE if and only if rrWhile is zero for all PEPs. If the port for which the condition is being evaluated is a PEP, then allSynced shall take the value of synced for the CEP, and reRooted shall be TRUE if and only if rrWhile is zero for the CEP.

13.41.5 Configuration parameters

All configuration parameters for RSTP should be set to their recommended defaults, with the exception of the following, which are chosen to minimize the chance of interfering with the customer's configuration (e.g., by the C-VLAN component becoming the root of the customer spanning tree), as follows:

a) The Bridge Priority (13.18, Table 13-3, 13.26.2) should be set to 61 440. This sets the priority part of the Bridge Identifier (the most significant 4 bits) to hex F.
b) The following 12 bits (the Bridge Identifier system ID extension) should be set to hex FFF.
c) The Port Priority (13.18, Table 13-3, 13.27.47) should be set to 32. This sets the priority part of the Port Identifier (the most significant 4 bits) to hex 2, a higher priority than the default (128, or hex 8).
d) The Port Path Cost values for PEPs should be set to 128.

All BPDUs generated by the Spanning Tree Protocol Entity within a C-VLAN component use the MAC address of the CEP as a source address and as the Bridge address portion of the Bridge Identifier. For each internal PEP, the protocol uses the S-VID associated with the corresponding internal CNP on the S-VLAN component as a port number. For the CEP, the value 0xFFF is used as the port number.

13.42 Virtual Instance Port (VIP) spanning tree operation

This subclause specifies the operation of the Spanning Tree Protocol Entity within an I-component in a BEB. The CNPs and VIPs are treated as separate Bridge Ports by the spanning tree protocol.

If the I-component has a single CNP and a single VIP supported by a point-to-point backbone service instance, then all frames (including ST BPDUs) addressed to the Provider Bridge Group address may be relayed between the two ports of the I-component without modification. Otherwise, the Spanning Tree Protocol Entity shall execute RSTP, as modified by the provisions of this subclause.

The RSTP enhancements specified ensure that connectivity for frames assigned to any given S-VLAN is loop-free.

The parameters and functions of the RSTP used on the VIPs get the same values and functionality as defined for PEPs of a C-VLAN component as defined in 13.41. The Bridge Identifier Priority and system ID extension get the values specified in 13.41.5. These changes in RSTP ensure that no VIP is blocked due to the operation of RSTP and the I-component will never be elected as root.

NOTE—The effect of not blocking any VIP in the I-component (never set the port role alternate to a VIP) will not cause a loop since the I-component maps any given S-VID to at most one VIP.

14. Encoding of Bridge Protocol Data Units (BPDUs)

This clause specifies formats, and the encoding, decoding, and validation of BPDUs exchanged by protocol entities operating RSTP, MSTP, and other protocols enhancing or designed to interoperate with STP, RSTP, or MSTP (Clause 13).

Interoperability with STP, as specified in IEEE Std 802.1D, 1998 Edition [B11], and prior revisions, is provided as specified by the state machines and procedures in Clause 13 of this standard. Parameter type encodings for STP BPDUs are a subset of those used for RSTP, MSTP, and SPT BPDUs, and the fields encoded in STP Configuration BPDUs are a subset of those used in RST BPDUs.

The format of MST BPDUs is compatible with that specified for RST BPDUs, with the addition of fields to convey information for the IST and each MSTI, and is shown in Figure 14-1.

The format of SPT BPDUs comprises the fields specified for MST BPDUs, with the addition of fields that communicate the Agreement Number, Discarded Agreement Number, and Agreement Digest (13.17).

The Protocol Version Identifier encoded in all BPDUs serves to distinguish RST BPDUs, MST BPDUs, and SPT BPDUs. A BPDU Type is also encoded in all BPDUs, and distinguishes the Configuration and TCN BPDUs used by STP and by the spanning tree protocols specified in this standard when interoperating with STP implementations.

Figure 14-1 shows the overall format of RST, MST, SPT, and STP Configuration BPDUs. Figure 14-2 shows the format of STP TCN BPDUs.

14.1 BPDU Structure

14.1.1 Transmission and representation of octets

All BPDUs shall contain an integral number of octets. The octets in a BPDU are numbered starting from 1 and increasing in the order they are put into a Data Link Service Data Unit (DLSDU).When bit positions in an octet or a sequence of octets encode a number, the number is encoded as an unsigned binary numeral with bit positions in lower octet numbers having more significance. Within an octet the bits are numbered from 8 to 1, where 1 is the low-order bit. Where sequences of bits are represented, high order bits are shown to the left of lower order bits in the same octet, and bits in lower octet numbers are shown to the left of bits in higher octet numbers.

14.1.2 Common BPDU fields

A Protocol Identifier is encoded in the initial octets of all BPDUs. The single Protocol Identifier value of 0000 0000 0000 0000 identifies the spanning tree family of protocols (STP, RSTP, and MSTP) and BPDUs whose formats are compatible with:

a) STP BPDUs, as specified in this clause and in IEEE Std 802.1D, 1998 Edition [B11]
b) RST BPDUs, as specified in this clause and Clause 9 of IEEE Std 802.1D-2004 [B12]
c) The BPDUs specified in IEEE Std 802.1G, now withdrawn
d) MST BPDUs, as specified in this clause
e) SPT BPDUs, as specified in this clause

NOTE—ISIS-SPB (Clause 27, Clause 28) sends and receives its own PDUs to support the distributed computation of symmetric SPTs.

A Protocol Version Identifier and BPDU Type are also encoded in all BPDUs.

	Octet
Protocol Identifier	1–2
Protocol Version Identifier	3
BPDU Type	4
CIST Flags	5
CIST Root Identifier	6–13
CIST External Path Cost	14–17
CIST Regional Root Identifier	18–25
CIST Port Identifier	26–27
Message Age	28–29
Max Age	30–31
Hello Time	32–33
Forward Delay	34–35
Version 1 Length = 0 (RST, MST, SPT BPDUs only)	36
Version 3 Length (MST, SPT BPDUs only)	37–38
MST Configuration Identifier	39–89
CIST Internal Root Path Cost	90–93
CIST Bridge Identifier	94–101
CIST Remaining Hops	102
MSTI Configuration Messages (may be absent)	103–*39* + *Version 3 Length*
Version 4 Length (SPT BPDUs only)	(40 + *Version 3 Length*) – (41 + *Version 3 Length*)
Auxiliary MCID (SPT BPDUs only)	(42 + *Version 3 Length*) – (92 + *Version 3 Length*)
SPT Agreement Number, Discarded Agreement Number, Agreement Digest (SPT BPDUs only)	(93 + *Version 3 Length*) – (41 + *Version 3 Length* + *Version 4 Length)*

NOTE—BPDUs are encoded in LLC Type 1 frames following the DSAP, LSAP, and UI fields, so if that frame is received from directly an IEEE 802.3 MAC with the MAC addresses aligned on an even octet boundaries then the BPDU octet pairs 6 and 7, 14 and 15, 18 and 19, etc. will also be aligned on those boundaries.

Figure 14-1—RST, MST, SPT, and STP Configuration BPDU format

	Octet
Protocol Identifier	1–2
Protocol Version Identifier	3
BPDU Type	4

Figure 14-2—STP TCN BPDU format

14.2 Encoding of parameter types

14.2.1 Encoding of Protocol Identifiers

A Protocol Identifier shall be encoded in two octets.

14.2.2 Encoding of Protocol Version Identifiers

A Protocol Version Identifier shall be encoded in one octet. If two Protocol Version Identifiers are interpreted as unsigned binary numbers, the greater identifies the more recently defined Protocol Version.

14.2.3 Encoding of BPDU types

The type of the BPDU shall be encoded as a single octet. The bit pattern contained in the octet merely serves to distinguish the type; no ordering relationship between BPDUs of different types is implied.

14.2.4 Encoding of flags

A flag shall be encoded as a bit in a single octet. A flag is set if the bit takes the value 1. A number of flags may be encoded in a single octet. Bits in the octet that do not correspond to flags defined for the BPDU's type are reset, i.e., shall take the value 0. No additional flags will be defined for a BPDU of given protocol version and type.

14.2.5 Encoding of Bridge Identifiers

A Bridge Identifier is a 64-bit unsigned integer. If two Bridge Identifiers are numerically compared, the lesser number denotes the Bridge of the better priority.

NOTE 1—Use of the terms "higher" and "lower" to describe both the relative numerical values and the relative priority of Spanning Tree information can cause confusion, as lesser numbers convey better priorities. In this clause and in Clause 13, relative numeric values are described as "least," "lesser," "equal," and "greater," and their comparisons as "less than," "equal to," or "greater than," while relative spanning tree priorities are described as "best," "better," "the same," "different," and "worse" and their comparisons as "better than," "the same as," "different from," and "worse than." The terms "superior" and "inferior" describe comparisons not simply based on strict ordered comparison of priority components.

The most significant 4 bits of a Bridge Identifier comprise a settable priority component (13.20, 13.26.2), and can be modified for the CIST or for an MSTI independently of those for other MSTIs (or for the CIST), allowing the Bridge Identifier priority to be used to provide full and independent control over the configuration of each of those trees. Each SPT uses the same Bridge Identifier as the CIST, so SPT Bridge Identifiers are not separately encoded.

NOTE 2—To maintain management compatibility with implementations of revisions of this standard prior to the IEEE Std 802.1s-2002 amendment, and of IEEE Std 802.1D, 1998 Edition [B11] and prior revisions, the priority component is considered to be a 16-bit value for management purposes, but the values that it can be set to are restricted to only those values where the least significant 12 bits are zero (i.e., only the most significant 4 bits are settable).

The next most significant 12 bits of a Bridge Identifier (when encoded, the least significant 4 bits of the most significant octet plus the second most significant octet) comprise a locally assigned system ID extension, that provides a distinct Bridge Identifier for each MSTI. The CIST is identified by the system ID extension of zero. Each MSTI has a system ID extension value equal to its MSTID, a convention used to convey the MSTID for each MSTI parameter set in an MST BPDU.

The least significant 48 bits of the Bridge Identifier ensure its uniqueness and are derived from the globally unique Bridge Address (8.13.8) and are encoded in the third through eighth most significant octets of the encoded identifier according to the following procedure.

The third most significant octet is derived from the initial octet of the MAC address; the LSB of the octet (Bit 1) is assigned the value of the first bit of the Bridge Address, the next most significant bit is assigned the value of the second bit of the Bridge Address, and so on. The fourth through eighth octets are similarly assigned the values of the second to the sixth octets of the Bridge Address.

14.2.6 Encoding of External Root Path Cost and Internal Root Path Cost

The External Root Path Cost shall be encoded in four octets as a number of arbitrary cost units. The Internal Root Path Cost is similarly encoded in four octets. Subclause 13.18 recommends Port Path Cost values so that a common interpretation can be placed on path cost values, and reasonable spanning tree configurations obtained without explicit management.

NOTE—IEEE Std 802.1D-2004 [B12] refers to the External Root Path Cost as Root Path Cost and does not use Internal Root Path Cost.

14.2.7 Encoding of Port Identifiers

A Port Identifier is a 16-bit unsigned integer. If two Port Identifiers are numerically compared, the lesser number denotes the port of better priority. The most significant 4 bits of a Port Identifier is a settable priority component that permits the relative priority of ports on the same Bridge to be managed (13.27.46), and can be modified independently for the CIST and each MSTI. The less significant 12 bits is the Port Number expressed as an unsigned binary number, and is same for the CIST and all MSTIs. The value 0 is not used as a Port Number.

The Port Identifier for the CIST is encoded in two octets, comprising both the CIST's priority component and the Port Number used for all spanning trees. The 4-bit priority component for each MSTI is encoded as a binary number, in the MSTI Configuration Message for that MSTI. Each SPT uses the same Port Identifier as the CIST, so SPT Port Identifiers are not separately encoded.

NOTE—IEEE Std 802.1D, 1998 Edition [B11], and prior revisions specified a priority component of 8 bits and a Port Number of 8 bits. To maintain management compatibility with prior implementations the priority component is still considered to be an 8-bit value, but its values are restricted to those where the least significant 4 bits are zero (and hence ignored in encoding).

14.2.8 Encoding of Timer Values

Timer Values shall be encoded in two octets, taken to represent an unsigned binary number multiplied by a unit of time of 1/256 of a second. This permits times in the range 0 to, but not including, 256 s to be represented.

14.2.9 Encoding of Port Role values

Port Role values shall be encoded in two consecutive flag bits, taken to represent an unsigned integer, as follows:

a) A value of 0 indicates Master Port
b) A value of 1 indicates Alternate or Backup
c) A value of 2 indicates Root
d) A value of 3 indicates Designated

NOTE—IEEE Std 802.1D-2004 [B12] identified the Port Role value of 0 as Unknown, as it not used as a CIST Port Role in transmitted BPDUs. A received BPDU with a CIST Port Role value of 0 is identified as a Configuration BPDU.

14.2.10 Encoding of Length Values

Version 1 Length Values are encoded in one octet, taken to represent an unsigned binary number. No further length values are encoded for Version 2. Length Values for Version 3 and 4 are encoded in two octets.

14.2.11 Encoding of Hop Counts

The number of remaining Hops parameter shall be encoded in a single octet.

14.3 Transmission of BPDUs

A Bridge Protocol Entity shall encode 0000 0000 0000 0000 in Octets 1 and 2 (conveying the Protocol Identifier), the remaining fields shall be encoded to convey an STP Configuration BPDU, an STP TCN BPDU, an RST BPDU, or an MST BDU as required by the Force Protocol Version parameter, the Port Protocol Migration state machine, and other protocol parameters, all as specified in Clause 13.

a) If transmission of an STP Configuration BPDU is required, the Protocol Version Identifier shall be 0, and the BPDU Type shall be 0000 0000.
b) If transmission of an STP TCN BPDU is required, the Protocol Version Identifier shall be 0, and the BPDU Type shall be 1000 0000.
c) If transmission of an RST BPDU is required, the Protocol Version Identifier shall be 2, and the BPDU Type shall be 0000 0010.
d) If transmission of an MST BPDU is required, the Protocol Version Identifier shall be 3, and the BPDU Type shall be 0000 0010.
e) If transmission of an SPT BPDU is required, the Protocol Version Identifier shall be 4, and the BPDU Type shall be 0000 0010.

The remaining parameters for STP Configuration, RST, MST, and SPT BPDUs shall be encoded as specified below (14.4).

14.4 Encoding and decoding of STP Configuration, RST, MST, and SPT BPDUs

STP Configuration, RST, MST, and SPT BPDU protocol parameters are encoded for transmission, and decoded, checked, or ignored on receipt as follows:

a) Bit 1 of Octet 5 conveys the CIST Topology Change flag.
b) Bit 2 of Octet 5 conveys the CIST Proposal flag in RST, MST, and SPT BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
c) Bits 3 and 4 of Octet 5 conveys the CIST Port Role in RST, MST, and SPT BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
d) Bit 5 of Octet 5 conveys the CIST Learning flag in RST, MST, and SPT BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
e) Bit 6 of Octet 5 conveys the CIST Forwarding flag in RST, MST, and SPT BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
f) Bit 7 of Octet 5 conveys the CIST Agreement flag in RST, MST, and SPT BPDUs. It is unused in STP Configuration BPDUs, and shall be transmitted as 0 and ignored on receipt.
g) Bit 8 of Octet 5 conveys the Topology Change Acknowledge Flag in STP Configuration BPDUs. It is unused in RST, MST, and SPT BPDUs, and shall be transmitted as 0 and ignored on receipt.
h) Octets 6 through 13 convey the CIST Root Identifier.

NOTE 1—The 12-bit system ID extension component of the CIST Root Identifier can be received and subsequently transmitted as an arbitrary value, even in MST BPDUs, since the CIST Root may be an STP Bridge.

i) Octets 14 through 17 convey the CIST External Root Path Cost.

j) Octets 18 through 25 shall take the value of the CIST Regional Root Identifier when transmitted in RST and MST BPDUs, and the value of the CIST Bridge Identifier of the transmitting Bridge when transmitted in STP Configuration BPDUs. On receipt of an STP Configuration or RST BPDU both the CIST Regional Root Identifier and the CIST Designated Bridge Identifier shall be decoded from this field. On receipt of an MST BPDU the CIST Regional Root Identifier shall be decoded from this field.
k) Octets 26 and 27 convey the CIST Port Identifier of the transmitting Bridge Port.
l) Octets 28 and 29 convey the Message Age timer value.
m) Octets 30 and 31 convey the Max Age timer value.
n) Octets 32 and 33 convey the Hello Time timer value used by the transmitting Bridge Port.
o) Octets 34 and 35 convey the Forward Delay timer value.

No further octets shall be encoded in STP Configuration BPDUs. Additional octets in received BPDUs identified by the validation procedure (14.5) as STP Configuration BPDUs shall be ignored. The specification of encoding or decoding of further octets in this subclause refers only to RST, MST, and SPT BPDUs.

p) Octet 36 conveys the Version 1 Length. This shall be transmitted as 0. It is checked on receipt by the validation procedure (14.5).

No further octets shall be encoded in RST BPDUs. Additional octets in received BPDUs identified by the validation procedure (14.5) as RST BPDUs shall be ignored. The specification of encoding or decoding of further octets in this subclause refers only to MST and SPT BPDUs.

NOTE 2—As Version 2 does not specify any additional fields beyond the end of the Version 0 information, there is no Version 2 Length field specified in Version 2 of the protocol and therefore no need for a Version 2 length field here.

q) Octets 37 and 38 convey the Version 3 Length. Its value is the number of octets taken by the parameters that follow in the BPDU. It is checked on receipt by the validation procedure (14.5).
r) Octets 39 through 89 convey the elements of the MCID (13.8):
    1) The Configuration Identifier Format Selector is encoded in octet 39 and shall take the value 0000 0000.
    2) The Configuration Name is encoded in octets 40 through 71.
    3) The Revision Level is encoded as a number in octets 72 through 73.
    4) The Configuration Digest is encoded in octets 74 through 89.
s) Octets 90 through 93 convey the CIST Internal Root Path Cost.
t) Octets 94 through 101 convey the CIST Bridge Identifier of the transmitting Bridge. The 12-bit system ID extension component of the CIST Bridge Identifier shall be transmitted as 0. The behavior on receipt is unspecified if it is nonzero.

NOTE 3—The most significant 4 bits of the Bridge Identifier constitute the manageable priority component for each MSTI and are separately encoded in MSTI Configuration Messages in the BPDU.

u) Octet 102 encodes the value of remaining Hops for the CIST.
v) A sequence of zero or more, up to a maximum of 64, MSTI Configuration Messages follows, each encoded as specified in 14.4.1.

No further octets shall be encoded in MST Configuration BPDUs. Additional octets in received BPDUs identified by the validation procedure (14.5) as MST Configuration BPDUs shall be ignored. The specification of encoding or decoding of further octets in this subclause refers only to SPT BPDUs.

w) Octets 1 and 2 following the Version 3 information convey the Version 4 Length. Its value is the number of octets that follow the Version 4 Length in the BPDU, up to but not including octets added by subsequent revisions of this standard and associated with Versions 5 or greater. It is checked on receipt by the validation procedure (14.5).

x) Octets 1 through 51 following the Version 4 Length encode the Auxiliary MCID (if present) as follows:
   1) The Configuration Identifier Format Selector is encoded in octet 1 and shall take the value 0000 0000.
   2) The Configuration Name is encoded in octets 2 through 33.
   3) The Revision Level is encoded as a number in octets 34 through 35.
   4) The Configuration Digest is encoded in octets 36 through 51.

y) Octets 1 and 2 following the Auxiliary MCID are encoded (if present) as follows:
   1) Bits 1 and 2 of Octet 1 convey the Agreement Number (13.27.11, 13.27.16).
   2) Bits 3 and 4 of Octet 1 convey the Discarded Agreement Number (13.27.12, 13.27.17).
   3) Bit 5 of Octet 1 conveys the Agreement Valid flag (13.27.7, 13.27.9).
   4) Bit 6 of Octet 1 conveys the Restricted Role flag (13.27.63, 27.20).
   5) Bits 7 through 8 of Octet 1 are unused, and shall be transmitted as 0 and ignored on receipt.
   6) Octet 2 is unused, and shall be transmitted as 0 and ignored on receipt.

z) The remaining Octets following the Version 4 Length and covered by that length comprise the Agreement Digest (13.17.1, 28.4).

No further octets shall be encoded in BPDUs. Additional octets in received BPDUs shall be ignored.

14.4.1 MSTI Configuration Messages

A single instance of the following set of parameters is encoded for each MSTI supported by the transmitting Bridge.

a) Bits 1, 2, 3 and 4, 5, 6, 7, and 8, respectively, of Octet 1 convey the Topology Change flag, Proposal flag, Port Role, Learning flag, Forwarding flag, Agreement flag, and Master flag for this MSTI.
b) Octets 2 through 9 convey the Regional Root Identifier (13.27.20) as illustrated in Figure 14-3. This includes the value of the MSTID for this Configuration Message encoded in bits 4 through 1 of Octet 1, and bits 8 through 1 of Octet 2.

NOTE—The most significant 4 bits of each MSTI's Regional Root Identifier constitute a manageable priority component.

c) Octets 10 through 13 convey the Internal Root Path Cost.
d) Bits 5 through 8 of Octet 14 convey the value of the Bridge Identifier Priority for this MSTI. Bits 1 through 4 of Octet 14 shall be transmitted as 0, and ignored on receipt.
e) Bits 5 through 8 of Octet 15 convey the value of the Port Identifier Priority for this MSTI. Bits 1 through 4 of Octet 15 shall be transmitted as 0, and ignored on receipt.
f) Octet 16 conveys the value of remainingHops for this MSTI (13.27.21).

	Octet
MSTI Flags	1
MSTI Regional Root Identifier	2–9
MSTI Internal Root Path Cost	10–13
MSTI Bridge Priority	14
MSTI Port Priority	15
MSTI Remaining Hops	16

Figure 14-3—MSTI Configuration Message parameters and format

14.5 Validation of received BPDUs

The receiving protocol entity shall examine Octets 1 and 2 (conveying the Protocol Identifier), Octet 3 (conveying the Protocol Version Identifier encoded as a number), Octet 4 (conveying the BPDU Type) and the total length of the received BPDU (including the preceding fields, but none prior to the Protocol Identifier) to determine the further processing required as follows:

a) If the Protocol Identifier is 0000 0000 0000 0000, the BPDU Type is 0000 0000, and the BPDU contains 35 or more octets, it shall be decoded as an STP Configuration BPDU.
b) If the Protocol Identifier is 0000 0000 0000 0000, the BPDU Type is 1000 0000 (where bit 8 is shown at the left of the sequence), and the BPDU contains 4 or more octets, it shall be decoded as an STP TCN BPDU (9.3.2 of IEEE Std 802.1D-2004 [B12]).
c) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 2, and the BPDU Type is 0000 0010 (where bit 8 is shown at the left of the sequence), and the BPDU contains 36 or more octets, it shall be decoded as an RST BPDU.
d) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 3 or greater, the BPDU Type is 0000 0010, the Bridge is configured as an MST Bridge or an SPT Bridge or according to a future revision of this standard that intends to provide interoperability with prior revisions, and the BPDU:
    1) Contains 35 or more but less than 103 octets, or
    2) Contains a Version 1 Length that is not 0, or
    3) Contains a Version 3 length that does not represent an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages,

    it shall be decoded as an RST BPDU.
e) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 3 or greater and the Bridge is configured as an MST Bridge or the Protocol Version Identifier is 3 and the Bridge is configured as an SPT Bridge or according to a future revision of this standard that intends to provide interoperability with prior revisions, the BPDU Type is 0000 0010, and the BPDU:
    1) Contains 102 or more octets, and
    2) Contains a Version 1 Length of 0, and
    3) Contains a Version 3 length representing an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages,

    it shall be decoded as an MST BPDU.
f) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 3 or greater, the BPDU Type is 0000 0010, the Bridge is configured as an SPT Bridge or according to a future revision of this standard that intends to provide interoperability with prior revisions, and the BPDU:
    1) Contains 102 or more octets, and
    2) Contains a Version 1 Length of 0, and
    3) Contains a Version 3 length representing an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages, and
    4) Is not a well-formed an SPT BPDU, i.e.,
        i) Contains less than 6 octets following the octets specified by the Version 3 length,
        ii) Has a Version 4 length that is less than 55,
        iii) Does not contain an MCID Format Selector of 1,

    it shall be decoded as an MST BPDU.
g) If the Protocol Identifier is 0000 0000 0000 0000, the Protocol Version Identifier is 4 or greater, the BPDU Type is 0000 0010, the Bridge is configured as an MST Bridge or an SPT Bridge or according to a future revision of this standard that intends to provide interoperability with prior revisions, and the BPDU:
    1) Contains 106 or more octets, and
    2) Contains a Version 1 Length of 0, and
    3) Contains a Version 3 length representing an integral number, from 0 to 64 inclusive, of MSTI Configuration Messages, and

4) Is a well-formed an SPT BPDU, i.e., contains
   i) At least 6 octets following the octets specified by the Version 3 length,
   ii) A Version 4 length of 55 or greater,
   iii) An MCID Format Selector of 1,

   it shall be decoded as an SPT BPDU.

h) Otherwise, the BPDU shall be discarded and not processed.

NOTE 1—The LLC LSAP that identifies BPDUs is reserved for standard protocols, no other protocols using that LSAP have been standardized though they may be at some future time. At that time, BPDUs with different PIDs may be processed according to the rules of those protocols but will still be discarded from the point of view of MSTP.

NOTE 2—These validation rules do not contain a loopback check of the form specified for use with STP Configuration BPDUs in 9.3.4 of IEEE Std 802.1D-2004 [B12].

14.6 Validation and interoperability

The validation rules above (14.5) follow a consistent general approach that allows future version enhancements to be made while retaining backwards compatibility. In particular, tests (a) and (b) in 14.5 above do not check the Protocol Version Identifier.

In general, for an implementation that supports version A of a given protocol, a received PDU of a given type that carries a protocol version number B is interpreted as follows:

a) Where B is greater than or equal to A, the PDU shall be interpreted as if it carried the supported version number, A. Specifically,
   1) All PDU types, parameters, and flags that are defined in version A shall be interpreted in the manner specified for version A of the protocol for the given BPDU type.
   2) All PDU types, parameters, and flags that are undefined in version A for the given BPDU type shall be ignored.
   3) All octets that appear in the PDU beyond the largest numbered octet defined for version A for the given BPDU type shall be ignored.

b) Where B is less than A, the PDU shall be interpreted as specified for the version number, B, carried in the BPDU. Specifically,
   1) All PDU parameters and flags shall be interpreted in the manner specified for version B of the protocol for the given PDU type.
   2) All PDU parameters and flags that are undefined in version B for the given BPDU type shall be ignored.
   3) All octets that appear in the PDU beyond the largest numbered octet defined for version B for the given BPDU type shall be ignored.

NOTE—In other words, if the protocol version implemented differs from the protocol version number carried in the PDU, then only those PDU types, parameters, and flags that are specified within the lesser numbered protocol version are interpreted by the implementation (in accordance with the lesser numbered protocol version's specification), and no attempt is made to interpret any additional PDU types, parameters, and flags that may be specified within the greater numbered protocol version. In the specific case of STP (version 0) and RSTP (version 2), as there is only a single RST BPDU type defined in version 2, and as the RST BPDU type is undefined in version 0, a version 0 implementation will ignore all RST BPDUs. Version 2 implementations, however, recognize and process both version 0 and version 2 BPDUs. As version 2 makes no changes to the BPDU types defined for version 0 (and always transmits such BPDU types with 0 as the version identifier), version 0 BPDUs are always interpreted by version 2 implementations according to their version 0 definition.

15. Support of the MAC Service by PBNs

Provider Bridges interconnect the separate MACs of the IEEE 802 LANs that compose a PBN, relaying frames to provide connectivity between all LANs that provide customer interfaces for each service instance. The position of the Provider Bridge S-VLAN component bridging function within the MAC Sublayer is shown in Figure 15-1.

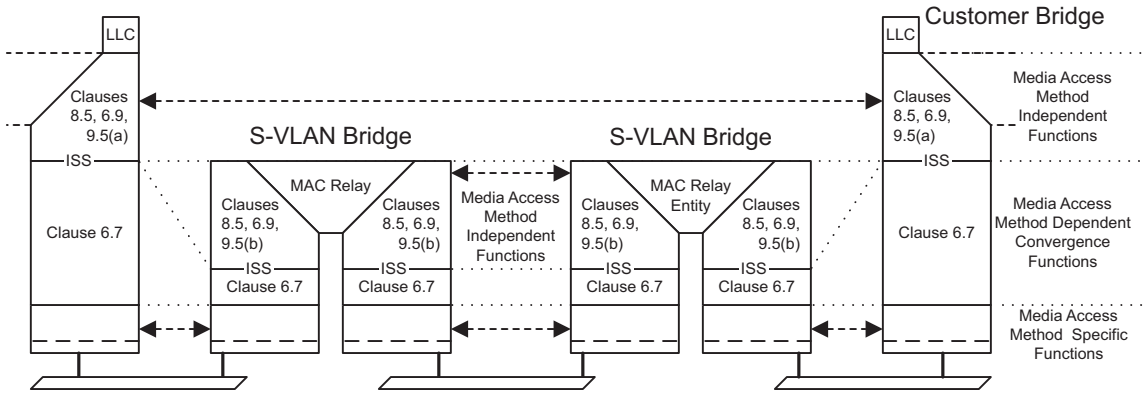


Figure 15-1—Internal organization of the MAC sublayer in a PBN

This clause discusses the following aspects of provisioning service instances on a PBN:

a) Service transparency
b) Customer service interfaces
c) Service instance segregation
d) Service instance selection and identification
e) Service priority selection
f) Service access protection

NOTE—In describing the MAC Service, this standard makes use of term “service” as defined by the OSI Reference Model (ISO/IEC 7498-1). In this sense, a service comprises a set of primitives and associated parameters, provided by one protocol layer in the architectural model to the protocol layer above, and the causal relationships between the primitives invoked by an upper layer protocol (ULP) entity in one system with those resulting indications to a peer entity in another system. The term “service” used by service providers, while including layering concepts, goes far beyond this formal definition, and commonly specifies some or all of the following: interfacing considerations across multiple protocol layers (including physical connectors, for example); selection of interface points; interfacing equipment; QoS guarantees and measurement methods; charging methods and responsibilities; connectivity verification and other management tools; and regulatory issues. Many of these aspects lie outside the scope of this standard; the reader is referred to the bibliography in Annex W, which includes references to completed and ongoing work in the MEF Forum and the ITU.

15.1 Service transparency

The operation of Provider Bridges and the networks they compose is, by design, largely transparent to Customer Bridges and CBNs as illustrated by Figure 15-1.

The service provided by Provider Bridges is transparent to the use of the MAC Service by end stations attached to the CBNs and transparent to the operation of media access method-independent functions by Customer Bridges.

The service is not transparent to the operation of media access method-dependent convergence functions, specified in IEEE Std 802.1AC, or to the operation of the media access method-specific functions specified by standards for each media access method. Media access method-dependent and -specific functions operate

between Bridges, whether Customer Bridges or Provider Bridges, attached to the same LAN. Where these functions make use of standard group MAC addresses, those addresses are included in the Reserved Addresses that are always filtered by Customer Bridges (Table 8-1) and by Provider Bridges (Table 8-2).

Frames transmitted and received by media access method-independent functions particular to PBN operation are not forwarded by Customer Bridges between provider networks. Where these frames are addressed using standard group MAC addresses, those addresses are included in the Reserved Addresses that are always filtered by Customer Bridges (Table 8-1). In addition, such frames may be filtered from PEPs.

15.2 Customer service interfaces

A service provider can offer a customer one or more types of service interfaces, each providing different capabilities for service selection, priority selection, and service access protection (15.8, 15.9, and 15.10). Some service interfaces are provided by the service provider operating systems that include C-VLAN components, or by customer operating systems that include S-VLAN components. In all cases, segregation of different service instances is achieved at an interface wholly under the control of the service provider by authentication and authorization of the attached customer systems, and by verification of customer provided parameters that provide service instance selection.

NOTE—The term “service access protection” describes provision of service access over multiple access LANs with redundancy and rapid failover in case of failure of an access LAN or attached equipment.

Access to a given service instance can be provided through different types of customer interface.

15.3 Port-based service interface

The customer service interfaces that can be provided by a provider network are specified by reference to a CNP provided by the S-VLAN component of a Provider Bridge. The CNP provides a single service instance, as illustrated in Figure 15-2 and Figure 15-3. The attached customer system can be a Bridge, a router, or an end station.

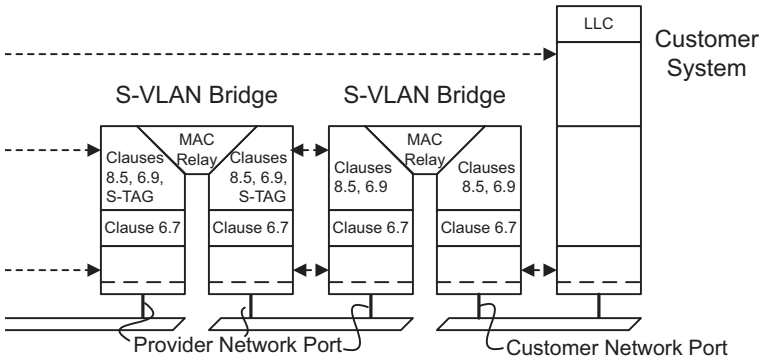


Figure 15-2—Port-based service interface to a PBN

This interface is Port-based; i.e., customers select and identify different service instances by associating each with a different CNP. Frames transmitted to a CNP by a C-VLAN-aware customer system do not include an S-VID but can be priority-tagged with an S-TAG (6.13).

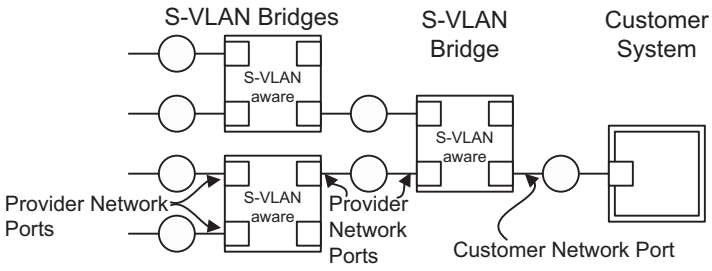


Figure 15-3—Port-based service interface to a PBN

NOTE—The terms "Customer Network Port," "Customer Edge Port," "Provider Network Port," and "Provider Edge Port," do not refer to the ownership of equipment, or necessarily to differently implemented Ports, but to Ports that are configured to fulfill the requirements of precise roles within a structured provider network design. These requirements are described in 15.6 through 15.10 and in Clause 16. All "Network" Ports are part of S-VLAN components, and all "Edge" Ports are part of C-VLAN components, whereas all "Customer" Ports receive data from a single customer inbound to the network and transmit data outbound from the network to a single customer. See Clause 3 for definitions.

15.4 C-tagged service interface

A C-tagged service interface can be provided by a Provider Edge Bridge comprising one or more C-VLAN components attached to Port-based service interfaces provided by a single S-VLAN component, as illustrated by Figure 15-4 and Figure 15-5.

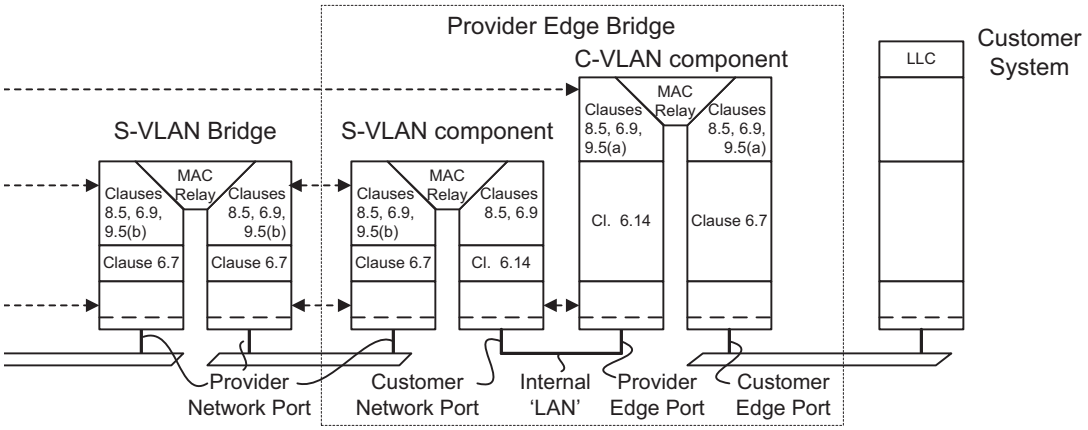


Figure 15-4—C-tagged service interface to a PBN

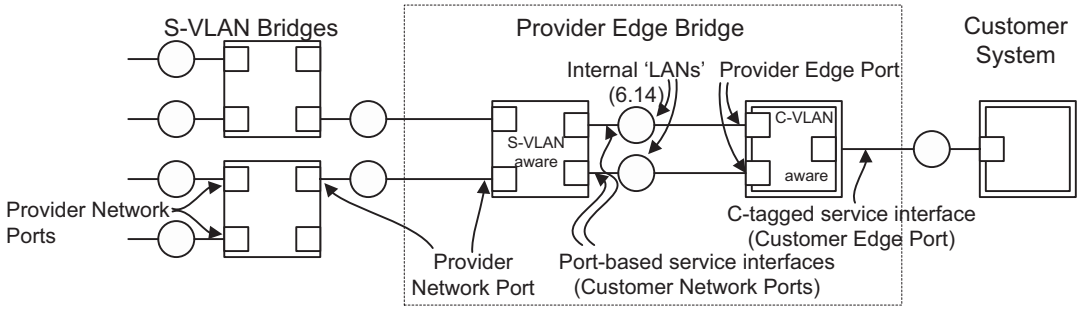


Figure 15-5—C-tagged service interface to a PBN

The C-tagged service interface allows service instance selection and identification by C-VID. Each frame from the customer system is assigned to a C-VLAN and presented at zero or one internal Port-based service interfaces, each supporting a single service instance that the customer desires to carry that C-VLAN.

NOTE—The restriction that each C-VLAN map to a single service instance allows the customer equipment receiving frames to correctly identify the service instance used, supports mechanisms that guard against accidental creation of data loops, and prevents configuration of the C-VLAN component to create a multi-point service from point-to-point service instances. The service provider can offer a multi-point service through appropriate configuration of the S-VLAN component.

Similarly frames from the provider network are assigned to an internal interface or "LAN" on the basis of the S-VID. As each internal interface supports a single service instance, no S-TAG is used at this interface. If multiple C-VLANs are supported by this service instance, the frames will have C-TAGs with the possible exception of frames for a single C-VLAN. The C-VLAN component applies a PVID to untagged frames received on each internal "LAN," allowing full control over the delivery of frames for each C-VLAN through the CEP.

Each Provider Edge Bridge can support multiple CEPs for the same customer or for multiple customers. Each CEP is supported by a dedicated C-VLAN component as illustrated in Figure 15-6.

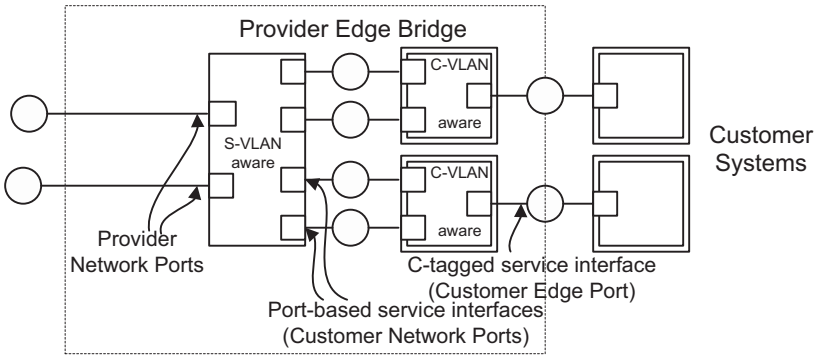


Figure 15-6—Customer Edge Ports (CEPs)

15.5 S-tagged service interface

An S-tagged service interface can be provided to an S-VLAN Bridge operated by a customer as illustrated by Figure 15-7 and Figure 15-8, or to a customer-operated Provider Edge Bridge that in turn provides C-tagged service interfaces within the customer's own network as described in 15.4.

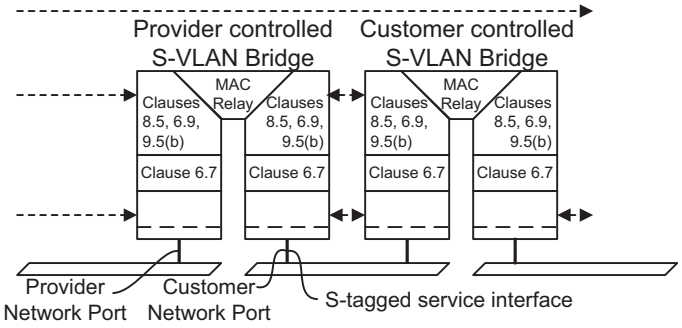


Figure 15-7—S-tagged service interface to a PBN

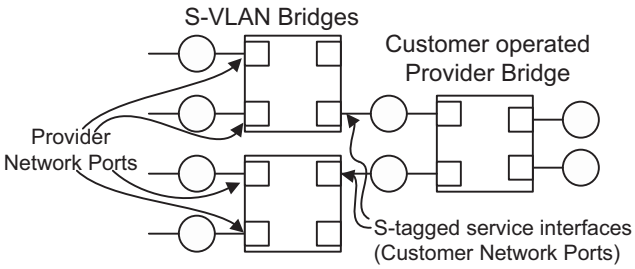


Figure 15-8—S-tagged interface to a PBN

15.6 Remote customer service interfaces (RCSIs)

An RCSI provides a C-tagged or Port-based service interface to a customer attached via an access PBN as depicted in Figure 16-2 (16.2). Multiple RCSIs can be provided over a LAN interconnecting two PBNs through the use of a Port-mapping S-VLAN component as shown in Figure 15-2. The Port-mapping S-VLAN component has one external port (RCAP) and one or more internal Ports (PAPs) that each support one RCSI. The Port-mapping S-VLAN component also can have an internal PNP for service instances that do not require an RCSI.

The Port-mapping S-VLAN component is configured to associate a unique S-VID with each PAP. Furthermore, each S-VID configured in the Port-mapping S-VLAN component has the RCAP and exactly one other Port in its member set. This ensures that each external service instance is mapped to only one internal port. See Figure 15-9.

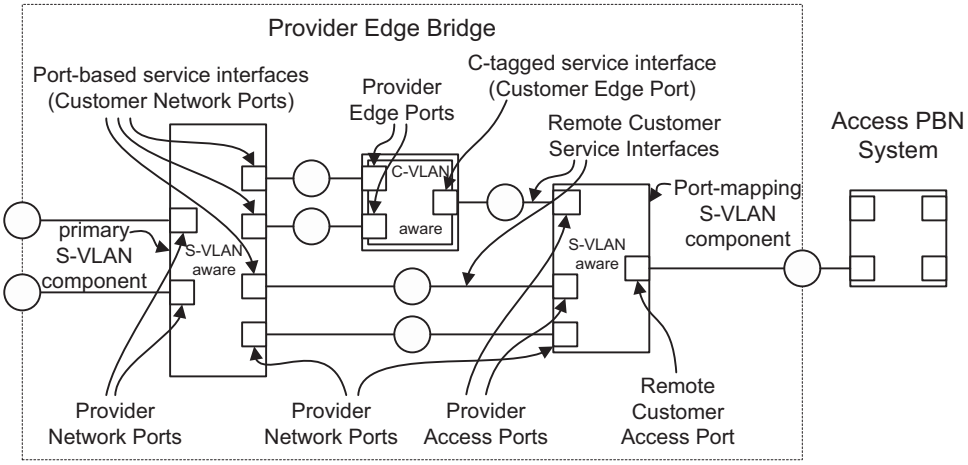


Figure 15-9—RCSIs to a PBN

Each RCSI supported by a RCAP is associated with a PAP connected via an internal LAN to either a CNP, providing a Port-based service interface (15.3), or a CEP, providing a C-tagged service interface (15.4). The external S-VID mapped to an RCSI identifies a service instance originating at a remote customer interface LAN attached to an access PBN (16.2). To provide separation between the external S-VID space used by the access PBN and the internal S-VID space for this PBN, frames on an RCSI do not carry an S-TAG. When frames transit an RCSI the internal S-VID is set by the PVID of the CNP and the external S-VID by the PVID of the PAP.

NOTE—If two CNPs associated with different RCSIs on the same RCAP belong to the same internal S-VLAN, frames received on the RCAP with one S-VID can be transmitted on that same external port with a different S-VID. This is sometimes referred to as “Hairpin Switching” and is described in 16.2.

In addition to the RCSIs, a PNP on the Port-mapping S-VLAN component is connected via an internal LAN to a PNP on the primary S-VLAN component. External service instances that are not associated with an RCSI can be mapped to this Port. This allows multiple service instances to be passed between the PBNs without requiring a separate Port for each service instance. On this interface service frames carry S-TAGs and the VID translation table of the PNP on the S-VLAN component is used to provide independence between internal and external S-VID spaces.

A Provider Edge Bridge can support multiple RCAPs connected to other PBNs. Each RCAP can support multiple RCSIs for one or more customers. Each RCAP is supported by a Port-mapping S-VLAN component as illustrated in Figure 15-10. As shown in the figure, each Port-mapping S-VLAN component with a RCAP can have one PNP and multiple PAPs providing either Port-based or C-tagged RCSIs.

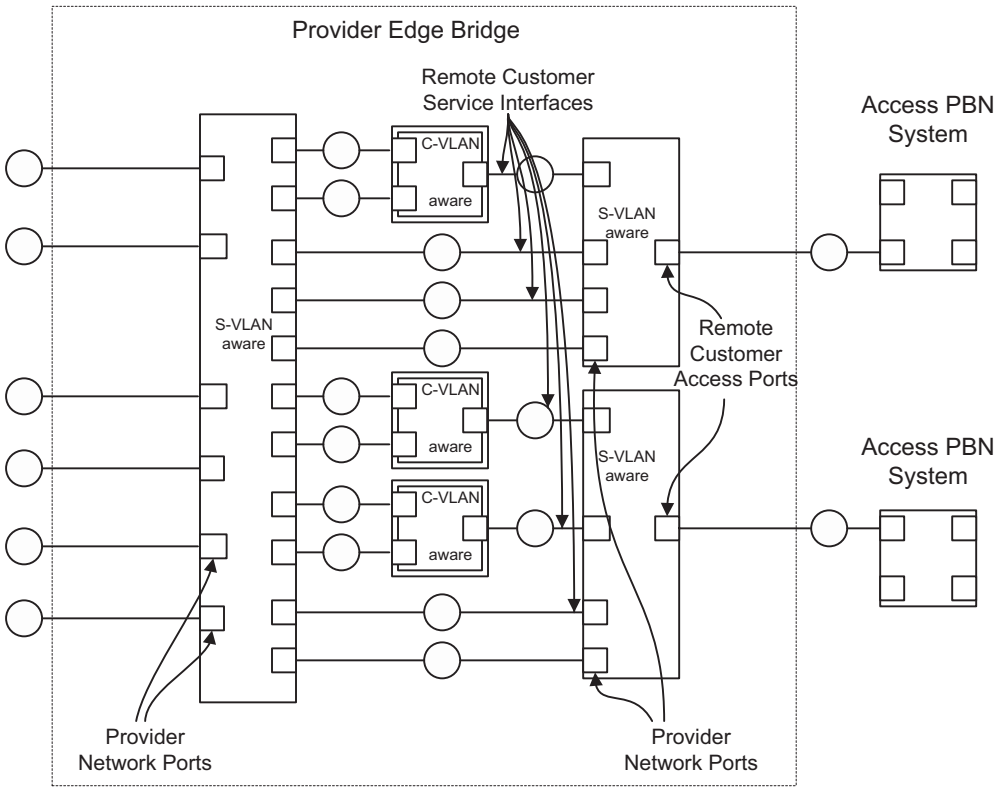


Figure 15-10—Remote Customer Access Ports (RCAPs)

Figure 15-11 shows a C-tagged RCSI. Since S-VLAN components are transparent to C-VLAN control PDUs, i.e., PDUs using addresses in Table 8-1 but not in Table 8-2, these control PDUs exchanged via the CEP reach the next (e.g., customer controlled) C-VLAN component across the access PBN. S-VLAN control PDUs, using addresses in Table 8-2, exchanged on the RCAP will normally reach the neighboring Provider Bridge in the adjacent PBN.

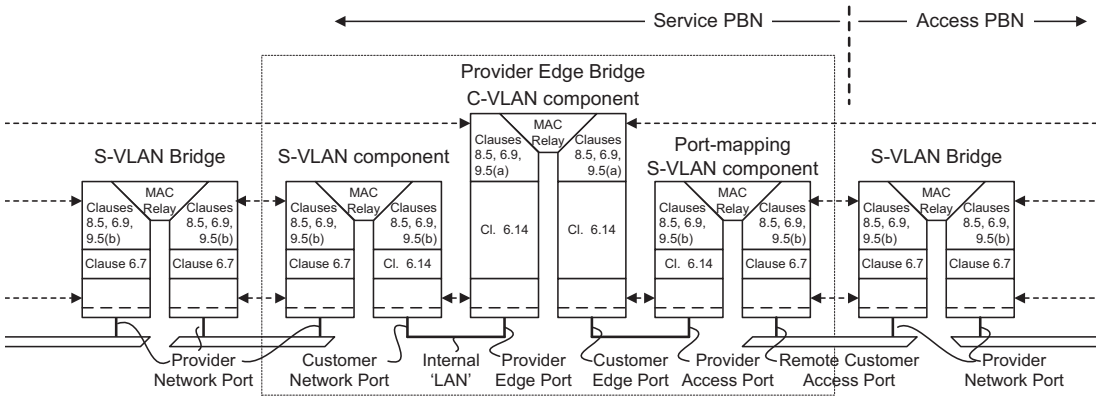


Figure 15-11—C-tagged RCSI to a PBN

Frames traversing the internal LAN between the Port-mapping S-VLAN component and the C-VLAN component do not contain an S-TAG. The S-VID for frames received on this interface by the Port-mapping S-VLAN component is provided by the PAP's PVID.

Figure 15-12 shows a Port-based RCSI. In this case the PAP is connected to a CNP on the S-VLAN component. Frames carried over the internal LAN between the PAP and CNP do not contain an S-TAG. An S-VID is provided at each Port by the respective Port's PVID. These S-VIDs are not required to have the same value.

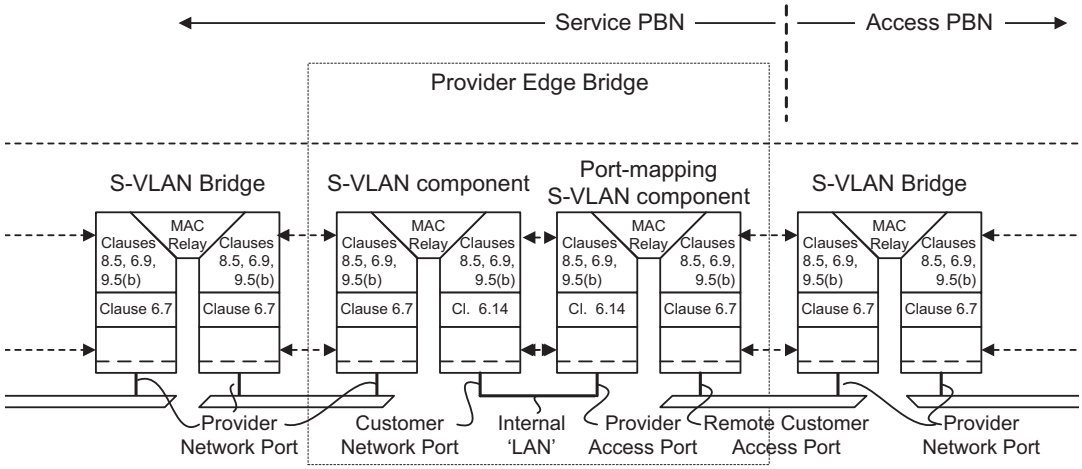


Figure 15-12—Port-based RCSI to a PBN

Figure 15-13 shows the PNP on the Port-mapping S-VLAN component connected to a PNP on the S-VLAN component. Service frames carried over this interface have S-TAGs and S-VID translation can be performed.

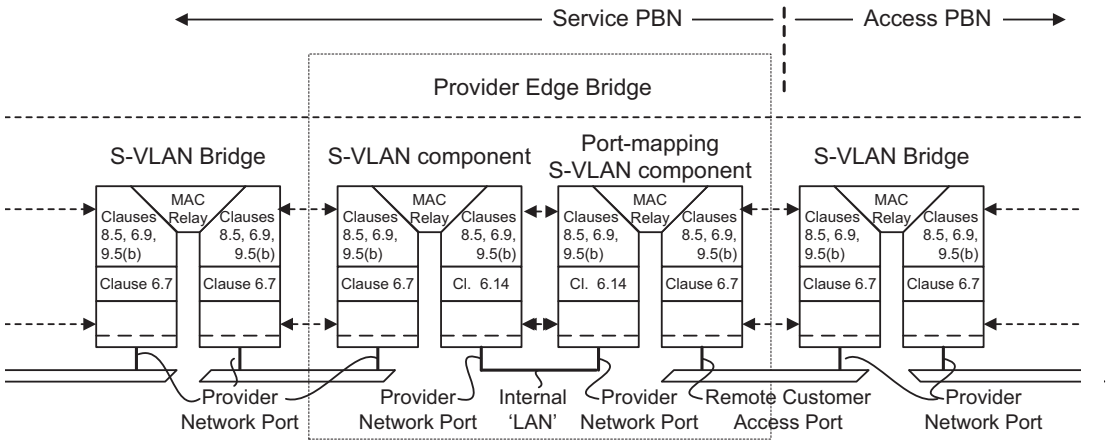


Figure 15-13—Provider Network Port (PNP) interface

15.7 Service instance segregation

Segregation of data frames associated with different MAC Service instances is achieved by supporting each service instance with a separate S-VLAN and ensuring that:

a) Provider Bridges are configured such that no customer data frames are transmitted through a PNP untagged, i.e., without an S-TAG.
b) No frames are accepted, i.e., received and relayed, from any customer system without first being subject to service instance selection.
c) No frames are delivered to any customer system without explicit service instance identification.
d) Prior to transmission through a PNP, customer data frames are received through a CNP within the provider network that is exclusively accessed by a single customer. The S-VIDs of all frames received through that CNP correspond to service instances that the customer is permitted to access.
e) Provider Bridges and the S-VLAN component of each Provider Edge Bridge within the provider network can only be directly controlled by the service provider. Customer equipment, including customer-owned Provider Bridges, are not within the provider network and are controlled by the customer.
f) Only frames that have been transmitted through a PNP can be received through other PNPs within the provider network.

15.8 Service instance selection and identification

Service instance selection is provided for Port-based service interfaces by configuring a CNP with a PVID value corresponding to the S-VID used to identify the service instance and an Acceptable Frame Types value of *Admit Only Untagged and Priority-tagged frames*.

Service instance selection is provided for C-tagged service interfaces by a C-VLAN component internal to a Provider Edge Bridge. The C-VLAN component uses the C-VID to direct frames to an internal PEP supporting a specific service instance. Frames for at most one C-VLAN can be conveyed untagged over a single service instance. Management control of associating C-VIDs with PEPs is accomplished using the C-VID Registration Table (12.13.2), which provides equivalent functionality to configuring the PVID of the internal CNP with the S-VID of the service instance, and adding the PEP to the Member Set, and possibly Untagged Set, of the C-VLAN. No management control is provided for Protocol-based VID assignment on internal CNPs.

NOTE 1—A Provider Edge Bridge can configure the C-VLAN component associated with a CEP to select the same service instance for all frames. This creates a service interface similar, but not identical, to a Port-based service interface. The C-VLAN component allows modification of the C-TAG (insertion of a C-TAG with the PVID value in untagged frames, assigning the PVID value to priority-tagged frames, or stripping the C-TAG from frames forwarded through the PEP) but never forwards a frame with a null C-VID. A Port-based service interface does not modify the C-TAG of received frames in any way. A Provider Edge Bridge may offer a Port-based service interface by configuring the Port to be a CNP rather than a CEP; in which case, there is no associated C-VLAN component.

Service instance selection is provided by the attached customer system for S-tagged service interfaces. The CNP is configured with Enable Ingress Filtering (8.6.2), and the Port is only included in the Member Set for S-VLANs corresponding to service instances that the customer is permitted to use.

For all service interfaces described, the CNP determines the S-VID for each customer data frame as specified in 6.9.1 for an EISS instance using an S-TAG type.

The VID Translation Table for the Port (6.9.1) allows a service provider to assign S-VIDs independently from those used by a customer (or other service provider) to identify service instances on an S-tagged service interface (15.5). The table also allows customers to identify the same service instance by different VIDs at different interfaces.

NOTE 2—The means used by a service provider and a customer to determine the VIDs used by the customer to select and identify a given service instance are outside the scope of this standard.

The service instance for each frame received by the attached customer system is identified in the same way as frames transmitted using the same interface, but not necessarily in the same way that the service instance is selected or identified at other interfaces. A single service instance can support Port-based, C-tagged, and S-tagged service interfaces.

15.9 Service priority selection

For all service interface types, the service priority is selected using the received priority for each frame, possible regenerated using the Priority Regeneration Table (6.9.4). The mechanism for determining the received priority varies with the type of service interface.

Service priority selection is provided for Port-based service interfaces using the received priority signaled from the media access method of the port. If the media access method used to attach to the interface does not directly support priority, this will result in the selection of a single value for all frames. A customer system may also signal priority to a Port-based service interface on a per-frame basis by priority-tagging each frame with an S-TAG with a null VID. Subclause 6.13 specifies a function to support priority-tagging with an S-TAG on Customer Bridges.

Service priority selection is provided by C-tagged service interfaces using the priority conveyed in the C-TAG of each frame. A C-tagged service interface can provide a single service instance for all C-VIDs received and in this way function much as a Port-based service interface with the addition of the capability of the customer to independently signal priority with each frame.

Service priority selection is provided by S-tagged interfaces using the received priority decoded from the PCP field in the S-TAG.

15.10 Service access protection

A customer system or systems at a single location can attach to two or more service interfaces using separate LANs for attachment, thus providing fault tolerance through redundancy of the interface components.

16. Principles of Provider Bridged Network (PBN) operation

This clause establishes the principles and a model of PBN operation. It provides the context necessary to understand how the:

a) Operation of individual Provider Bridges (Clause 8),

b) Configuration and management of individual Provider Bridges (Clause 12), and

c) Management of spanning tree and VLAN topologies within a provider network (Clause 7, Clause 11, Clause 13)

support, preserve, and maintain the quality of each instance of the MAC Service offered to the customers of the provider network (Clause 6, Clause 15), including:

d) Independence of each service instance supported by a service provider from other service instances (Clause 15).

e) Identification of service instances within the provider network (Clause 15, 8.8).

f) Maintenance of service availability in the event of the failure, restoration, removal, or insertion of LAN components connecting a customer network to a provider network (Clause 6, Clause 11, Clause 13, 16.2).

A PBN is a Virtual Bridged Network that comprises Provider Bridges (S-VLAN Bridges and Provider Edge Bridges) and attached LANs, under the administrative control of a single service provider. The principal elements of provider network operation are those specified in Clause 7 for Virtual Bridged Networks in general, as amended by this clause.

NOTE 1—Unless explicitly stated, the term “provider network” in this standard refers to a PBN. The term “Provider Bridged Network (PBN)” is used exclusively to refer to networks configured and managed as specified by this clause and comprising only (a) Provider Bridges and Provider Edge Bridges and (b) communications media and equipment providing the ISS (IEEE Std 802.1AC). Although the requirements of Clause 15 are generally applicable to similar services, a generalized framework for all network designs that could support these requirements, while useful in the context of other equipment and services, is outside the scope of this standard. This clause describes specific best practice for PBNs to ensure that the requirements for Bridge functionality are clear. Conformance of a Provider Bridge implementation to this standard does not require that the implementation be used as specified in this clause, merely that it is capable of being so used.

NOTE 2—Within a provider network, an instance or instances of the MAC Service are reserved for the service provider’s own use to configure and manage the network. All frames associated with such service instances, and that are not confined to an individual LAN, are subject to service instance selection, segregation, and identification as specified in 16.1.

16.1 PBN overview

The principal elements of PBN operation comprise:

a) Service instance segregation within the provider network for customer frames (15.6).

b) Service instance selection on ingress, and service instance identification on egress, for each customer frame (15.8).

c) Resource allocation and configuration to provide service instance connectivity (16.3).

The principal elements of PBN operation may also include:

d) Management of customer end station address learning (16.4).

e) Prevention of connectivity loops formed through attached networks (16.5).

16.2 Provider Bridged Network (PBN)

An example PBN is illustrated by Figure 16-1.

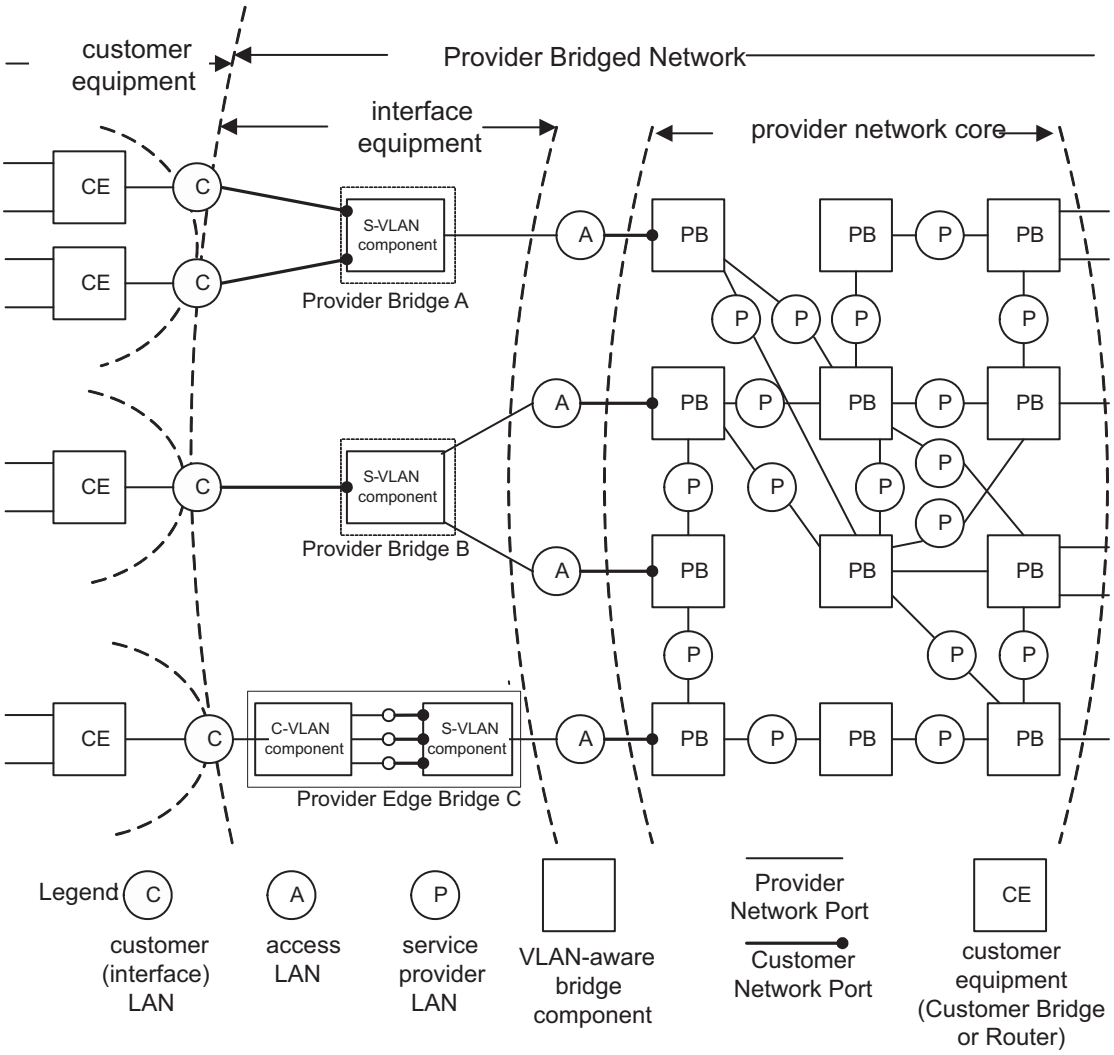


Figure 16-1—PBN with interface examples

Customer equipment attaches, via one or more customer interface LANs, to equipment that provides the service interfaces specified in Clause 15. That interface equipment can be located in the core of the provider network, such that both the equipment and the attached LANs are secure against direct addition of frames either by the customer or by others. More commonly the interface equipment connects to the network core using one or more access LANs, which can be subject to external interference. Figure 16-1 provides examples. Within the network core, Provider Bridges and LANs are secured so that only the service provider can manage the reception, transmission, and relay of frames between Provider Bridges.

The arbitrary physical network topology of the network core and the connectivity that it provides to support segregated instances (15.6) of the MAC Service is designed and managed (16.3) by the service provider to meet bandwidth and service availability requirements at the PNPs. Application of the S-VLAN ingress and egress rules at these Ports in support of service instance selection and identification (15.8) ensures that frames cannot be transmitted or received on any service instance by any customer's equipment without prior agreement with the service provider.

Although the application of the ingress and egress rules, together with the use of the MSTP restrictedRole and restrictedTcn (13.27.64, 13.27.65) parameters and MVRP registration controls (16.3), permit service providers to allow direct attachment of customer-operated equipment to access LANs, there are commonly other reasons, such as Operations, Administration, and Maintenance (OAM) support of access LANs, why interface equipment is mandated. The interface equipment, as illustrated by, but not limited to, the examples in Figure 16-1 can be used to partition and enhance network access functionality to provide:

a) Service instance multiplexing on a single access LAN
b) Provision of resilient, and optionally physically route diverse, access
c) Reduced management of customer use of multiple service instances
d) Selective multiplexing of C-VLANs onto service instances
e) Reliable identification of the customer point of attachment

without requiring customer systems to understand the internal details of the provider network.

Provider Bridge A in Figure 16-1 uses physically separate customer interface LANs to provide separate Port-based service interfaces to the customer equipment and uses S-TAGs to multiplex the corresponding service instances over a single access LAN. The interface equipment can be managed by the service provider to use S-VIDs that do not require use of a VID Translation Table at the edge of the core network. Alternatively, the latter can translate S-VIDs to remove the need for such management, with all interface equipment using the same S-VIDs in the same way.

Provider Bridge B in Figure 16-1 uses a single customer interface LAN to provide a Port-based service interface to the customer equipment and uses two access LANs to provide resilient connectivity to distinct Provider Bridges in the core network. Receipt of Provider Bridge BPDUs by Bridge B protects against the failure of an access LAN, of one of the core Bridges, or of some internal physical connectivity within the provider network. Use of the MSTP restrictedRole and restrictedTcn parameters by PNPs ensures that receipt of frames from the access LANs cannot disrupt the active topology or address learning within the core network. Where multiple service instances are provided at a single customer point of attachment, both access links can be used.

Provider Edge Bridge C in Figure 16-1 provides a C-tagged service interface to the customer equipment and uses C-TAGs on the customer interface LAN to select between multiple S-VLAN-tagged service instances on the access LAN. Individual C-VLANs can be conveyed on any service instance, and this distribution of C-VLANs can be changed in response to changes in the connectivity offered by the service instances through customer systems at other points of customer attachment. The traffic for a particular C-VLAN can be the majority of that carried on a specific service instance; specifying that frames for that C-VLAN are untagged on the internal LAN that corresponds to that service instance within the Provider Edge Bridge allows those frames to be carried through the provider network without a C-VID following the S-VID if the overhead of conveying the additional octets is a concern.

NOTE 1—In the scenario where a customer network has multiple service interfaces to a provider network, and the customer network VLAN topology is such that frames sent from a single MAC source on different C-VLANs will enter the provider network on different service interfaces and be mapped to the same service instance (same S-VLAN), then the C-MAC address will appear to be duplicated and potentially cause oscillation in the learning process within the Provider Network. This scenario can be avoided by restricting a MAC address to enter the provider network at the same service interface for all C-VLANs, or by mapping the different C-VLANs to different service instances (different S-VLANs), or by restricting the service instance to be point-to-point so the provider Bridges do not need to learn the C-MAC addresses.

In some cases a service provider needs to reach a customer interface LAN that is not directly attached to the service provider’s network but is attached instead to another PBN. Figure 16-2 shows some examples in which a customer interface LAN is connected to an access PBN that is not the PBN providing service to the customer.

NOTE 2—The PBN providing access to the customer interface LANs in these examples can provide other services to its own customers as well.

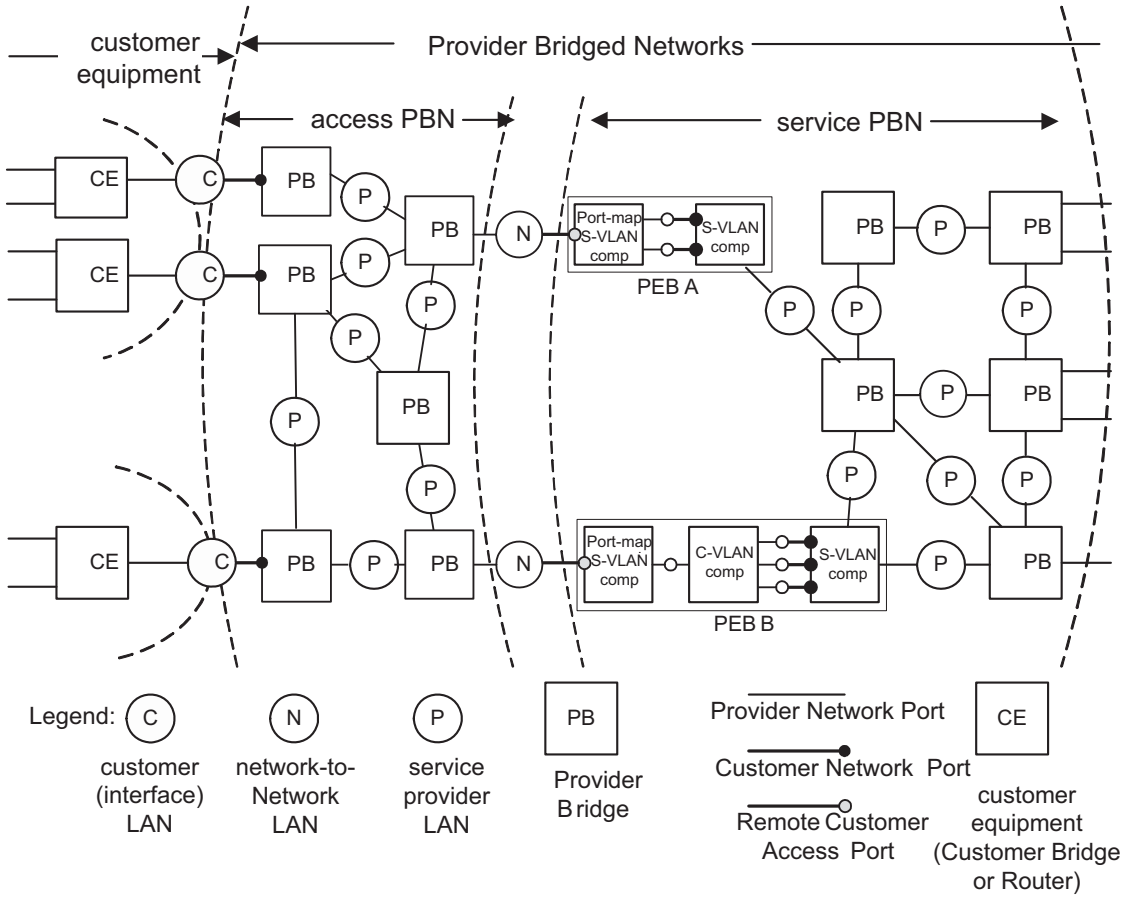


Figure 16-2—Examples of remote customer service access via a second PBN

In these examples the service provider uses a Port-based service provided by the access PBN to reach the customer interface LANs. Each such access service is identified by a distinct S-VID at the network-to-network interface LAN. The service PBN uses this S-VID to select an RCSI that provides either a Port-based or C-tagged service interface as specified in Clause 15. An RCSI provides service instance selection and identification (15.3) and service management for each customer interface LAN. Each RCSI carries frames to/from a single customer interface LAN.

PEB A in Figure 16-2 receives traffic from two customer interface LANs attached to the access PBN. The traffic from each customer interface LAN is carried over a separate RCSI. In the example shown each RCSI is connected to a Port-based service interface (CNP). If the two customer interface LANs participate in the same service instance (i.e., their RCSI CNPs belong to the same S-VLAN) a frame received from one RCSI CNP can be transmitted on the other RCSI CNP. Thus a frame received on the network-to-network LAN with one S-VID can be subsequently transmitted on that same external LAN with a different S-VID. This behavior is sometimes called “Hairpin Switching”.[27]

The structure allowing a frame to be received and subsequently transmitted on the same external interface while avoiding loops and misdelivery of multicast frames is illustrated in Figure 16-3. Frames from/to CE_1 have S-VID A and frames from/to CE_2 have S-VID B. Thus the two customer interface LANs cannot exchange traffic within the access PBN. In PEB A external S-VIDs A and B select or identify different RCSI PAPs.

[27] For example, this behavior is called “Hairpin Switching” in MEF 26 [B53].

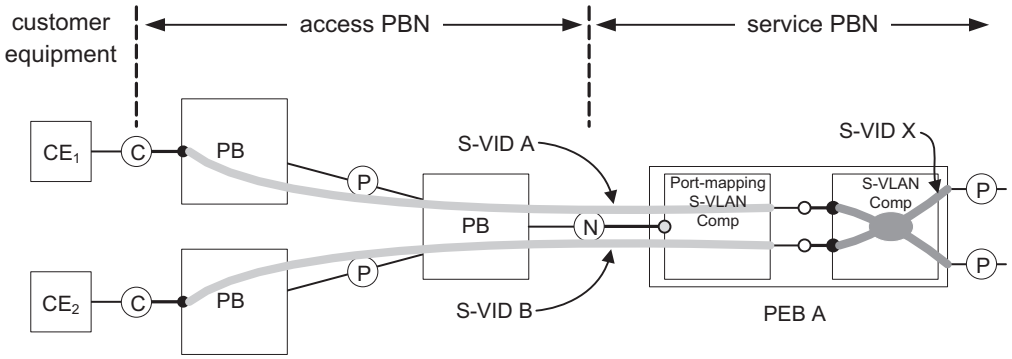


Figure 16-3—Access service separation and "Hairpin Switching"

In this example, both RCSI CNPs belong to the same internal S-VLAN in the service provider's network identified by S-VID X. Frames can be relayed between all Ports belonging to S-VID X, including between the two RCSIs. When a frame is received on one RCSI and subsequently transmitted on the other RCSI the frame is received and transmitted on the same external RCAP. However, in this case the external S-VIDs in the received and transmitted frames are different. If the sets of endpoints in the access PBN associated with each external S-VID are disjoint there is no possibility of looping or misdelivery of multicast frames.

PEB B in Figure 16-2 receives traffic from a customer interface LAN and provides a C-tagged RCSI (CEP). The capabilities of a C-tagged RCSI are the same as those provided by an external CEP as described above.

16.3 Service instance connectivity

The VLAN Topology of each S-VLAN is established by the mechanisms introduced in 7.1 and Figure 7-1. The service provider can use and configure MSTP to provide a number of independent spanning tree active topologies and can assign each S-VLAN independently to one of these to best use the resources in the network. MVRP running in the context of each spanning tree active topology configures the extent of each S-VLAN to the subset of that active topology necessary to support connectivity between the customer points of attachment to the MAC Service instance provided, and it can reconfigure that connectivity as required if the spanning tree active topology changes.

NOTE 1—Autoconfiguration of the extent of each S-VLAN is accomplished by the service provider configuring the MVRP Administrative Control "Registration Fixed (New ignored)" for the S-VLAN on each CNP where the corresponding MAC Service Instance can be selected. The Enable Ingress Filtering parameter is not typically used within an individual provider network, as it limits the ability of the network to carry service instances following changes in the active topology. However, it can be used to limit the reachability of service instances used by the service provider for network management and to restrict service instances carried from one provider network domain to another.

The operation of MSTP within a provider network is independent of the operation of any spanning tree protocol within attached customer networks. This independence is achieved by using the Provider Bridge Group Address (Table 8-1) as the destination address of all MSTP BPDUs transmitted on all Provider Bridge Ports and by setting the restrictedRole and restrictedTcn parameters (13.27.64, 13.27.65) for CNPs. Frames received by CNPs and addressed to the Bridge Group Address are subject to service instance selection and relay in the same way as customer data frames.

NOTE 2—Customer BPDUs addressed to the Bridge Group Address are conveyed transparently, allowing the customer to use an instance of MSTP or RSTP that is completely independent of the provider network to establish and maintain full and loop-free connectivity of the customer connected networks and services. A customer can also use MVRP to limit the transmission of frames assigned to C-VLANs to the service instances required for C-VLAN connectivity.

The operation of MVRP within a provider network is independent of the operation of any configuration protocol within attached customer networks. The Provider Bridge MVRP Address (Table 8-1) is used as the destination address of all MVRPDUs transmitted in support of the MVRP Application. Frames received by CNPs and addressed to an MRP Application Address (Table 10-1) not in use by the S-VLAN component are subject to service instance selection and relay in the same way as customer data frames. The MVRP Administrative Control for each S-VLAN is either “Registration Fixed (New ignored)” or “Registration Forbidden” on all CNPs, so no information is received from any Provider Bridge MVRPDU that has been erroneously transmitted by a customer system.

16.4 Service provider learning of customer end station addresses

Customer data frames for any given MAC Service instance are restricted to that part of the provider network that supports the VLAN topology of the associated S-VLAN as described in 16.3 and are further restricted by learning the source addresses of frames as described in Clause 7 and Clause 8.

In a PBN that commonly provides interfaces to each customer at a small fraction of the total number of customer interfaces provided, the requirement for learning customer end station addresses can be much reduced by applying enhanced filtering utility criteria (8.7). In particular, learning can be restricted to the ingress and egress Provider Bridge Ports of each S-VLAN that connects only two customer points of attachment, or to the customer systems attached to those Ports.

The “new” flag in MVRP can be used to flush learned addresses on a specific service instance in a PBN in response to a topology change in the Customer Network.

16.5 Detection of connectivity loops through attached networks

The transmission and reception of MSTP BPDUs through CNPs will detect accidental direct connection of those ports, or their interconnection by a network that is transparent to frames with the Provider Bridge Group Address as the destination MAC address. However, a service provider cannot rely on any customer network relaying such frames and should develop a policy and mechanisms to deal with potential data loops that can arise if the attached customer systems do not correctly operate their own instance or instances of a spanning tree protocol.

NOTE 1—Use of the restrictedRole parameter at ingress ports ensures that receipt of BPDUs addressed to the Provider Bridge Group Address cannot disrupt internal connectivity within the provider network.

NOTE 2—Specification of service provider policies, mechanisms, and heuristics used to detect or minimize the impact of data loops created by customer systems is not addressed by this standard. They can include, but are not limited to, bandwidth limitation, charging policies, detection of the repetitive movement of the apparent location of customer stations, and customer agreement to allow the use of service provider loop detection protocols by not filtering the associated frames.

NOTE 3—A data loop is not the only possible cause of excess bandwidth consumption by a given customer of a provider network, and the service provider is usually required to meet service guarantees to other customers irrespective of the cause of the excess bandwidth demand. Data loops are not a unique threat to satisfactory overall network performance. Their distinct characteristic is consumption of discretionary bandwidth without benefiting any customer. The customer that creates the loop can suffer particularly serious network degradation or excess cost as the service provider limits the total bandwidth consumed by that customer. It is therefore in the interests of each customer and the service provider to raise service satisfaction by preventing and detecting loops.

Each C-VLAN component within a Provider Edge Bridge implements RSTP, with the enhancements to support loop-free connectivity between CEPs, as specified in 13.41, thus interoperating with customer equipment and spanning tree configurations to support reliable and deterministic prevention of loops, and supporting provision of redundant connectivity.

16.6 Network management

Management of a Provider Bridge is directly under the control of the service provider. Provider network customers shall not have access to managed objects related to elements of Provider Bridges within the provider network.

17. Management Information Base (MIB)

This clause (Clause 17) contains a complete SMIv2 MIB set for all features of this standard.

17.1 Internet Standard Management Framework

For a detailed overview of the documents that describe the Internet Standard Management Framework, refer to section 7 of IETF RFC 3410 (2002).

Managed objects are accessed via a virtual information store, termed the *Management Information Base* or *MIB*. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This clause specifies a MIB module that is compliant to the SMIv2, which is described in IETF STD 58, IETF RFC 2578, IETF RFC 2579, and IETF RFC 2580.

Control of the transmission of Fault Alarms, which are Notifications in SNMP, are described by IETF STD 62, IETF RFC 3413, IETF RFC 3417, and IETF RFC 4789. As a consequence of the concentration of control of the reporting of SNMP Notifications in the SNMP-TARGET-MIB and SNMP-NOTIFICATION-MIB of IETF RFC 3413, the variables controlling Fault Alarm notifications require no specific objects in the MIB modules defined in this standard.

17.2 Structure of the MIB

The IEEE 802.1Q MIB set comprises a number of modules. These are summarized in Table 17-1 with the name of each module and references to its specification in this clause (Clause 17) and to the clause that specifies the managed functionality. The table also identifies the amendment or amendment project that introduced that functionality[28] (and unless otherwise noted) the MIB module for its management. The definitive specification of both functionality and MIB module is provided by this standard, not by any prior amendment.

Prior revisions of this standard relied on MIB modules defined by the IETF Bridge Working Group. IETF RFC 4663 [B35] describes more details of the IETF transition of responsibility for bridging-related MIB modules from the IETF Bridge MIB Working Group to the IEEE 802.1 Working Group.

The REVISION statements in each MIB module describe its history and development.

[28] Functionality added to an IEEE standard is often referred to using an amendment or amendment project designation long after it has been incorporated in a revision of the standard, even if the amendment was not independently published and the functionality has since been revised. This table column is provided as an aid to identifying this standard's specification of that functionality and MIB module.

Table 17-1—IEEE 802.1Q MIB modules

Module	Structure, relationships, security considerations, module definition	Managed functionality	Initial functionality and MIB specification
IEEE8021-TC-MIB	17.2.1, 17.3.1, 17.4.1, 17.7.1	Textual conventions	IEEE Std 802.1ap
IEEE8021-BRIDGE-MIB	17.2.2, 17.3.2, 17.4.2, 17.7.2	Clause 8	IEEE Std 802.1D, 802.1p, IEEE Std 802.1t. MIB adapted from IETF RFC 4188, IETF RFC 4363
IEEE8021-SPANNING-TREE-MIB	17.2.3, 17.3.3, 17.4.3, 17.7.3	Clause 13	IEEE Std 802.1w. MIB adapted from IETF RFC 4318
IEEE8021-Q-BRIDGE-MIB	17.2.4, 17.3.4, 17.4.4, 17.7.4	Clause 8	IEEE Std 802.1Q, IEEE Std 802.1u, IEEE Std 802.1v. MIB adapted from IETF RFC 4363.
IEEE8021-PB-MIB	17.2.5, 17.3.5, 17.4.5, 17.7.5	Clause 16	IEEE Std 802.1ad. MIB in IEEE Std 802.1ap
IEEE8021-MSTP-MIB	17.2.6, 17.3.6, 17.4.6, 17.7.6	Clause 13	IEEE Std 802.1s. MIB in IEEE Std 802.1ap
IEEE8021-CFM-MIB	17.2.7, 17.3.7, 17.4.7, 17.7.7.1	Clause 20	IEEE Std 802.1ag
IEEE8021-CFM-V2-MIB	17.2.7, 17.3.7, 17.4.7, 17.7.7.2	Clause 20	IEEE Std 802.1ag. MIB updated in IEEE Std 802.1ap
IEEE8021-PBB-MIB	17.2.8, 17.3.8, 17.4.8, 17.7.8	Clause 26	IEEE Std 802.1ah. MIB updated in IEEE Std 802.1ap
IEEE8021-DDCFM-MIB	17.2.9, 17.3.9, 17.4.9, 17.7.9	Clause 29	IEEE Std 802.1Qaw
IEEE8021-PBBTE-MIB	17.2.10, 17.3.10, 17.4.10, 17.7.10	25.10	IEEE Std 802.1Qay
IEEE8021-TPMR-MIB	17.2.11, 17.3.11, 17.4.11, 17.7.11	5.13, 5.15	IEEE Std 802.1aj
IEEE8021-FQTSS-MIB	17.2.12, 17.3.12, 17.4.1, 17.7.12	Clause 34	IEEE Std 802.1Qav
IEEE8021-CN-MIB	17.2.13, 17.3.13, 17.4.13, 17.7.13	Clause 30	IEEE Std 802.1Qau
IEEE8021-SRP-MIB	17.2.14, 17.3.14, 17.4.14, 17.7.14	Clause 35	IEEE Std 802.1Qat
IEEE8021-MVRPX-MIB	17.2.15, 17.3.15, 17.4.15, 17.7.15	11.2	IEEE Std 802.1Qbe
IEEE8021-MIRP-MIB	17.2.16, 17.3.16, 17.4.16, 17.7.16	Clause 39	IEEE Std 802.1Qbe
IEEE8021-PFC-MIB	17.2.17, 17.3.17, 17.4.17, 17.7.17	Clause 36	IEEE Std 802.1Qbb
IEEE8021-TEIPS-MIB	17.2.18, 17.3.18, 17.4.18, 17.7.18	26.11	IEEE Std 802.1Qbf
IEEE8021-SPB-MIB	17.2.19, 17.3.19, 17.4.19, 17.7.19	Clause 27, Clause 28, Clause 45	IEEE Std 802.1aq. IEEE Std 802.1Qca added PCR and MIB objects.
IEEE8021-EVB-MIB	17.2.20, 17.3.20, 17.4.20, 17.7.20	5.23, 5.24	IEEE Std 802.1Qbg
IEEE8021-ECMP-MIB	17.2.21, 17.3.21, 17.4.21, 17.7.21	Clause 44, Clause 28	IEEE Std 802.1Qbp
IEEE8021-ST-MIB	17.2.22, 17.3.22, 17.4.22, 17.7.22	8.6, 12.29	IEEE Std 802.1Qbv
IEEE8021-Preemption-MIB	17.2.23, 17.3.23, 17.4.23, 17.7.23	8.6, 12.30	IEEE Std 802.1Qbu
IEEE8021-PSFP-MIB	17.2.24, 17.3.24, 17.4.24, 17.7.24	8.6, 12.31	IEEE Std 802.1Qci
IEEE8021-TSN-REMOTE-MANAGEMENT-MIB	17.2.25, 17.3.25, 17.4.25, 17.7.25	12.32	IEEE Std 802.1Qcc

17.2.1 Structure of the IEEE8021-TC-MIB

The IEEE8021-TC-MIB defines textual conventions used throughout the IEEE 802.1Q MIB modules and summarized in Table 17-2. Textual conventions (TCs) originally appeared in each of the MIB modules for IEEE Std 802.lQ produced by the IETF. Many of the original IETF TCs are still used in the various MIB modules for VLAN-Bridge management and have not been imported into this module.

Table 17-2—IEEE8021-TC-MIB structure

IEEE8021-TC-MIB object	Reference
IEEE8021PbbComponentIdentifier	12.3 l)
IEEE8021PbbComponentIdentifierOrZero	12.3 l)
IEEE8021PbbServiceIdentifier	12.16.3, 12.16.5
IEEE8021PbbServiceIdentifierOrUnassigned	12.16.3, 12.16.5
IEEE8021PbbIngressEgress	12.16.3, 12.16.5
IEEE8021PriorityCodePoint	12.6.2
IEEE8021BridgePortNumber	12.3 i), 17.3.2.2
IEEE8021BridgePortNumberOrZero	12.3 i), 17.3.2.2
IEEE8021BridgePortType	12.16.1.1.3 h4), 12.16.2.1, 12.13.1.1, 12.13.1.2
IEEE8021VlanIndex	9.6
IEEE8021VlanIndexOrWildcard	9.6
IEEE8021MstIdentifier	13.8
IEEE8021ServiceSelectorType	—
IEEE8021ServiceSelectorValueOrNone	—
IEEE8021ServiceSelectorValue	—
IEEE8021PortAcceptableFrameTypes	12.10.1.3, 12.13.2.3, 12.13.2.4
IEEE8021PriorityValue	12.13.2.3
IEEE8021PbbTeProtectionGroupId	12.19.2
IEEE8021PbbTeEsp	3.86
IEEE8021PbbTeTSidId	3.278
IEEE8021PbbTeProtectionGroupConfigAdmin	26.10.3.3.4, 26.10.3.3.5, 26.10.3.3.6, 26.10.3.3.7, 12.18.2.1.3d)
IEEE8021PbbTeProtectionGroupActiveRequests	12.18.2.3.2
ieee8021TeipsV2Ipgid	12.24.2
ieee8021TeipsV2IpgConfigAdmin	26.10.3.3.4, 26.10.3.3.5, 26.10.3.3.6, 26.10.3.3.7, 12.14.2.1.2 f) and j)
ieee8021TeipsV2IpgActiveRequests	12.24.2.2.1 b)
ieee8021TeipsV2Segid	26.11.1, 3.115
ieee8021TeipsV2Smpid	26.11.1, 3.225

The IEEE8021-FQTSS-MIB module in 17.7.12 defines additional TEXTUAL-CONVENTIONs that are utilized by the managed objects that support use of the Credit-based shaper algorithm (8.6.8.2, Clause 34).

The textual conventions used by IEEE 802.1Q MIB modules not contained in this TC module, but contained in IETF RFC 4318 and IETF RFC 4363 are as follows:

BridgeId
Timeout
PortList
VlanIdOrAny
VlanIdOrNone
VlanIdOrAnyOrNone

17.2.2 Structure of the IEEE8021-BRIDGE-MIB

This MIB module is based upon the BRIDGE MIB version in IETF RFC 4188 and the P-BRIDGE MIB originally in IETF RFC 4363. While many tables and objects are similar, the IEEE8021-BRIDGE-MIB has been reindexed and rerooted.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. The overall structure and assignment of objects to their subtrees is shown below. Where appropriate, the corresponding IETF RFC 4188 object name, IEEE 802.1D™-2004 [B12] management object name, and reference are also included. If the IETF RFC mapping is missing, it means there is no equivalent in the original IETF MIB modules. If the Managed Object is missing, it means that no managed object is specified in the referenced clause.

Table 17-3 indicates the structure of the IEEE8021-BRIDGE-MIB module as well as showing its relationship to the IETF MIB that is being obsoleted.

Table 17-3—IEEE8021-BRIDGE-MIB structure

IEEE8021-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021BridgeBaseTable	**dot1dBase**	12.4.1
ieee8021BridgeBaseComponentId*	—	—
ieee8021BridgeBaseBridgeAddress	dot1dBaseBridgeAddress	12.4.1.1.3 a)
ieee8021BridgeBaseNumPorts	dot1dBaseNumPorts	12.4.1.1.3 c)
ieee8021BridgeBaseComponentType	—	12.3 m)
ieee8021BridgeBaseDeviceCapabilities	dot1dDeviceCapabilities	12.10.1.1.3 b)
ieee8021BridgeBaseTrafficClassesEnabled	dot1dTrafficClassesEnabled	—
ieee8021BridgeBaseMmrpEnabledStatus	dot1dGmrpStatus	—
ieee8021BridgeBaseRowStatus	—	—

Table 17-3—IEEE8021-BRIDGE-MIB structure *(continued)*

IEEE8021-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021BridgeBasePortTable	**dot1dBasePortTable**	12.4.2
ieee8021BridgeBasePortComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	12.4.2.1
ieee8021BridgeBasePortIfIndex	dot1dBasePortIfIndex	—
ieee8021BridgeBasePortDelayExceededDiscards	dot1dBasePortDelayExceededDiscards	12.6.1.1.3 f)
ieee8021BridgeBasePortMtuExceededDiscards	dot1dBasePortMtuExceededDiscards	12.6.1.1.3 g)
ieee8021BridgePortCapabilities	dot1dPortCapabilities	12.10.1.1.3 c)
ieee8021BridgeBasePortTypeCapabilities	—	—
ieee8021BridgeBasePortType	—	—
ieee8021BridgeBasePortExternal	—	—
ieee8021BridgeBasePortAdminPointToPoint	dot1dStpPortAdminPointToPoint	12.8.2.1.3 o)
ieee8021BridgeBasePortOperPointToPoint	dot1dStpPortOperPointToPoint	12.8.2.1.3 p)
ieee8021BridgeBasePortName	ifDescr	12.4.2.1
ieee8021BridgeTpPortTable	**dot1dTpPortTable**	12.4.2
ieee8021BridgeTpPortComponentId*	—	—
ieee8021BridgeTpPort*	dot1dTpPort	—
ieee8021BridgeTpPortMaxInfo	dot1dTpPortMaxInfo	—
ieee8021BridgeTpPortInFrames	dot1dTpPortInFrames	12.6.1.1.3 a)
ieee8021BridgeTpPortOutFrames	dot1dTpPortOutFrames	12.6.1.1.3 d)
ieee8021BridgeTpPortInDiscards	dot1dTpPortInDiscards	12.6.1.1.3 c)
ieee8021BridgePortPriorityTable	**dot1dPortPriorityTable**	12.6.2
(AUGMENTS ieee8021BridgeBasePortEntry)	(AUGMENTS dot1dBasePortEntry)	—
ieee8021BridgePortDefaultUserPriority	dot1dPortDefaultUserPriority	—
ieee8021BridgePortNumTrafficClasses	dot1dPortNumTrafficClasses	—
ieee8021BridgePortPriorityCodePointSelection	—	12.6.2.6, 12.6.2.7
ieee8021BridgePortUseDEI	—	12.6.2.11, 12.6.2.12
ieee8021BridgePortRequireDropEncoding	—	12.6.2.13, 12.6.2.14
ieee8021BridgePortServiceAccessPrioritySelection	—	12.6.2.15, 12.6.2.16

Table 17-3—IEEE8021-BRIDGE-MIB structure *(continued)*

IEEE8021-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021BridgeUserPriorityRegenTable	**dot1dUserPriorityRegenTable**	IEEE Std 802.1AC
ieee8021BridgeUserPriorityRegenComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	—
ieee8021BridgeUserPriority*	dot1dUserPriority	—
ieee8021BridgeRegenUserPriority	dot1dRegenUserPriority	—
ieee8021BridgeTrafficClassTable	**dot1dTrafficClassTable**	Table 8-5
ieee8021BridgeTrafficClassComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	—
ieee8021BridgeTrafficClassPriority*	dot1dTrafficClassPriority	—
ieee8021BridgeTrafficClass	dot1dTrafficClass	—
ieee8021BridgePortOutboundAccessPriorityTable	**dot1dPortOutboundAccessPriorityTable**	Table 8-5
ieee8021BridgePortOutboundAccessPriorityComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	—
ieee8021BridgePortOutboundAccessPriority*	dot1dPortOutboundAccessPriority	—
ieee8021BridgePortDecodingTable	—	12.6.2
ieee8021BridgePortDecodingComponentId*	—	—
ieee8021BridgePortDecodingPortNum*	—	—
ieee8021BridgePortDecodingPriorityCodePointRow*	—	—
ieee8021BridgePortDecodingPriorityCodePoint*	—	—
ieee8021BridgePortDecodingPriority	—	12.6.2.7, 12.6.2.8
ieee8021BridgePortDecodingDropEligible	—	12.6.2.11, 12.6.2.12
ieee8021BridgePortEncodingTable	—	12.6.2
ieee8021BridgePortEncodingComponentId*	—	—
ieee8021BridgePortEncodingPortNum*	—	—
ieee8021BridgePortEncodingPriorityCodePointRow*	—	—
ieee8021BridgePortEncodingPriorityCodePoint*	—	—
ieee8021BridgePortEncodingDropEligible*	—	—
ieee8021BridgePortEncodingPriority	—	12.6.2.9, 12.6.2.10

Table 17-3—IEEE8021-BRIDGE-MIB structure *(continued)*

IEEE8021-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021BridgeServiceAccessPriorityTable	—	—
ieee8021BridgeServiceAccessPriorityComponentId*	—	—
ieee8021BridgeServiceAccessPriorityPortNum*	—	—
ieee8021BridgeServiceAccessPriorityReceived*	—	—
ieee8021BridgeServiceAccessPriorityValue	—	12.6.2.15, 12.6.2.16
ieee8021BridgePortMrpTable	**dot1dPortGarpTable**	12.9
(AUGMENTS ieee8021BridgeBasePortEntry)	(AUGMENTS dot1dBasePortEntry)	12.9.1.1, 12.9.1.2
ieee8021BridgePortMrpJoinTime	dot1dPortGarpJoinTime	—
ieee8021BridgePortMrpLeaveTime	dot1dPortGarpLeaveTime	—
ieee8021BridgePortMrpLeaveAllTime	dot1dPortGarpLeaveAllTime	—
ieee8021BridgePortMmrpTable	**dot1dPortGmrpTable**	12.11
(AUGMENTS ieee8021BridgeBasePortEntry)	(AUGMENTS dot1dBasePortEntry)	—
ieee8021BridgePortMmrpEnabledStatus	dot1dPortGmrpStatus	—
ieee8021BridgePortMmrpFailedRegistrations	dot1dPortGmrpFailedRegistrations	—
ieee8021BridgePortMmrpLastPduOrigin	dot1dPortGmrpLastPduOrigin	—
ieee8021BridgePortRestrictedGroupRegistration	dot1dPortRestrictedGroupRegistration	12.11.1.3
ieee8021BridgeILanIfTable	—	17.3.2.2
ieee8021BridgeILanIfRowStatus	—	—
ieee8021BridgeDot1dPortTable	—	17.5.3
ieee8021BridgeBasePortComponentId*	—	—
ieee8021BridgeBasePort*	—	—
ieee8021BridgeDot1dPortRowStatus	—	—
ieee8021BridgePortTable	—	12.5.1
ieee8021BridgePhyPort	—	—
ieee8021BridgePhyIfIndex	—	—
8021BridgePhyMacAddress	—	—
ieee8021BridgePhyPortToComponentId	—	—
ieee8021BridgePhyPortToInternalPort	—	—
ieee8021BridgeBaseIfToPortTable	—	17.3.2
ieee8021BridgeBaseIfToPortComponentID	—	—
ieee8021BridgeBaseIfIndexPort	—	—

*This object is an INDEX of the table in which it resides.

The IEEE8021-BRIDGE-MIB contains the following object subtrees:

a) The ieee8021BridgeBase Subtree
   This subtree contains the objects that are applicable to all types of Bridges.
b) The ieee8021BridgeTp Subtree
   This subtree contains objects that describe the entity's state with respect to transparent bridging. If transparent bridging is not supported, this subtree will not be implemented. This subtree is applicable to transparent-only Bridges.
c) The ieee8021BridgePriority Subtree
   This subtree contains the objects for configuring and reporting status of Priority-based queuing mechanisms in a Bridge. This includes per Bridge Port user_priority treatment, mapping of user_priority in frames into internal traffic classes, and outbound user_priority and access_priority.
d) The ieee8021BridgeMrp Subtree
   This subtree contains the objects for configuring and reporting on operation of the Multiple Registration Protocol (MRP).
e) The ieee8021BridgeMmrp Subtree
   This subtree contains the objects for configuring and reporting on operation of the Multiple MAC Registration Protocol (MMRP).
f) The ieee8021BridgeInternal LAN Subtree
   This subtree contains the objects for configuring and reporting on operation of the Internal LAN interface. An I-LAN Interface is used to create internal connections between Bridge Ports in an IEEE 802.1 device.

The IEEE 802.1D-2004 [B12] management objects in Table 17-4 have not been included in the IEEE8021-BRIDGE-MIB module for the indicated reasons. Note that there is a conformance requirement that the base modules SNMPv2-MIB [RFC3418] and IF-MIB [RFC2863] will be implemented as a default on all Bridges.

Table 17-4—IEEE 802.1D objects not in the IEEE8021-BRIDGE-MIB

IEEE 802.1D object	Disposition
Bridge.BridgeName	Same as sysDescr (SNMPv2-MIB)
Bridge.BridgeUpTime	Same as sysUpTime (SNMPv2-MIB)
Bridge.PortAddresses	Same as ifPhysAddress (IF-MIB)

17.2.3 Structure of the IEEE8021-SPANNING-TREE MIB

A RSTP MIB originally appeared in IETF RFC 4318. While many tables and objects are similar, the IEEE8021-SPANNING-TREE-MIB has been merged with spanning tree objects from the BRIDGE MIB in IETF RFC 4188 and also reindexed and rerooted with its inclusion in this subclause.

This subclause defines an SMIv2 MIB module for managing RSTP capability originally defined by the IEEE Std 802.1t™ and IEEE Std 802.1w™ amendments to IEEE Std 802.1D, 1998 Edition [B11], for bridging between LANs. The objects in this MIB are defined to apply both to transparent bridging and to Bridges connected by subnetworks other than LANs.

The MIB module in this clause is based on IEEE Std 802.1D-2004 [B12], though the references are to this standard.

Table 17-5 indicates the structure of the IEEE8021-SPANNING_TREE-MIB module as well as showing its relationship to the IETF MIB that is being obsoleted.

Table 17-5—IEEE8021-SPANNING-TREE MIB structure

IEEE8021-SPANNING-TREE MIB table/object	IETF MIB table/object	Reference
ieee8021SpanningTreeTable	**dot1dStp**	12.8.1
ieee8021SpanningTreeComponentId*	—	—
ieee8021SpanningTreeProtocolSpecification	dot1dStpProtocolSpecification	—
ieee8021SpanningTreePriority	dot1dStpPriority	12.8.1.1.3 a)
ieee8021SpanningTreeTimeSinceTopologyChange	dot1dStpTimeSinceTopologyChange	12.8.1.1.3 b)
ieee8021SpanningTreeTopChanges	dot1dStpTopChanges	12.8.1.1.3 c)
ieee8021SpanningTreeDesignatedRoot	dot1dStpDesignatedRoot	12.8.1.1.3 e)
ieee8021SpanningTreeRootCost	dot1dStpRootCost	12.8.1.1.3 f)
ieee8021SpanningTreeRootPort	dot1dStpRootPort	12.8.1.1.3 g)
ieee8021SpanningTreeMaxAge	dot1dStpMaxAge	12.8.1.1.3 h)
ieee8021SpanningTreeHelloTime	dot1dStpHelloTime	12.8.1.1.3 k)
ieee8021SpanningTreeHoldTime	dot1dStpHoldTime	12.8.1.1.3 m)
ieee8021SpanningTreeForwardDelay	dot1dStpForwardDelay	12.8.1.1.3 i)
ieee8021SpanningTreeBridgeMaxAge	dot1dStpBridgeMaxAge	12.8.1.1.3 j)
ieee8021SpanningTreeBridgeHelloTime	dot1dStpBridgeHelloTime	12.8.1.1.3 k)
ieee8021SpanningTreeBridgeForwardDelay	dot1dStpBridgeForwardDelay	12.8.1.1.3 l)
ieee8021SpanningTreeVersion	dot1dStpVersion	12.8.1.1.3 n)
ieee8021SpanningTreeRstpTxHoldCount	dot1dStpTxHoldCount	12.8.1.1.3 m)
ieee8021SpanningTreePortTable	**dot1dStpPortTable**	12.8.2
ieee8021SpanningTreePortComponentId*	—	—
ieee8021SpanningTreePort*	dot1dStpPort	12.8.2.1.2 a)
ieee8021SpanningTreePortPriority	dot1dStpPortPriority	12.8.2.1.3 c)
ieee8021SpanningTreePortState	dot1dStpPortState	12.8.2.1.3 b)
ieee8021SpanningTreePortEnable	dot1dStpPortEnable	12.8.2.1.3 m)
ieee8021SpanningTreePortPathCost	dot1dStpPortPathCost	12.8.2.1.3 d)
ieee8021SpanningTreePortDesignatedRoot	dot1dStpPortDesignatedRoot	12.8.2.1.3 e)
ieee8021SpanningTreePortDesignatedCost	dot1dStpPortDesignatedCost	12.8.2.1.3 f)
ieee8021SpanningTreePortDesignatedBridge	dot1dStpPortDesignatedBridge	12.8.2.1.3 g)
ieee8021SpanningTreePortDesignatedPort	dot1dStpPortDesignatedPort	12.8.2.1.3 h)
ieee8021SpanningTreePortForwardTransitions	dot1dStpPortForwardTransitions	—
ieee8021SpanningTreeRstpPortProtocolMigration	dot1dStpPortProtocolMigration	12.8.2.5
ieee8021SpanningTreeRstpPortAdminEdgePort	dot1dStpPortAdminEdgePort	12.8.2.1.3 k)
ieee8021SpanningTreeRstpPortOperEdgePort	dot1dStpPortOperEdgePort	12.8.2.1.3 l)

Table 17-5—IEEE8021-SPANNING-TREE MIB structure *(continued)*

IEEE8021-SPANNING-TREE MIB table/object	IETF MIB table/object	Reference
ieee8021SpanningTreeRstpPortAdminPathCost	dot1dStpPortAdminPathCost	12.8.2.1.3 d)
ieee8021SpanningTreePortExtensionTable AUGMENTS **ieee8021SpanningTreePortEntry**	—	12.8.2
ieee8021SpanningTreeRstpPortAutoEdgePort	—	12.8.2.1.3
ieee8021SpanningTreeRstpPortAutoIsolatePort	—	12.8.2.1.3
ieee8021SpanningTreeRstpPortIsolatePort	—	12.8.2.1.3

*This object is an INDEX of the table in which it resides.

The IEEE8021-SPANNING-TREE MIB contains the following object subtrees:

a) The ieee8021SpanningTree Subtree
   This subtree contains the objects that denote the Bridge's state with respect to the spanning tree protocol.
b) The ieee8021SpanningTreePort Subtree
   This subtree contains the objects that denote the Bridge Port's state with respect to the spanning tree protocol.

For compatibility with the original MIB defined in IETF RFC 4318, the IEEE8021-SPANNING-TREE-MIB continues to use disabled, blocking, listening, learning, forwarding, and broken ieee8021SpanningTreePortStates. The learning and forwarding states correspond exactly to the Learning and Forwarding Port States specified in Clause 12 of this standard. Disabled, blocking, listening, and broken all correspond to the Discarding Port State—while those ieee8021SpanningTreePortStates serve to distinguish reasons for discarding frames, the operation of the Forwarding and Learning processes is the same for all of them. The ieee8021SpanningTreePortState broken represents the failure or unavailability of the Port's MAC as indicated by MAC_Operational FALSE; disabled represents exclusion of the Port from the active topology by management setting of the Administrative Port State to Disabled; blocking represents exclusion of the Port from the active topology by the spanning tree algorithm [computing an Alternate or Backup Port Role (17.7 of IEEE Std 802.1D-2004 [B12])]; listening represents a Port that the spanning tree algorithm has selected to be part of the active topology (computing a Root Port or Designated Port role) but is temporarily discarding frames to guard against loops or incorrect learning.

The IEEE 802.1D management objects in Table 17-6 have not been included for the indicated reasons.

Table 17-6—Clause 12 objects not in the IEEE8021-SPANNING-TREE MIB

IEEE 802.1D object	Disposition
SpanningTreeProtocol	
.BridgeIdentifier	Combination of ieee8021SpanningTreePriority and ieee8021BridgeBaseBridgeAddress
SpanningTreeProtocolPort	
.Uptime	Same as ifLastChange (IF-MIB)
.PortIdentifier	Combination of ieee8021SpanningTreePort and ieee8021SpanningTreePortPriority
.DiscardLackOfBuffers	Redundant

17.2.4 Structure of the IEEE8021-Q-BRIDGE-MIB

A Q-BRIDGE MIB originally appeared in IETF RFC 4363. While many tables and objects are similar, it has been reindexed and rerooted with its inclusion in this subclause.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding IETF RFC 4363 object name and IEEE Std 802.1Q management reference is also included.

Unlike IEEE Std 802.1D, 1998 Edition [B11], this standard does not define exact syntax for a set of managed objects. The following cross-references indicate only the subclause numbering of the descriptions of management operations from Clause 12.

Table 17-7 indicates the structure of the IEEE8021-Q-BRIDGE-MIB module as well as showing its relationship to the IETF MIB that is being obsoleted.

Table 17-7—IEEE8021-Q-BRIDGE MIB structure

IEEE8021-Q-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021QBridgeTable	**dot1qBase**	12.4
ieee8021QBridgeComponentId*	—	—
ieee8021QBridgeVlanVersionNumber	dot1qVlanVersionNumber	12.10.1.1
ieee8021QBridgeMaxVlanId	dot1qMaxVlanId	9.6
ieee8021QBridgeMaxSupportedVlans	dot1qMaxSupportedVlans	12.10.1.1
ieee8021QBridgeNumVlans	dot1qNumVlans	12.7.1.1
ieee8021QBridgeMvrpEnabledStatus	dot1qGvrpStatus	—
ieee8021QBridgeCVlanPortTable	—	—
ieee8021QBridgeCVlanPortComponentId*	—	—
ieee8021QBridgeCVlanPortNumber	—	—
ieee8021QBridgeCVlanPortRowStatus	—	—
ieee8021QBridgeFdbTable	**dot1qFdbTable**	12.7.1
ieee8021QBridgeFdbComponentId*	—	—
ieee8021QBridgeFdbId*	dot1qFdbId	—
ieee8021QBridgeFdbDynamicCount	dot1qFdbDynamicCount	12.7.1.1.3
ieee8021QBridgeFdbLearnedEntryDiscards	—	—
ieee8021QBridgeFdbAgingTime	—	—

Table 17-7—IEEE8021-Q-BRIDGE MIB structure *(continued)*

IEEE8021-Q-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021QBridgeTpFdbTable	**dot1qTpFdbTable**	12.7.1
ieee8021QBridgeFdbComponentId*	—	—
ieee8021QBridgeFdbId*	—	—
ieee8021QBridgeTpFdbAddress*	dot1qTpFdbAddress	—
ieee8021QBridgeTpFdbPort	dot1qTpFdbPort	—
ieee8021QBridgeTpFdbStatus	dot1qTpFdbStatus	—
ieee8021QBridgeTpGroupTable	**dot1qTpGroupTable**	12.7.4
ieee8021QBridgeVlanCurrentComponentId*	—	—
ieee8021QBridgeVlanIndex*	—	—
ieee8021QBridgeTpGroupAddress*	dot1qTpGroupAddress	—
ieee8021QBridgeTpGroupEgressPorts	dot1qTpGroupEgressPorts	—
ieee8021QBridgeTpGroupLearnt	dot1qTpGroupLearnt	—
ieee8021QBridgeForwardAllTable	**dot1qForwardAllTable**	12.7.2, 12.7.7
ieee8021QBridgeForwardAllComponentId*	—	—
ieee8021QBridgeVlanIndex*	—	—
ieee8021QBridgeForwardAllPorts	dot1qForwardAllPorts	—
ieee8021QBridgeForwardAllStaticPorts	dot1qForwardAllStaticPorts	—
ieee8021QBridgeForwardAllForbiddenPorts	dot1qForwardAllForbiddenPorts	—
ieee8021QBridgeForwardUnregisteredTable	**dot1qForwardUnregisteredTable**	12.7.2, 12.7.7
ieee8021QBridgeForwardUnregisteredComponentId*	—	—
ieee8021QBridgeVlanIndex*	—	—
ieee8021QBridgeForwardUnregisteredPorts	dot1qForwardUnregisteredPorts	—
ieee8021QBridgeForwardUnregisteredStaticPorts	dot1qForwardUnregisteredStaticPorts	—
ieee8021QBridgeForwardUnregisteredForbiddenPorts	dot1qForwardUnregisteredForbiddenPorts	—
ieee8021QBridgeStaticUnicastTable	**dot1qStaticUnicastTable**	12.7.7, 8.8.1
ieee8021QBridgeFdbComponentId*	—	—
ieee8021QBridgeFdbId*	—	—
ieee8021QBridgeStaticUnicastAddress*	dot1qStaticUnicastAddress	—
ieee8021QBridgeStaticUnicastReceivePort*	dot1qStaticUnicastReceivePort	—
ieee8021QBridgeStaticUnicastStaticEgressPorts	dot1qStaticUnicastAllowedToGoTo	8.5
ieee8021QBridgeStaticUnicastForbiddenEgressPorts	dot1qStaticUnicastAllowedToGoTo	8.5
ieee8021QBridgeStaticUnicastStorageType	—	—
ieee8021QBridgeStaticUnicastRowStatus	dot1qStaticUnicastStatus	—

Table 17-7—IEEE8021-Q-BRIDGE MIB structure *(continued)*

IEEE8021-Q-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021QBridgeStaticMulticastTable	**dot1qStaticMulticastTable**	12.7.7, 8.8.1
ieee8021QBridgeVlanCurrentComponentId*	—	—
ieee8021QBridgeVlanIndex*	—	—
ieee8021QBridgeStaticMulticastAddress*	dot1qStaticMulticastAddress	—
ieee8021QBridgeStaticMulticastReceivePort*	dot1qStaticMulticastReceivePort	—
ieee8021QBridgeStaticMulticastStaticEgressPorts	dot1qStaticMulticastStaticEgressPorts	—
ieee8021QBridgeStaticMulticastForbiddenEgressPorts	dot1qStaticMulticastForbiddenEgressPorts	—
ieee8021QBridgeStaticMulticastStorageType	—	—
ieee8021QBridgeStaticMulticastRowStatus	dot1qStaticMulticastStatus	—
ieee8021QBridgeVlan	**dot1qVlan**	—
ieee8021QBridgeVlanNumDeletes	dot1qVlanNumDeletes	—
ieee8021QBridgeVlanCurrentTable	**dot1qVlanCurrentTable**	12.10.2
ieee8021QBridgeVlanCurrentComponentId*	—	—
ieee8021QBridgeVlanTimeMark*	dot1qVlanTimeMark	—
ieee8021QBridgeVlanIndex*	dot1qVlanIndex	—
ieee8021QBridgeVlanFdbId	dot1qVlanFdbId	—
ieee8021QBridgeVlanCurrentEgressPorts	dot1qVlanCurrentEgressPorts	12.10.2.1
ieee8021QBridgeVlanCurrentUntaggedPorts	dot1qVlanCurrentUntaggedPorts	12.10.2.1
ieee8021QBridgeVlanStatus	dot1qVlanStatus	—
ieee8021QBridgeVlanCreationTime	dot1qVlanCreationTime	—
ieee8021QBridgeVlanStaticTable	**dot1qVlanStaticTable**	12.7.5
ieee8021QBridgeVlanStaticComponentId*	—	—
ieee8021QBridgeVlanStaticVlanIndex*	—	—
ieee8021QBridgeVlanStaticName	dot1qVlanStaticName	12.10.2.1
ieee8021QBridgeVlanStaticEgressPorts	dot1qVlanStaticEgressPorts	12.7.7.3, 11.2.3.2.3
ieee8021QBridgeVlanForbiddenEgressPorts	dot1qVlanForbiddenEgressPorts	12.7.7.3, 11.2.3.2.3
ieee8021QBridgeVlanStaticUntaggedPorts	dot1qVlanStaticUntaggedPorts	12.10.2.1
ieee8021QBridgeVlanStaticRowStatus	dot1qVlanStaticRowStatus	—
ieee8021QBridgeNextFreeLocalVlanTable	**dot1qVlan**	—
ieee8021QBridgeNextFreeLocalVlanComponentId*	—	—
ieee8021QBridgeNextFreeLocalVlanIndex	dot1qNextFreeLocalVlanIndex	—

Table 17-7—IEEE8021-Q-BRIDGE MIB structure *(continued)*

IEEE8021-Q-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021QBridgePortVlanTable	**dot1qPortVlanTable**	12.10.1
(AUGMENTS ieee8021BridgeBasePortEntry)	(AUGMENTS dot1dBasePortEntry)	—
ieee8021QBridgePvid	dot1qPvid	12.10.1.1
ieee8021QBridgePortAcceptableFrameTypes	dot1qPortAcceptableFrameTypes	12.10.1.3
ieee8021QBridgePortIngressFiltering	dot1qPortIngressFiltering	12.10.1.4
ieee8021QBridgePortmvrpEnabledStatus	dot1qPortGvrpStatus	—
ieee8021QBridgePortmvrpFailedRegistrations	dot1qPortGvrpFailedRegistrations	—
ieee8021QBridgePortmvrpLastPduOrigin	dot1qPortGvrpLastPduOrigin	—
ieee8021QBridgePortRestrictedVlanRegistration	dot1qPortRestrictedVlanRegistration	11.2.3.2.3, 12.10.1.7
ieee8021QBridgePortVlanStatisticsTable	**dot1qPortVlanStatisticsTable**	12.1.3
ieee8021BridgeBasePortComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	—
ieee8021QBridgeVlanIndex*	dot1qVlanIndex	—
ieee8021QBridgeTpVlanPortInFrames	dot1qTpVlanPortInFrames dot1qTpVlanPortHCInFrames	12.6.1.1.3 a)
ieee8021QBridgeTpVlanPortOutFrames	dot1qTpVlanPortOutFrames dot1qTpVlanPortHCOutFrames	12.6.1.1.3 d)
ieee8021QBridgeTpVlanPortInDiscards	dot1qTpVlanPortInDiscards dot1qTpVlanPortHCInDiscards	12.6.1.1.3
ieee8021QBridgeProtocolGroupTable	**dot1vProtocolGroupTable**	12.10.1
ieee8021QBridgeProtocolGroupComponentId*	—	—
ieee8021QBridgeProtocolTemplateFrameType*	dot1vProtocolTemplateFrameType	12.10.1.7
ieee8021QBridgeProtocolTemplateProtocolValue*	dot1vProtocolTemplateProtocolValue	12.10.1.7
ieee8021QBridgeProtocolGroupId	dot1vProtocolGroupId	12.10.1.7
ieee8021QBridgeProtocolGroupRowStatus	dot1vProtocolGroupRowStatus	—
ieee8021QBridgeProtocolPortTable	**dot1vProtocolPortTable**	12.10.1
ieee8021BridgeBasePortComponentId*	—	—
ieee8021BridgeBasePort*	dot1dBasePort	—
ieee8021QBridgeProtocolPortGroupId*	dot1vProtocolPortGroupId	12.10.1.7
ieee8021QBridgeProtocolPortGroupVid	dot1vProtocolPortGroupVid	12.10.1.7
ieee8021QBridgeProtocolPortRowStatus	dot1vProtocolPortRowStatus	—

Table 17-7—IEEE8021-Q-BRIDGE MIB structure *(continued)*

IEEE8021-Q-BRIDGE-MIB table/object	IETF MIB table/object	Reference
ieee8021QBridgeVidXTable	—	12.10.1.8, 12.13.2.1
ieee8021QBridgeBasePortComponentId*	—	—
ieee8021QBridgeBasePort*	—	—
ieee8021QBridgeVidXLocalVid*	—	—
ieee8021QBridgeVidXRelayVid	—	—
ieee8021QBridgeVidXRowStatus	—	—
ieee8021QBridgeEgressVidXV2Table	—	12.10.1.9, 12.13.2.1
ieee8021BridgeBasePortComponentId*	—	—
ieee8021QBridgeBasePort*	—	—
ieee8021QBridgeEgressVidXV2RelayVid*	—	—
ieee8021QBridgeEgressVidXV2LocalVid	—	—
ieee8021QBridgeEgressVidXV2RowStatus	—	—

*This object is an INDEX of the table in which it resides.

The IEEE8021-Q-BRIDGE-MIB contains the following object subtrees:

a) The ieee8021QBridgeBase Subtree
This subtree contains the objects that are applicable to all Bridges implementing IEEE Std 802.1Q VLANs.
b) The ieee8021QBridgeTp Subtree
This subtree contains objects that control the operation and report the status of transparent bridging. This includes management of the dynamic FDBs for both unicast and multicast forwarding. This subtree will be implemented by all Bridges that perform destination-address filtering.
c) The ieee8021QBridgeStatic Subtree
This subtree contains objects that control static configuration information for transparent bridging. This includes management of the static entries in the FDBs for both unicast and multicast forwarding.
d) The ieee8021QBridgeVlan Subtree
This subtree contains objects that control configuration and report status of the VLANs known to a Bridge. This includes management of the statically configured VIDs as well as reporting VIDs discovered by other means [e.g., Multiple VLAN Registration Protocol (MVRP)]. It also controls configuration and reports status of per-Port objects relating to VIDs and reports traffic statistics. It also provides for management of the VID to FID allocation.
e) The ieee8021QBridgeProtocol Subtree
This subtree contains objects that control configuration and report status of the mappings from Protocol Templates to Protocol Group Identifiers used for Port-and-Protocol-based VLAN classification.
f) The ieee8021QBridgeVIDX Subtree
This subtree contains objects that control configuration of VID translation for VLAN ports. A single symmetric translation value or an individual ingress and egress translation is allowed depending on the management table supported.

The Clause 12 management objects in Table 17-8 have not been included in the IEEE8021-Q-BRIDGE-MIB for the indicated reasons. Note that the assumption is made the base modules SNMPv2-MIB and IF-MIB will be implemented as a default on all Bridges.

Table 17-8—Clause 12 management not in IEEE8021-Q-BRIDGE-MIB

Clause 12 operation	Disposition
Reset Bridge (12.4.1.4)	Not appropriate for this MIB module
Reset VLAN Bridge (12.10.1.5)	Not appropriate for this MIB module
Read Permanent Database (12.7.6.1)	Count rows
Permanent Database Size	Count rows
Number of Static Filtering Entries	Count rows in ieee8021QBridgeStaticUnicastTable + ieee8021QBridgeStaticMulticastTable
Number of Static VLAN Registration Entries	Count rows in ieee8021QBridgeVlanStaticTable
Read Filtering Entry Range (12.7.7.4)	Use GetNext operation
Read Filtering Database (12.7.1.1)	Count rows
Filtering Database Size	Count rows
Number of Dynamic Group Address Entries	Count rows applicable to each FDB in ieee8021QBridgeTpGroupTable

17.2.5 Structure of the IEEE8021-PB-MIB

The IEEE8021-PB-MIB provides objects to configure and manage Provider Bridges.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-9 indicates the structure of the IEEE8021-PB-MIB module.

Table 17-9—IEEE8021-PB-MIB structure

IEEE8021-PB-MIB table/object	Reference
ieee8021PbCVidRegistrationTable	12.13.2.1, 12.13.2.2
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbCVidRegistrationCVid*	—
ieee8021PbCVidRegistrationSVid	—
ieee8021PbCVidRegistrationUntaggedPep	—
ieee8021PbCVidRegistrationUntaggedCep	—
ieee8021PbCVidRegistrationRowStatus	—

Table 17-9—IEEE8021-PB-MIB structure *(continued)*

IEEE8021-PB-MIB table/object	Reference
ieee8021PbEdgePortTable	12.13.2.3, 12.13.2.4
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbEdgePortSVid*	—
ieee8021PbEdgePortPVID	—
ieee8021PbEdgePortDefaultUserPriority	—
ieee8021PbEdgePortAcceptableFrameTypes	—
ieee8021PbEdgePortEnableIngressFiltering	—
ieee8021PbServicePriorityRegenerationTable	12.13.2.5, 12.13.2.6
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbServicePriorityRegenerationSVid*	—
ieee8021PbServicePriorityRegenerationReceivedPriority*	—
ieee8021PbServicePriorityRegenerationRegeneratedPriority	—
ieee8021PbCnpTable	12.13.2
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbCnpCComponentId	—
ieee8021PbCnpSVid	—
ieee8021PbCnpRowStatus	—
ieee8021PbPnpTable	12.13.2
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbPnpRowStatus	—
ieee8021PbCepTable	12.13.2
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbCepCComponentId	—
ieee8021PbCepCepPortNumber	—
ieee8021PbCepRowStatus	—

Table 17-9—IEEE8021-PB-MIB structure *(continued)*

IEEE8021-PB-MIB table/object	Reference
ieee8021PbRcapTable	12.13.3
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbRcapSComponentId	—
ieee8021PbRcapRcapPortNumber	—
ieee8021PbRcapRowStatus	—
ieee8021PbInternalInterfaceTable	12.13.3
ieee8021BridgeBasePortComponentId*	—
ieee8021BridgeBasePort*	—
ieee8021PbIiExternalSVid*	—
ieee8021PbIiInternalPortNumber	—
ieee8021PbIiInternalPortType	—
ieee8021PbIiInternalSVid	—
ieee8021PbIiRowStatus	—

*This object is an INDEX of the table in which it resides.

17.2.6 Structure of the IEEE8021-MSTP-MIB

The IEEE8021-MSTP-MIB provides objects to configure and manage multiple spanning trees.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-10 indicates the structure of the IEEE8021-MSTP-MIB module.

Table 17-10—IEEE8021-MSTP-MIB structure

IEEE8021-MSTP-MIB table/object	Reference
ieee8021MstpCistTable	12.8.1.1, 12.8.1.3
ieee8021MstpCistComponentId*	—
ieee8021MstpCistBridgeIdentifier	—
ieee8021MstpCistTopologyChange	—
ieee8021MstpCistRegionalRootIdentifier	13.26.3
ieee8021MstpCistPathCost	13.9 d), 13.11
ieee8021MstpCistMaxHops	13.26.4
ieee8021MstpTable	12.8.1.2, 12.8.1.4, 12.12.3.2, 12.12.1

Table 17-10—IEEE8021-MSTP-MIB structure *(continued)*

IEEE8021-MSTP-MIB table/object	Reference
ieee8021MstpComponentId*	—
ieee8021MstpId*	—
ieee8021MstpBridgeId	13.26.2
ieee8021MstpTimeSinceTopologyChange	13.23
ieee8021MstpTopologyChanges	13.23
ieee8021MstpTopologyChange	—
ieee8021MstpDesignatedRoot	13.26.3
ieee8021MstpRootPathCost	13.26.3
ieee8021MstpRootPort	13.26.9
ieee8021MstpBridgePriority	13.26.3
ieee8021MstpVids0	—
ieee8021MstpVids1	—
ieee8021MstpVids2	—
ieee8021MstpVids3	—
ieee8021MstpRowStatus	—
ieee8021MstpCistPortTable	12.8.2.1, 12.8.2.3, 12.8.2.5
ieee8021MstpCistPortComponentId*	—
ieee8021MstpCistPortNum*	—
ieee8021MstpCistPortUptime	—
ieee8021MstpCistPortAdminPathCost	13.27.25
ieee8021MstpCistPortDesignatedRoot	13.27.20
ieee8021MstpCistPortTopologyChangeAck	13.27.72
ieee8021MstpCistPortAdminHelloTime	12.8.2.1
ieee8021MstpCistPortAdminEdgePort	13.27.1
ieee8021MstpCistPortOperEdgePort	13.27.44
ieee8021MstpCistPortOperHelloTime	12.8.2.1
ieee8021MstpCistPortMacEnabled	12.8.2.1.3 m)
ieee8021MstpCistPortMacOperational	12.8.2.1.3 n)
ieee8021MstpCistPortRestrictedRole	13.27.63
ieee8021MstpCistPortRestrictedTcn	13.27.65
ieee8021MstpCistPortRole	—
ieee8021MstpCistPortDisputed	13.27.22
ieee8021MstpCistPortCistRegionalRootId	13.9 c), 13.11
ieee8021MstpCistPortCistPathCost	13.27.25
ieee8021MstpCistPortProtocolMigration	13.27.22

Table 17-10—IEEE8021-MSTP-MIB structure *(continued)*

IEEE8021-MSTP-MIB table/object	Reference
ieee8021MstpCistPortEnableBPDURx	13.27.31
ieee8021MstpCistPortEnableBPDUTx	13.27.32
ieee8021MstpCistPortPseudoRootId	13.27.33
ieee8021MstpCistPortIsL2Gp	13.27.31
ieee8021MstpPortTable	12.8.2.2, 12.8.2.4
ieee8021MstpPortComponentId*	—
ieee8021MstpPortMstpId*	—
ieee8021MstpPortNum*	—
ieee8021MstpPortUptime	—
ieee8021MstpPortState	13.38
ieee8021MstpPortPriority	13.27.47
ieee8021MstpPortPathCost	13.27.25
ieee8021MstpPortDesignatedRoot	13.27.20
ieee8021MstpPortDesignatedCost	13.27.20
ieee8021MstpPortDesignatedBridge	13.27.20
ieee8021MstpPortDesignatedPort	13.27.20
ieee8021MstpPortRole	—
ieee8021MstpPortDisputed	13.27.22
ieee8021MstpFidToMstiV2Table	12.12.2.2
ieee8021MstpFidToMstiV2ComponentId*	—
ieee8021MstpFidToMstiV2Fid*	—
ieee8021MstpFidToMstiV2MstpId*	—
ieee8021MstpVlanV2Table	12.12.3.1
ieee8021MstpVlanV2ComponentId*	—
ieee8021MstpVlanV2Id*	—
ieee8021MstpVlanV2MstpId*	—
ieee8021MstpConfigIdTable	12.12.3.3, 12.12.3.4
ieee8021MstpConfigIdComponentId*	—
ieee8021MstpConfigIdFormatSelector	13.8:1
ieee8021MstpConfigurationName	13.8:2
ieee8021MstpRevisionLevel	13.8:3

Table 17-10—IEEE8021-MSTP-MIB structure *(continued)*

IEEE8021-MSTP-MIB table/object	Reference
ieee8021MstpConfigurationDigest	13.8:4
ieee8021MstpCistPortExtensionTable AUGMENTS **ieee8021MstpCistPortEntry**	12.8.2
ieee8021MstpCistPortAutoEdgePort	12.8.2.1.3
ieee8021MstpCistPortAutoIsolatePort	12.8.2.1.3

*This object is an INDEX of the table in which it resides.

17.2.7 Structure of the IEEE8021-CFM-MIB

Subclause 12.14 of this document defines the information model associated with this standard in a protocol-independent manner. Table 17-11 and Table 17-12 describe the relationship between the SMIv2 objects defined in the MIB module in 17.4.9, the variables defined in Clause 20, and the protocol-independent objects defined in 12.14.

Note that there are actually two MIB modules—IEEE8021-CFM-MIB and IEEE8021-CFM-V2-MIB. The former contains all original and current tables as well as deprecated tables. The latter contains reindexed tables (to support PBB per Clause 26) and a complete conformance clause that lists all the current tables. Table 17-11 lists only the current tables (i.e., the deprecated tables are not listed) in the IEEE8021-CFM-MIB module, and Table 17-12 lists the reindexed tables in the IEEE8021-CFM-V2-MIB module (that replace the deprecated tables of IEEE8021-CFM-MIB).

Table 17-11—IEEE8021-CFM-MIB structure

Variable	IEEE8021-CFM-MIB table/object	Reference
Maintenance Domain managed object (12.14.5)	**dot1agCfmMdTable**	—
	dot1agCfmMdIndex*	12.14.1.1.3 a2)
	dot1agCfmMdFormat, dot1agCfmMdName	12.14.1.2.2 a)
mdLevel (20.7.1)	dot1agCfmMdMdLevel	12.14.5.1.3 b)
	dot1agCfmMdMhfCreation	12.14.5.1.3 c)
	dot1agCfmMdMhfIdPermission	12.14.5.1.3 d)
	fault alarm controlled by IETF RFC 3413	12.14.5.1.3 e)
	dot1agCfmMdIndex	12.14.5.1.3 f)
Maintenance Association managed object (12.14.6)	**dot1agCfmMaNetTable, dot1agCfmMaMepListTable**	—
	dot1agCfmMaIndex*	12.14.6.1.2 a)
	dot1agCfmMaNetFormat, dot1agCfmMaNetName	12.14.5.3.2 b)
	dot1agCfmVlanVid, dot1agCfmMaCompNumberOfVids	12.14.6.1.3 b)
	dot1agCfmMaCompMhfCreation	12.14.6.1.3 c)

Table 17-11—IEEE8021-CFM-MIB structure *(continued)*

Variable	IEEE8021-CFM-MIB table/object	Reference
	dot1agCfmMaCompIdPermission	12.14.6.1.3 d)
CCMinterval (20.8.1)	dot1agCfmMaNetCcmInterval	12.14.6.1.3 e)
	fault alarm controlled by IETF RFC 3413	12.14.6.1.3 f)
	dot1agCfmMaMepListIdentifier	12.14.6.1.3 g)
MEP managed object (12.14.7)	**dot1agCfmMepTable**	—
	dot1agCfmMdIndex* dot1agCfmMaIndex* dot1agCfmMepIdentifier*	12.14.7.1.2 a)
	dot1agCfmMepIfIndex	12.14.7.1.3 b)
	dot1agCfmMepDirection	12.14.7.1.3 c)
	dot1agCfmMepPrimaryVid	12.14.7.1.3 d)
MEPactive (20.9.1)	dot1agCfmMepActive	12.14.7.1.3 e)
20.37	dot1agCfmMepFngState	12.14.7.1.3 f)
CCIenabled (20.10.1)	dot1agCfmMepCciEnabled	12.14.7.1.3 g)
	dot1agCfmMepCcmLtmPriority	12.14.7.1.3 h)
	dot1agCfmMepMacAddress	12.14.7.1.3 i)
	fault alarm controlled by IETF RFC 3413	12.14.7.1.3 j)
lowestAlarmPri (20.9.5)	dot1agCfmMepLowPrDef	12.14.7.1.3 k)
fngAlarmTime (20.35.3)	dot1agCfmMepFngAlarmTime	12.14.7.1.3 l)
fngResetTime (20.35.4)	dot1agCfmMepFngResetTime	12.14.7.1.3 m)
highestDefect (20.35.9)	dot1agCfmMepHighestPrDefect	12.14.7.1.3 n)
someRDIdefect (20.35.7)	dot1agCfmMepDefects	12.14.7.1.3 o)
someMACstatusDefect (20.35.6)		12.14.7.1.3 p)
someRMEPCCMdefect (20.35.5)		12.14.7.1.3 q)
errorCCMdefect (20.21.3)		12.14.7.1.3 r)
xconCCMdefect (20.23.3)		12.14.7.1.3 s)
errorCCMlastFailure (20.21.2)	dot1agCfmMepErrorCcmLastFailure	12.14.7.1.3 t)
xconCCMlastFailure (20.23.2)	dot1agCfmMepXconCcmLastFailure	12.14.7.1.3 u)
CCMsequenceErrors (20.16.12)	dot1agCfmMepCcmSequenceErrors	12.14.7.1.3 v)
CCIsentCCMs (20.10.2)	dot1agCfmMepCciSentCcms	12.14.7.1.3 w)
nextLBMtransID (20.30.2)	dot1agCfmMepNextLbmTransId	12.14.7.1.3 x)
	dot1agCfmMepLbrIn	12.14.7.1.3 y)
	dot1agCfmMepLbrInOutOfOrder	12.14.7.1.3 z)
	dot1agCfmMepLbrBadMsdu	12.14.7.1.3 aa)

Table 17-11—IEEE8021-CFM-MIB structure *(continued)*

Variable	IEEE8021-CFM-MIB table/object	Reference
nextLTMtransID (20.41.1)	dot1agCfmMepLtmNextSeqNumber	12.14.7.1.3 ab)
	dot1agCfmMepUnexpLtrIn	12.14.7.1.3 ac)
	dot1agCfmMepLbrOut	12.14.7.1.3 ad)
	dot1agCfmMepPbbTeCanReportPbbTePresence	12.14.7.1.3 af)
	dot1agCfmMepPbbTeTrafficMismatchDefect	12.14.7.1.3 ah)
	dot1agCfmMepPbbTeLbmReverseVid	12.14.7.3.2 f)
	dot1agCfmMepPbbTeLtmReverseVid	12.14.7.4.2 e)
	dot1agCfmMepPbbTeMismatchAlarm	12.14.7.1.3 ag)
	dot1agCfmMepPbbTeMismatchDefect	12.14.7.1.3 ai)
	dot1agCfmMepPbbTeMismatchSinceReset	12.14.7.1.3 aj)
Transmit Loopback Messages (12.14.7.3)	**dot1agCfmMepTable,** dot1agCfmMepTransmitLbmStatus	—
	dot1agCfmMdIndex* dot1agCfmMaIndex* dot1agCfmMepIdentifier*	12.14.7.3.2 a)
	dot1agCfmMepTransmitLbmDestMacAddress, dot1agCfmMepTransmitLbmDestMepId, dot1agCfmMepTransmitLbmDestIsMepId	12.14.7.3.2 b)
	dot1agCfmMepTransmitLbmMessages	12.14.7.3.2 c)
	dot1agCfmMepTransmitLbmDataTlv	12.14.7.3.2 d)
	dot1agCfmMepTransmitLbmVlanPriority, dot1agCfmMepTransmitLbmVlanDropEnable	12.14.7.3.2 e)
	dot1agCfmMepTransmitLbmResultOK	12.14.7.3.3 a)
	dot1agCfmMepTransmitLbmSeqNumber	12.14.7.3.3 b)
Transmit Linktrace Message (12.14.7.4)	**dot1agCfmMepTable**	—
	dot1agCfmMdIndex* dot1agCfmMaIndex* dot1agCfmMepIdentifier*	12.14.7.4.2 a)
	dot1agCfmMepTransmitLtmFlags	12.14.7.4.2 b)
	dot1agCfmMepTransmitLtmTargetMacAddress, dot1agCfmMepTransmitLtmTargetMepId, dot1agCfmMepTransmitLtmTargetIsMepId	12.14.7.4.2 c)
	dot1agCfmMepTransmitLtmTtl	12.14.7.4.2 d)
	dot1agCfmMepTransmitLtmResult	12.14.7.4.3 a)
	dot1agCfmMepTransmitLtmSeqNumber	12.14.7.4.3 b)
	dot1agCfmMepTransmitLtmEgressIdentifier	12.14.7.4.3 c)

Table 17-11—IEEE8021-CFM-MIB structure *(continued)*

Variable	IEEE8021-CFM-MIB table/object	Reference
Read Linktrace Reply (12.14.7.5)	**dot1agCfmLtrTable**	—
	dot1agCfmMdIndex* dot1agCfmMaIndex* dot1agCfmMepIdentifier*	12.14.7.5.2 a)
	dot1agCfmLtrSeqNumber*	12.14.7.5.2 b)
	dot1agCfmLtrReceiveOrder*	12.14.7.5.2 c)
ltrReplyTTL (20.41.2.2)	dot1agCfmLtrTtl	12.14.7.5.3 b)
ltrFlags (20.41.2.1)	dot1agCfmLtrForwarded	12.14.7.5.3 c)
	dot1agCfmLtrTerminalMep	12.14.7.5.3 d)
ltrLastEgressId (20.41.2.3)	dot1agCfmLtrLastEgressIdentifier	12.14.7.5.3 e)
ltrNextEgressId (20.41.2.4)	dot1agCfmLtrNextEgressIdentifier	12.14.7.5.3 f)
ltrRelayAction (20.41.2.5)	dot1agCfmLtrRelay	12.14.7.5.3 g)
ltrIngressAction (20.41.2.6)	dot1agCfmLtrIngress	12.14.7.5.3 k)
ltrIngressAddress (20.41.2.7)	dot1agCfmLtrIngressMac	12.14.7.5.3 l)
ltrIngressPortIdSubtype (20.41.2.8)	dot1agCfmLtrIngressPortIdSubtype	12.14.7.5.3 m)
ltrIngressPortId (20.41.2.9)	dot1agCfmLtrIngressPortId	12.14.7.5.3 n)
ltrEgressAction (20.41.2.10)	dot1agCfmLtrEgress	12.14.7.5.3 o)
ltrEgressAddress (20.41.2.11)	dot1agCfmLtrEgressMac	12.14.7.5.3 p)
ltrEgressPortIdSubtype (20.41.2.12)	dot1agCfmLtrEgressPortIdSubtype	12.14.7.5.3 q)
ltrEgressPortId (20.41.2.13)	dot1agCfmLtrEgressPortId	12.14.7.5.3 r)
ltrOrgSpecTlv (20.41.2.15)	dot1agCfmLtrOrganizationSpecificTlv	12.14.7.5.3 s)
ltrSenderIdTlv (20.41.2.14)	dot1agCfmLtrChassisIdSubtype	12.14.7.5.3 h)
	dot1agCfmLtrChassisId	12.14.7.5.3 i)
	dot1agCfmLtrManAddressDomain dot1agCfmLtrManAddress	12.14.7.5.3 j)

Table 17-11—IEEE8021-CFM-MIB structure *(continued)*

Variable	IEEE8021-CFM-MIB table/object	Reference
Read MEP Database (12.14.7.6)	**dot1agCfmMepDbTable**	—
	dot1agCfmMdIndex* dot1agCfmMaIndex* dot1agCfmMepIdentifier*	12.14.7.6.2 a)
	dot1agCfmMepDbRMepIdentifier*	12.14.7.6.2 b)
20.20	dot1agCfmMepDbRMepState	12.14.7.6.3 b)
	dot1agCfmMepDbRMepFailedOkTime	12.14.7.6.3 c)
rMEPmacAddress (20.19.7)	dot1agCfmMepDbMacAddress	12.14.7.6.3 d)
rMEPlastRDI and rMEPlastRDI[i] (20.19.2)	dot1agCfmMepDbRdi	12.14.7.6.3 e)
rMEPlastPortState (20.19.3)	dot1agCfmMepDbPortStatusTlv	12.14.7.6.3 f)
rMEPlastInterfaceStatus (20.19.4)	dot1agCfmMepDbInterfaceStatusTlv	12.14.7.6.3 g)
rMEPlastSenderId (20.19.5)	dot1agCfmMepDbChassisIdSubtype	12.14.7.6.3 h)
	dot1agCfmMepDbChassisId	
	dot1agCfmMepDbManAddressDomain dot1agCfmMepDbManAddress	
	dot1agCfmMepDbRMepIsActive	12.14.7.1.3 ae)
Transmit MEP Fault Alarm (12.14.7.7)	dot1agCfmFaultAlarm	—
	dot1agCfmMepHighestPrDefect	12.14.7.7.2 b), 12.14.7.7.2 c)

*This object is an INDEX of the table in which it resides.

Table 17-12—IEEE8021-CFM-V2-MIB structure

Variable	IEEE-CFM-V2-MIB table/object	Reference
CFM Stack managed object (12.14.2)	**ieee8021CfmStackTable**	—
	ieee8021CfmStackifIndex*	12.14.2.1.2 a)
	ieee8021CfmStackServiceSelectorType*	12.14.2.1.2 d)
	ieee8021CfmStackServiceSelectorOrNone*	12.14.2.1.2 d)
	ieee8021CfmStackMdLevel*	12.14.2.1.2 b)
	ieee8021CfmStackDirection*	12.14.2.1.2 c)
	ieee8021CfmStackMdIndex	12.14.2.1.3 b)
	ieee8021CfmStackMaIndex	12.14.2.1.2 c)
	ieee8021CfmStackMepId	12.14.2.1.3 d)
	ieee8021CfmStackMacAddress	12.14.2.1.3 e)

Table 17-12—IEEE8021-CFM-V2-MIB structure *(continued)*

Variable	IEEE-CFM-V2-MIB table/object	Reference
Default MD Level managed object (12.14.3)	**ieee8021CfmDefaultMdTable**	—
	ieee8021CfmDefaultMdComponentId* ieee8021CfmDefaultMdPrimarySelectorType* ieee8021CfmDefaultMdPrimarySelector*	12.14.3.1.3 a), 12.14.3.2.2 a)
	ieee8021CfmDefaultMdStatus	12.14.3.1.3 b)
	ieee8021CfmDefaultMdLevel	12.14.3.2.2 b)
	ieee8021CfmDefaultMdDefMhfCreation ieee8021CfmDefaultMdMhfCreation	12.14.3.1.3 d)
	ieee8021CfmDefaultMdDefIdPermission ieee8021CfmDefaultMdIdPermission	12.14.3.1.3 e)
Configuration Error List managed object (12.14.4)	**ieee8021CfmConfigErrorListTable**	—
	ieee8021CfmConfigErrorListSelectorType* ieee8021CfmConfigErrorListSelector*	12.14.4.1.2 a)
	ieee8021CfmConfigErrorListIfIndex*	12.14.4.1.2 b)
	ieee8021CfmConfigErrorListErrorType	12.14.4.1.3 b)
Maintenance Association managed object (12.14.6)	**ieee8021CfmVlanTable**	12.14.3.1.3 a), 12.14.3.2.2 a), 12.14.5.3.2 c), 12.14.6.1.3 b)
	ieee8021CfmVlanComponentId*	—
	ieee8021CfmVlanSelector*	—
	ieee8021CfmVlanRowStatus	—
Maintenance Association managed object (12.14.6)	**ieee8021CfmMaCompTable**	—
	ieee8021CfmMaComponentId* dot1agCfmMdIndex* dot1agCfmMaIndex*	12.14.6.1.2 a)
	ieee8021CfmMaCompPrimarySelectorType ieee8021CfmMaCompPrimarySelectorOrNone	—
	ieee8021CfmMaNetFormat ieee8021CfmMaNetName	12.14.5.3.2 b)
	ieee8021CfmMaCompNumberOfVids	12.14.6.1.3 b)
	ieee8021CfmMaCompMhfCreation	12.14.6.1.3 c)
	ieee8021CfmMaCompIdPermission	12.14.6.1.3 d)
CCMinterval (20.8.1)	ieee8021CfmMaNetCcmInterval	12.14.6.1.3 e)
	controlled by IETF RFC 3413	12.14.6.1.3 f)

*This object is an INDEX of the table in which it resides.

17.2.8 Structure of the IEEE8021-PBB-MIB

The IEEE8021-PBB-MIB provides objects to configure and manage PBBs.

Objects in this MIB module are arranged based on their description in Clause 12. Where appropriate in the table, the corresponding Clause 12 management reference is included.

Table 17-13 indicates the structure of the IEEE8021-PBB-MIB module.

Table 17-13—IEEE8021-PBB-MIB structure

Variable	IEEE8021-PBB-MIB table/group	Reference
Backbone Edge Bridge Configuration	**ieee8021PbbBackboneEdgeBridgeObjects**	12.16.1.1, 12.16.1.2
	ieee8021PbbBackboneEdgeBridgeAddress	—
	ieee8021PbbBackboneEdgeBridgeName	—
	ieee8021PbbNumberOfIComponents	—
	ieee8021PbbNumberOfBComponents	—
	ieee8021PbbNumberOfBebPorts	—
	ieee8021PbbNextAvailablePipIfIndex	—
Virtual Instance Port Configuration	**ieee8021PbbVipTable**	12.16.2.1
	ieee8021BridgeBasePortComponentId*	—
	ieee8021BridgeBasePort*	—
	ieee8021PbbVipPipIfIndex	—
	ieee8021PbbVipISid	—
	ieee8021PbbVipDefaultDstBMAC	—
	ieee8021PbbVipRowStatus	—
I-SID to VIP Cross Reference	**ieee8021IsidToVipTable**	12.16.3.1, 12.16.3.2
	ieee8021PbbISidToVipISid*	—
	ieee8021PbbISidToVipComponentId	—
	ieee8021PbbISidToVipPort	—

Table 17-13—IEEE8021-PBB-MIB structure *(continued)*

Variable	IEEE8021-PBB-MIB table/group	Reference
Provider Instance Port Configuration	**ieee8021PbbPipTable**	12.16.4.1, 12.16.4.2
	ieee8021PbbPipIfIndex*	—
	ieee8021PbbPipBMACAddress	—
	ieee8021PbbPipName	—
	ieee8021PbbPipIComponentId	—
	ieee8021PbbPipVipMap	—
	ieee8021PbbPipVipMap1	—
	ieee8021PbbPipVipMap2	—
	ieee8021PbbPipVipMap3	—
	ieee8021PbbPipVipMap4	—
	ieee8021PbbPipRowStatus	—
Provider Instance Port Priority	**ieee8021PbbPipPriorityTable**	12.16.4.1, 12.16.4.2
	(AUGMENTS ieee8021PbbPipEntry)	—
	ieee8021PbbPipPriorityCodePointSelection	12.16.4.5, 12.16.4.6
	ieee8021PbbPipUseDEI	12.16.4.11, 12.16.4.12
	ieee8021PbbPipRequireDropEncoding	12.16.4.13, 12.16.4.14
Provider Instance Port Traffic Class	**ieee8021PbbPipTrafficClassTable**	—
	ieee8021PbbPipIfIndex*	—
	ieee8021PbbPipTrafficClassPriority*	—
	ieee8021PbbPipTrafficClass	—
PIP Priority Code Point Decoding Table	**ieee8021PbbPipDecodingTable**	12.16.4.7, 12.16.4.8
	ieee8021PbbPipIfIndex*	—
	ieee8021PbbPipDecodingPriorityCodePointRow*	—
	ieee8021PbbPipDecodingPriorityCodePoint*	—
	ieee8021PbbPipDecodingPriority	—
	ieee8021PbbPipDecodingDropEligible	—

Table 17-13—IEEE8021-PBB-MIB structure *(continued)*

Variable	IEEE8021-PBB-MIB table/group	Reference
PIP Priority Code Point Encoding Table	**ieee8021PbbPipEncodingTable**	12.16.4.9, 12.16.4.10
	ieee8021PbbPipIfIndex*	—
	ieee8021PbbPipEncodingPriorityCodePointRow*	—
	ieee8021PbbPipEncodingPriorityCodePoint*	—
	ieee8021PbbPipEncodingDropEligible*	—
	ieee8021PbbPipEncodingPriority	—
VIP to PIP Cross Reference	**ieee8021PbbVipToPipMappingTable**	12.16.4.3, 12.16.4.4
	ieee8021BridgeBasePortComponentId*	—
	ieee8021BridgeBasePort*	—
	ieee8021PbbVipToPipMappingPipIfIndex	—
	ieee8021PbbVipToPipMappingStorageType	—
	ieee8021PbbVipToPipMappingRowStatus	—
Customer Backbone Port Configuration	**ieee8021PbbCBPServiceMappingTable**	12.16.5.1, 12.16.5.2
	ieee8021BridgeBasePortComponentId*	—
	ieee8021BridgeBasePort*	—
	ieee8021PbbCBPServiceMappingBackboneSid*	—
	ieee8021PbbCBPServiceMappingBVid	—
	ieee8021PbbCBPServiceMappingDefaultBackboneDest	—
	ieee8021PbbCBPServiceMappingLocalSid	—
	ieee8021PbbCBPServiceMappingRowStatus	—
Customer Backbone Port creation/deletion	**ieee8021PbbCbpTable**	17.5.3.3.4
	ieee8021BridgeBasePortComponentId*	—
	ieee8021BridgeBasePort*	—
	ieee8021PbbCbpRowStatus	—

*This object is an INDEX of the table in which it resides.

17.2.9 Structure of the IEEE8021-DDCFM-MIBs

The IEEE8021-DDCFM-MIB provides objects to configure and manage the DDCFM capabilities.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects as follows:

a) RR subtree: this subtree contains the objects that are applicable to Bridges that support DDCFM's RR function.
b) RFM Receiver subtree: this subtree contains the objects that are applicable to Bridges or end stations that support DDCFM's RFM Receiver function.
c) DR subtree: this subtree contains the objects that are applicable to Bridges that support DDCFM's DR function.
d) SFM Originator subtree: this subtree contains the objects that are applicable to Bridges or end stations that support DDCFM's SFM Originator function.

Table 17-14 indicates the structure of the IEEE8021-DDCFM-MIB module.

Table 17-14—IEEE8021-DDCFM-MIB structure

Variable	IEEE8021-DDCFM-MIB Table/Group	Reference
	ieee8021DdcfmStackTable	**DDCFM Stack managed object (12.17.1)**
	ieee8021DdcfmStackIfIndex	12.17.1.1.2 a)
	ieee8021DdcfmStackRrMdLevel	12.17.1.1.3 b1)
	ieee8021DdcfmStackRrDirection	
	ieee8021DdcfmStackRFMreceiverMdLevel	12.17.1.1.3 b2)
	ieee8021DdcfmStackDrMdLevel	12.17.1.1.3 b3)
	ieee8021DdcfmStackDrVlanIdOrNone	
	ieee8021DdcfmStackSFMOriginatorMdLevel	12.17.1.1.3 b4)
	ieee8021DdcfmStackSFMOriginatorVlanIdOrNone	
	ieee8021DdcfmStackSFMOriginatorDirection	
	ieee8021DdcfmRrTable	**Reflection Responder managed object (12.17.2)**
	ieee8021DdcfmRr	—
	ieee8021DdcfmRrIfIndex	12.17.2.1.2 a1)
	ieee8021DdcfmRrMdIndex	12.17.2.1.2 a2)
	ieee8021DdcfmRrDirection	12.17.2.1.2 a3)
	ieee8021DdcfmRrPrimaryVlanIdOrNone	12.17.2.2.2 b1)
	ieee8021DdcfmRrFilter	12.17.2.2.2 b2)
	ieee8021DdcfmRrSamplingInterval	12.17.2.2.2 b3)

Table 17-14—IEEE8021-DDCFM-MIB structure *(continued)*

Variable	IEEE8021-DDCFM-MIB Table/Group	Reference
	ieee8021DdcfmRrTargetAddress	12.17.2.2.2 b4)
	ieee8021DdcfmRrContinueFlag	12.17.2.2.2 b5)
	ieee8021DdcfmRrDuration	12.17.2.2.2 b7)
	ieee8021DdcfmRrDurationInTimeFlag	12.17.2.2.2 b6)
	ieee8021DdcfmRrVlanPriority ieee8021DdcfmRrVlanDropEligible	12.17.2.2.2 b9)
	ieee8021DdcfmRrFloodingFlag	12.17.2.2.2 b10)
	ieee8021DdcfmRrTruncationFlag	12.17.2.2.2 b.11
ReflectionRequest (29.3.1.15)	ieee8021DdcfmRrActivationStatus	12.18.1.2.3 b12)
RRwhile (29.3.1.9)	ieee8021DdcfmRrRemainDuration	12.17.2.3.3 b13)
nextRFMtransID (29.3.1.16)	ieee8021DdcfmRrNextRfmTransID	12.17.2.3.3 b14)
	ieee8021DdcfmRFMReceiverTable	**RFM Receiver managed object (12.17.3)**
	ieee8021DdcfmRFMReceiver	—
	ieee8021DdcfmRfmReceiverIfIndex ieee8021DdcfmRfmReceiverMdIndex	12.18.2.1.2 a2)
	ieee8021DdcfmDrTable	**Decapsulator Responder managed object (12.17.4)**
	ieee8021DdcfmDr	—
	ieee8021DdcfmDrIfIndex ieee8021DdcfmDrMdIndex ieee8021DdcfmDrVlanIdOrNone	12.17.3.1.2 a2)
	ieee8021DdcfmDrSourceAddressStayFlag	12.17.4.3.2 b1)
	ieee8021DdcfmDrSfmOriginator	12.17.4.3.2 b2)
	ieee8021DdcfmDrFloodingFlag	12.17.4.3.2 b3)
DRtime (29.3.8.2)	ieee8021DdcfmDrDuration	12.17.4.3.2 b4)
DRactive (29.3.8.4)	ieee8021DdcfmDrActivationStatus	12.17.3.2.3 b6)
DRwhile (29.3.8.1)	ieee8021DdcfmDrRemainDuration	12.17.3.2.3 b7)
SFMsequenceErrors (29.3.8.7)	ieee8021DdcfmDrSFMsequenceErrors	12.17.4.2.3 b8)
	ieee8021DdcfmSoTable	**SFM Originator managed object (12.17.5)**
	ieee8021DdcfmSFMOriginator	—

Table 17-14—IEEE8021-DDCFM-MIB structure *(continued)*

Variable	IEEE8021-DDCFM-MIB Table/Group	Reference
	ieee8021DdcfmSfmIfIndex ieee8021DdcfmSoMdIndex ieee8021DdcfmSoVlanIdOrNone ieee8021DdcfmSoDirection	12.17.4.1.2 a2)
	ieee8021DdcfmSoDrMacAddress	12.17.5.4.3 b2)
	ieee8021DdcfmSoDuration	12.17.5.4.3 b3)
	ieee8021DdcfmSoActivationStatus	12.17.4.2.3 b4)
	ieee8021DdcfmSoRemainDuration	12.17.4.2.3 b5)

17.2.10 Structure of the IEEE8021-PBBTE-MIB

The IEEE8021-PBBTE-MIB provides objects to configure and manage PBBs that support Traffic Engineering.

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-15 shows the mapping of the PBB-TE Clause 12 managed objects to the tables and columns of the PBB-TE MIB that model those managed objects.

Table 17-15—IEEE8021-PBBTE-MIB structure

Variable	IEEE8021- PBBTE-MIB table/object	Reference
—	**ieee8021PbbTeProtectionGroupListTable**	—
—	ieee8021PbbTeProtectionGroupListGroupId	12.18.1
—	ieee8021PbbTeProtectionGroupListWorkingMA	12.18.1.1.3 a)
—	ieee8021PbbTeProtectionGroupListProtectionMA	12.18.1.1.3 b)
—	**ieee8021PbbTeMASharedGroupTable**	—
—	ieee8021PbbTeMASharedGroupId	12.18.1.1.3 c)
—	**ieee8021PbbTeTesiTable**	—
—	ieee8021PbbTeTesiComponent	12.16.5.3.2 a)
—	ieee8021PbbTeTesiBridgePort	12.16.5.3.2 b)
—	**ieee8021PbbTeTeSiEspTable**	—
—	ieee8021PbbTeTeSiEspEspIndex	12.16.5.3.2 c)
—	ieee8021PbbTeTeSiEspEsp	12.16.5.3.2 c)
—	**ieee8021PbbTeProtectionGroupConfigTable**	—
—	ieee8021PbbTeProtectionGroupConfigState	12.18.2.1.3 d)

Table 17-15—IEEE8021-PBBTE-MIB structure *(continued)*

Variable	IEEE8021- PBBTE-MIB table/object	Reference
—	ieee8021PbbTeProtectionGroupConfigCommandStatus	12.18.2.1.3 d)
—	ieee8021PbbTeProtectionGroupConfigCommandLast	12.18.2.1.3 b)
—	ieee8021PbbTeProtectionGroupConfigAdmin	12.18.2.3.2 b)
—	ieee8021PbbTeProtectionGroupConfigActiveRequests	12.18.2.1.3 d)
WTRwhile (26.10.3.2.1)	ieee8021PbbTeProtectionGroupConfigWTR	12.18.2.1.3 e)
HoldOffWhile (26.10.3.2.2)	ieee8021PbbTeProtectionGroupConfigHoldOff	12.18.2.1.3 f)
—	**ieee8021PbbTeProtectionGroupISidTable**	—
—	ieee8021PbbTeProtectionGroupISidGroupId	12.18.2.1.3 b)
—	**ieee8021PbbTeBridgeStaticForwardAnyUnicastTable**	—
—	ieee8021PbbTeBridgeStaticForwardAnyUnicastVlanIndex	8.8.1
—	ieee8021PbbTeBridgeStaticForwardAnyUnicastEgressPorts	8.8.1
—	ieee8021pbbTeBridgeStaticForwardAnyUnicastForbiddedPorts	8.8.1

This standard defines a TE-SID as an implementation-dependent identifier used to refer to a TESI. However, TE-SIDs are used externally by management to refer to these TESIs; in particular they are used to create MAs that monitor the health of a TESI. Thus, while the identifier itself is implementation dependent, a canonical external representation of the identifiers is needed for the purpose of MIB definition. The textual convention `IEEE8021PbbTeTSidId` is used to represent TE-SID values externally. This convention defines TE-SIDs to be a simple integer of local significance to a particular Bridge component for the purpose of MIB management.

A TESI consists of a set of ESPs. Each ESP is identified by a 3 tuple consisting of an <ESP-DA,ESP-SA,ESP-VID>. These tuples are represented by the textual convention `IEEE8021PbbTeEsp`, which is a fixed length octet string containing the two MAC addresses along with the VID value.

TESIs themselves are represented by the `ieee8021PbbTeTeSiEspTable`. This table has five columns. Two are indices and consist of the TE-SID and an index into the list of ESPs. The remaining columns consist of the ESP itself along with a storage type and row status. The storage type indicates if the value defined by this row of the MIB persists across system restarts. The row status column is used by the management station to add, delete, activate, and deactivate rows from this table. Consider Figure 26-7 of this standard. The `ieee8021PbbTeTeSiEspTable` for that switch would have the information shown in Table 17-16, assuming no other TESIs were configured. In the example shown in Table 17-16, two TESIs are present in the system. The first has a single ESP, while the second has two ESPs.

17.2.10.1 Using the MIB to create MAs associated with TESIs

In order to support protection switching, PBB-TE defines a mechanism to allow redundant TESIs to carry the same traffic. The implementation of protection switching requires a mechanism to monitor the health of this TESI. The CFM MA is used as this mechanism.

Configuring an MA requires adding a row to the CFM MIB's StackTable. Two columns are used in the StackTable to define the data stream upon which the MA operates. These are the

Table 17-16—Example of ieee8021PbbTeTeSiEspTable

ID	EspIndex	Esp	StorageType	RowStatus
1	1	<DA3, SA1, VID-1>	nonVolatile	Active
2	1	<DA3, SA2, VID-1>	nonVolatile	Active
2	2	<DA3, SA3,VID-2>	nonVolatile	Active

`IEEE8021ServiceSelectorType` column and the `IEEE8021ServiceSelectorValue` column. The first column defines how the value in the second column is to be interpreted. If the value of the first column is set to `tesid(3)`, then the second column is interpreted as the external representation of a TE-SID.

Thus, TESIs, and their corresponding identifiers, configured in the `ieee8021PbbTeTeSiEspTable` provide the TE-SID values that are used as parameters to rowcreate operations for the `CFMStackTable` to create MAs that monitor the health of TESIs in a PBB-TE network. Creating entries in the `CFMStackTable`, in turn, defines `MAID` values, represented as unsigned integers, that are used subsequently to configure the protected service.

17.2.10.2 Using the MIB to create protection groups

A TE protection group is a group of two TESIs referred to as WORKING and PROTECTION between a pair of CBPs. The TE protection group carries a set of backbone service instances between these CBPs and in the event of failure of one of the TESIs, the other TESI is used to transport the backbone service instances.

The TE protection groups are created by adding rows to the `ieee8021PbbTeProtectionGroupListTable`. Each entry in the table contains two columns indicating the MAs associated with the TESIs used to carry the traffic and a RowStatus column used to managed the creation and deletion of the TE protection group. The MAs are referred to by MAID and can be found in the `StackTable` of the CFM MIB managed objects.

17.2.10.3 Using the MIB to query and configure protection groups

Each configuration group has status and configuration information that can be managed. This information is located in the `ieee8021PbbTeProtectionGroupConfigTable.` This table allows management stations to determine which TESI is being used to transmit traffic and it also allows for management commands to switch the traffic between the two TESIs. There are also optional parameters that configure the time to trigger a switchover and the time to restore after a failure condition has cleared.

17.2.10.4 Using the MIB to prevent erroneous forwarding in the PBB-TE network

Normally in a bridged network, a frame with an unknown unicast destination address is flooded to an appropriate set of ports determined by the frame's VID. PBB-TE networks do not operate this way. A frame with an unknown unicast destination MAC address whose VID is an ESP-VID is discarded. Item a) 3) of 8.8.1 takes care of this. This clause allows for a new kind of filtering entry. This filtering entry applies to all frames with individual, as opposed to group or broadcast, destination addresses to which no other filtering entry applies. By associating a drop action with this filtering action, the relay function will cause all frames that arrive with a VID belonging to the set of PBB-TE VIDs with an unknown DA to be dropped. The table that sets up these filtering entries is called the `ieee8021PbbTeBridgeStaticForwardAnyUnicastTable.`

17.2.11 Structure of the TPMR MIB

The TPMR MIB is organized into the following MIB groups:

TPMR Configuration
TPMR Port Configuration
TPMR Port Counters
TPMR Port Discard Details
TPMR MSP Configuration
TPMR MSP Statistics

Clause 12 defines the information model associated with this standard in a protocol-independent manner. Table 17-17 describes the relationship between the SMIv2 objects defined in this MIB module and the protocol-independent objects defined in Clause 12.

Table 17-17—IEEE8021-TPMR-MIB structure

Managed object definition	IEEE8021-TPMR-MIB table/object	Reference
	system (SNMPv2-MIB)	
TPMR name	sysName	12.19.1.1.1.3:a and 12.19.1.1.2.2:a
TPMR uptime	sysUpTime	12.19.1.1.1.3:c
	ifTable (IF-MIB)	
TPMR port name	ifName	12.19.1.2.1.3:a and 12.19.1.2.2.2:b
TPMR port type	ifType	12.19.1.2.1.3:b
TPMR port MAC address	ifPhysAddress	12.19.1.1.1.3:b,2
	ieee8021TpmrPortTable	
TPMR port number	ieee8021TpmrPortNumber	12.19.1.1.1.3:b,1
TPMR port management MAC address	ieee8021TpmrPortMgmtAddr	12.19.1.1.1.3:b,3
TPMR port management MAC address forwarding	ieee8021TpmrPortMgmtAddrForwarding	12.19.1.2.1.3:c
	ieee8021TpmrPortStatsTable AUGMENTS **ieee8021TpmrPortTable**	
TPMR port Rx Frames	ieee8021TpmrPortStatsRxFrames	12.19.3.1.1.3:a
TPMR port Rx Octets	ieee8021TpmrPortStatsRxOctets	12.19.3.1.1.3:b
TPMR port Forwarded Frames	ieee8021TpmrPortStatsFramesForwarded	12.19.3.1.1.3:d
TPMR port Discarded Frames	ieee8021TpmrPortStatsFramesDiscarded	12.19.3.1.1.3:c
TPMR port Discarded Frames Queue Full	ieee8021TpmrPortStatsFramesDiscardedQueueFull	12.19.3.1.1.3:e
TPMR port Discarded Frames Lifetime	ieee8021TpmrPortStatsFramesDiscardedLifetime	12.19.3.1.1.3:f
TPMR port Discarded Frames Error	ieee8021TpmrPortStatsFramesDiscardedError	12.19.3.1.1.3:g
	ieee8021TpmrPortDiscardDetailsTable	
	ieee8021BridgeBasePortComponentId*	
	ieee8021TpmrPortNumber*	
	ieee8021TpmrPortDiscardDetailsIndex*	
TPMR port discard details: source address	ieee8021TpmrPortDiscardDetailsSource	12.19.3.1.1.3:h
TPMR port discard details: error reason	ieee8021TpmrPortDiscardDetailsReason	12.19.3.1.1.3:h

Table 17-17—IEEE8021-TPMR-MIB structure *(continued)*

Managed object definition	IEEE8021-TPMR-MIB table/object	Reference
	ieee8021TpmrMspTable AUGMENTS **ieee8021TpmrPortTable**	
TPMR MSP link notify	ieee8021TpmrMspLinkNotify	12.19.4.1.1.3:a and 12.19.4.1.2.2:b
TPMR MSP link notify wait	ieee8021TpmrMspLinkNotifyWait	12.19.4.1.1.3:b and 12.19.4.1.2.2:c
TPMR MSP link notify retry	ieee8021TpmrMspLinkNotifyRetry	12.19.4.1.1.3:c and 12.19.4.1.2.2:d
TPMR MSP MAC notify	ieee8021TpmrMspMacNotify	12.19.4.1.1.3:d and 12.19.4.1.2.2:e
TPMR MSP MAC notify time	ieee8021TpmrMspMacNotifyTime	12.19.4.1.1.3:e and 12.19.4.1.2.2:f
TPMR MSP MAC notify recover	ieee8021TpmrMspMacRecoverTime	12.19.4.1.1.3:f and 12.19.4.1.2.2:g
	ieee8021TpmrMspStatsTable AUGMENTS **ieee8021TpmrPortTable**	
TPMR MSP tx acks	ieee8021TpmrMspStatsTxAcks	12.19.4.1.3.3:a
TPMR MSP tx add notifications	ieee8021TpmrMspStatsTxAddNotifications	12.19.4.1.3.3:b
TPMR MSP tx add conformations	ieee8021TpmrMspStatsTxAddConfirmations	12.19.4.1.3.3:c
TPMR MSP tx loss notifications	ieee8021TpmrMspStatsTxLossNotifications	12.19.4.1.3.3:d
TPMR MSP tx loss conformations	ieee8021TpmrMspStatsTxLossConfirmations	12.19.4.1.3.3:e
TPMR MSP rx acks	ieee8021TpmrMspStatsRxAcks	12.19.4.1.3.3:f
TPMR MSP rx add notifications	ieee8021TpmrMspStatsRxAddNotifications	12.19.4.1.3.3:g
TPMR MSP rx add conformations	ieee8021TpmrMspStatsRxAddConfirmations	12.19.4.1.3.3:h
TPMR MSP rx loss notifications	ieee8021TpmrMspStatsRxLossNotifications	12.19.4.1.3.3:i
TPMR MSP rx loss conformations	ieee8021TpmrMspStatsRxLossConfirmations	12.19.4.1.3.3:j
TPMR MSP add events	ieee8021TpmrMspStatsAddEvents	12.19.4.1.3.3:k
TPMR MSP loss events	ieee8021TpmrMspStatsLossEvents	12.19.4.1.3.3:l
TPMR MSP MAC status notifications	ieee8021TpmrMspStatsMacStatusNotifications	12.19.4.1.3.3:m

*This object is an INDEX of the table in which it resides.

17.2.12 Structure of the IEEE8021-FQTSS-MIB

The IEEE8021-FQTSS-MIB provides objects to configure and manage those aspects of a VLAN Bridge that are related to Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS) (see Clause 34).

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-18 indicates the structure of the IEEE8021-FQTSS-MIB module.

Table 17-18—IEEE8021-FQTSS-MIB structure

IEEE8021-FQTSS-MIB table/object	References
ieee8021FqtssBap subtree	
ieee8021FqtssBapTable	Bandwidth Availability Parameter Table, 12.20.1, 34.3
ieee8021FqtssBAPTrafficClass*	Traffic class
ieee8021FqtssDeltaBandwidth	deltaBandwidth, 12.20.1, 34.3
ieee8021FqtssOperIdleSlopeMs	operIdleSlope, 12.20.1, 34.3
ieee8021FqtssOperIdleSlopeLs	operIdleSlope, 12.20.1, 34.3
ieee8021FqtssAdminIdleSlopeMs	adminIdleSlope, 12.20.1, 34.3
ieee8021FqtssAdminIdleSlopeLs	adminIdleSlope, 12.20.1, 34.3
ieee8021FqtssMappings subtree	
ieee8021FqtssTxSelectionAlgorithmTable	Transmission Selection Algorithm Table, 12.20.2, 8.6.8
ieee8021FqtssTrafficClass*	Traffic class
ieee8021FqtssTxSelectionAlgorithmID	Transmission selection algorithm, 12.20.2, 8.6.8
ieee8021FqtssSrpRegenOverrideTable	SRP domain boundary port priority regeneration override table, 12.20.3, 35.1.4, 6.9.4
ieee8021FqtssSrClassPriority*	Received priority
ieee8021FqtssPriorityRegenOverride	Regenerated priority, 12.20.3, 6.9.4
ieee8021FqtssSrpBoundaryPort	SRPdomainBoundaryPort, 12.20.3, 35.1.4

*This object is an INDEX of the table in which it resides.

17.2.13 Structure of the IEEE8021-CN-MIB

Table 17-19 describes the relationship between the SMIv2 objects defined in the IEEE8021-CN-MIB module (17.7.13) and the Congestion Notification variables and managed objects defined in Clause 12 and Clause 32.

Table 17-19—IEEE8021-CN-MIB structure

Clause 32 table or variable	Clause 12/ Clause 32 reference	IEEE8021-CN-MIB table/object
CN component managed object, CN component variables	12.21.1 32.2	**ieee8021CnGlobalTable**
cngMasterEnable	32.2.1	ieee8021CnGlobalMasterEnable
cngCnmTransmitPriority	32.2.2	ieee8021CnGlobalCnmTransmitPriority
cngDiscardedFrames	32.2.3	ieee8021CnGlobalDiscardedFrames
cngErroredPortList	32.2.4	ieee8021CnErroredPortTable
CN component priority managed object, congestion notification per-CNPV variables	12.21.2 32.3	**ieee8021CnCompntPriTable**
cncpDefModeChoice	32.3.1	ieee8021CnComPriDefModeChoice
cncpAlternatePriority	32.3.2	ieee8021CnComPriAlternatePriority
cncpAutoAltPri	32.3.3	ieee8021CnComPriAutoAltPri
cncpAdminDefenseMode	32.3.4	ieee8021CnComPriAdminDefenseMode
cncpCreation	32.3.5	ieee8021CnComPriCreation
cncpLldpInstanceChoice	32.3.6	ieee8021CnComPriLldpInstanceChoice
cncpLldpInstanceSelector	32.3.7	ieee8021CnComPriLldpInstanceSelector
CN Port priority managed object, CND defense per-Port per-CNPV variables	12.21.2 32.4	**ieee8021CnPortPriTable**
cnpdDefModeChoice	32.4.1	ieee8021CnPortPriDefModeChoice
cnpdAdminDefenseMode	32.4.2	ieee8021CnPortPriAdminDefenseMode
cnpdAutoDefenseMode	32.4.3	ieee8021CnPortPriAutoDefenseMode
cnpdLldpInstanceChoice	32.4.4	ieee8021CnPortPriLldpInstanceChoice
cnpdLldpInstanceSelector	32.4.5	ieee8021CnPortPriLldpInstanceSelector
cnpdAlternatePriority	32.4.6	ieee8021CnPortPriAlternatePriority

Table 17-19—IEEE8021-CN-MIB structure *(continued)*

Clause 32 table or variable	Clause 12/ Clause 32 reference	IEEE8021-CN-MIB table/object
Congestion Point managed object, CP variables	12.21.4 32.8	**ieee8021CnCpTable**
cpMacAddress	32.8.1	ieee8021CnCpMacAddress
cpId	32.8.2	ieee8021CnCpIdentifier
cpQSp	32.8.3	ieee8021CnCpQueueSizeSetPoint
cpW	32.8.6	ieee8021CnCpFeedbackWeight
cpSampleBase	32.8.11	ieee8021CnCpMinSampleBase
cpDiscardedFrames	32.8.12	ieee8021CnCpDiscardedFrames
cpTransmittedFrames	32.8.13	ieee8021CnCpTransmittedFrames
cpTransmittedCnms	32.8.14	ieee8021CnCpTransmittedCnms
cpMinHeaderOctets	32.8.15	ieee8021CnCpMinHeaderOctets
(None)[a]	**(none)**	**ieee8021CnCpidToInterfaceTable**
Reaction Point port priority managed object, RP per-Port per-CNPV variables	12.21.5 32.10	**ieee8021CnRpPortPriTable**
rpppMaxRps	32.10.1	ieee8021CnRpPortPriMaxRps
rpppCreatedRps	32.10.2	ieee8021CnRpPortPriCreatedRps
rpppRpCentiseconds	32.10.3	ieee8021CnRpPortPriCentiseconds
Reaction Point group managed object, RP group variables	12.21.6 32.11	**ieee8021CnRpGroupTable**
rpgEnable	32.11.1	ieee8021CnRpgEnable
rpgTimeReset	32.11.2	ieee8021CnRpgTimeReset
rpgByteReset	32.11.3	ieee8021CnRpgByteReset
rpgThreshold	32.11.4	ieee8021CnRpgThreshold
rpgMaxRate	32.11.5	ieee8021CnRpgMaxRate
rpgAiRate	32.11.6	ieee8021CnRpgAiRate
rpgHaiRate	32.11.7	ieee8021CnRpgHaiRate
rpgGd	32.11.8	ieee8021CnRpgGd
rpgMinDecFac	32.11.9	ieee8021CnRpgMinDecFac
rpgMinRate	32.11.10	ieee8021CnRpgMinRate

[a] This table is an artifact of SNMP, required to find an entry in the ieee8021CnCpTable, given a CPID (32.8.2, 33.4.4).

17.2.14 Structure of the IEEE8021-SRP-MIB

The IEEE8021-SRP-MIB provides objects to configure and manage those aspects of a VLAN Bridge that are related to the Stream Reservation Protocol (SRP).

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-20 indicates the structure of the IEEE8021-SRP-MIB module.

Table 17-20—IEEE8021-SRP-MIB structure

IEEE8021-SRP-MIB table/object	References
ieee8021SrpConfiguration subtree	
ieee8021SrpBridgeBaseTable	SRP control and status information for a Bridge. AUGMENTS ieee8021BridgeBaseEntry.
ieee8021SrpBridgeBaseMsrpEnabledStatus	Is MSRP enabled on this device? True or False. 12.22.1, 35.2.1.4 d).
ieee8021SrpBridgeBaseMsrpTalkerPruning	talkerPruning, 12.22.1, 35.2.1.4 b).
ieee8021SrpBridgeBaseMsrpMaxFanInPorts	msrpMaxFanInPorts, 12.22.1, 35.2.1.4 f).
ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize	msrpLatencyMaxFrameSize, 12.22.1, 35.2.1.4 g).
ieee8021SrpBridgePortTable	SRP Control and Status information for each port on the Bridge. AUGMENTS ieee8021BridgeBasePortEntry.
ieee8021SrpBridgePortMsrpEnabledStatus	Is MSRP enabled on this port? True or False. 12.22.2, 35.2.1.4 e).
ieee8021SrpBridgePortMsrpFailedRegistrations	How many failed registrations have there been on this port, 10.7.12.1, 12.22.2.
ieee8021SrpBridgePortMsrpLastPduOrigin	Source MAC address of last MSRPDU received on this port, 10.7.12.2, 12.22.2.
ieee8021SrpBridgePortSrPvid	Default VID for Streams on this port, Table 9-2, Table 12-15, 12.22.2, 35.2.1.4 i).
ieee8021SrpLatency subtree	
ieee8021SrpLatencyTable	Maximum port latency per traffic class, 12.22.3, 35.2.2.8.6.
ieee8021SrpTrafficClass	Traffic class (Table index).
ieee8021SrpPortTcLatency	Maximum port latency for the associated traffic class, 12.22.3, 35.2.1.4 a), 35.2.2.8.6.
ieee8021SrpStreams subtree	
ieee8021SrpStreamTable	Components that define the characteristics of a Stream., 12.22.4, 35.2.2.8.
ieee8021SrpStreamID	StreamID (Table index), 12.22.4, 35.2.2.8.2.
ieee8021SrpStreamDestinationAddress	Stream destination MAC address, 12.22.4, 35.2.2.8.3 a).
ieee8021SrpStreamVlanID	VID for Stream (0=default), 12.22.4, 35.2.2.8.3 b).

Table 17-20—IEEE8021-SRP-MIB structure *(continued)*

IEEE8021-SRP-MIB table/object	References
ieee8021SrpStreamTspecMaxFrameSize	Maximum frame size sent by Talker, 12.22.4, 35.2.2.8.4 a).
ieee8021SrpStreamTspecMaxIntervalFrames	Maximum number of frames sent per class measurement interval, 12.22.4, 35.2.2.8.4 b), 34.4.
ieee8021SrpStreamDataFramePriority	The Priority Code Point (PCP) value that the data Stream will be tagged with, 12.22.4, 35.2.2.8.5 a).
ieee8021SrpStreamRank	Emergency/nonemergency Rank associated with the Stream, 12.22.4, 35.2.2.8.5 b).
ieee8021SrpReservations subtree	
ieee8021SrpReservationsTable	A table containing Stream attribute registrations per port, 12.22.5, 35.2.4.
ieee8021SrpReservationStreamId	StreamID (Table index), 12.22.5, 35.2.2.8.2.
ieee8021SrpReservationDirection	Talker or Listener (Table index), 12.22.5, 35.2.1.2.
ieee8021SrpReservationDeclarationType	Advertise or Failed for Talkers. Asking Failed, Ready, or Ready Failed for Listeners.12.22.5, 35.2.1.3.
ieee8021SrpReservationAccumulatedLatency	Latency at ingress port for Talker registrations, or latency at end of egress media for Listener Declarations, 12.22.5, 35.2.2.8.6.
ieee8021SrpReservationFailureSystemId	system ID of system that changed Talker Advertise to Talker Failed, 12.22.5, 35.2.2.8.7 a).
ieee8021SrpReservationFailureCode	Failure Code associated with system that changed Talker Advertise to Talker Failed, 12.22.5, 35.2.2.8.7 b).
ieee8021SrpReservationDroppedStreamFrames	Number of stream data frames (not MSRPDUs) that have been dropped for this stream on this port, 12.22.5, 35.2.5.1.
ieee8021SrpReservationStreamAge	Number of seconds since reservation was established, 12.22.5, 35.2.1.4 c).

17.2.15 Structure of the IEEE8021-MVRPX-MIB

The IEEE8021-MVRPX-MIB extends the Bridge Port VLAN table to add three variables to control whether the MVRP Participant on each Port operates as a Full Participant or a New-Only Participant (10.6), how New messages are treated, and whether to transmit the 0 VID. Table 17-21 describes the relationship between the SMIv2 objects defined in the MIB module in 17.7.15 and the variables and managed objects defined in Clause 12.

Table 17-21—IEEE8021-MVRPX-MIB structure

IEEE8021-MVRPX-MIB table/object	Reference
ieee8021MvrpxPortTable	12.9.2
(AUGMENTS ieee8021BridgeBasePortEntry)	—
ieee8021MvrpxPortNewOnly	12.9.2.1.3, 12.9.2.2.2
ieee8021MvrpxPortMvrpNewPropagated	12.7.7.1.2 d), 12.7.7.3.3 d)
ieee8021MvrpxPortXmitZero	12.9.2.1.3 c), 12.9.2.2.2 e)

17.2.16 Structure of the IEEE8021-MIRP-MIB

The IEEE8021-MIRP-MIB provides objects to configure the Multiple I-SID Registration Protocol defined in Clause 39. Table 17-22 describes the relationship between the SMIv2 objects defined in the MIB module in 17.7.13 and the variables and managed objects defined in Clause 12.

Table 17-22—IEEE8021-MIRP-MIB structure

IEEE8021-MIRP-MIB table/object	Reference
ieee8021MirpV2PortTable	12.7.7
(AUGMENTS ieee8021BridgeBasePortEntry)	—
ieee8021MirpV2PortEnabledStatus	12.7.7.1, 12.7.7.2
ieee8021PbbBackboneEdgeBridgeObjects	12.6.1.1, 12.16.1.2
ieee8021PbbMirpEnableStatus	12.16.1.1.3 i)
ieee8021PbbMirpBvid	12.16.1.1.3 j), 12.16.1.2.2 c)
ieee8021PbbMirpDestSelector	Table 8-1, 12.16.1.1.3 k), 12.16.1.2.2 d)
ieee8021PbbMirpPnpEnable	12.16.1.1.3 j), 12.16.1.2.2 c)
ieee8021PbbMirpPnpPortNumber	12.16.1.1.3 j), 12.16.1.2.2 c)

17.2.17 Structure of the IEEE8021-PFC-MIB

Table 17-23 describes the relationship between the SMIv2 objects defined in the PFC-MIB module (17.7.13) and the variables and managed objects defined in Clause 12 and Clause 36.

Table 17-23—PFC-MIB structure

Variable	Reference	IEEE8021-PFC-MIB table/object
PFC Interface Table	17.7.13	**ieee8021PfcIfTable**
(AUGMENTS ifEntry)	—	—
PFCLinkDelayAllowance	12.22.6	ieee8021PfcLinkDelayAllowance
PFCRequests	12.22.6	ieee8021PfcRequests
PFCIndications	12.22.6	ieee8021PfcIndications

17.2.18 Structure of the IEEE8021-TEIPS-MIB

The IEEE8021-TEIPS-MIB provides objects to configure and manage IPS in PBB-TE Region (26.11).

Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included.

Table 17-24 shows the mapping of the IPS Clause 12 managed objects to the tables and columns of the TEIPS MIB that model those managed objects.

Table 17-24—IEEE8021-TEIPS MIB structure

Variable	IEEE8021-TEIPS-MIB table/object	Reference
	ieee8021TeipsV2IpgTable	
	ieee8021TeipsV2Ipgid	12.24.1.1.3 a)
	ieee8021TeipsV2IpgWorkingMA	12.24.1.1.3 b)
	ieee8021TeipsV2IpgProtectionMA	12.24.1.1.3 c)
	ieee8021TeipsV2IpgWorkingPortNumber	12.24.2.2.1 b)
	ieee8021TeipsV2IpgProtectionPortNumber	12.24.2.1.1 c)
	ieee8021TeipsV2TesiTable	
	ieee8021TeipsV2TesiId	12.24.2.1.3 f)
	ieee8021TeipsV2CandidatePsTable	
	ieee8021TeipsV2CandidatePsMA	12.24.2.1.3 e)
	ieee8021TeipsV2CandidatePsPortNumber	12.24.2.1.3 e)
	ieee8021TeipsV2CandidatePsOperational	12.24.2.1.3 e)

Table 17-24—IEEE8021-TEIPS MIB structure *(continued)*

Variable	IEEE8021-TEIPS-MIB table/object	Reference
	ieee8021TeipsV2IpgConfigTable	
	ieee8021TeipsV2IpgConfigState	12.24.2.1.3 g)
	ieee8021TeipsV2IpgConfigCommandStatus	12.24.2.1.3 h)
	ieee8021TeipsV2IpgConfigCommandLast	12.24.2.3.2 b)
	ieee8021TeipsV2IpgConfigAdmin	12.24.2.2.1 b)
	ieee8021TeipsV2IpgConfigActiveRequests	12.24.2.1.3 h)
WTRwhile (26.10.3.2.1)	ieee8021TeipsV2IpgConfigWTR	12.24.2.1.3 i)
HoldOffWhile (26.10.3.2.2)	ieee8021TeipsV2IpgConfigHoldOff	12.24.2.1.3 j)
	ieee8021TeipsV2IpgM1ConfigState	12.24.2.1.3 k)
WTRwhile (26.10.3.2.1)	ieee8021TeipsV2IpgConfigMWTR	12.24.2.1.3 l)

An IPG can be referenced externally. For this reason, a canonical external IPG identifier is provided via the textual convention `IEEE8021TeipsIpgid`. The convention defines a simple integer of local significance to a particular Bridge component for the purpose of MIB management.

An Infrastructure Segment can be referenced externally. For this reason, a canonical external Infrastructure Segment Identifier (SEG-ID) is provided via the textual convention `IEEE8021TeipsSegid`. The convention defines a simple integer of local significance to a particular Bridge component for the purpose of MIB management.

In the case of 1:1 IPS, an IPG specifies a Working Segment and a Protection Segment. In the case of M:1 IPS, the IPG specifies a Working Segment and a list of candidate Protection Segments from which the Protection Segment is selected. Each Infrastructure Segment is associated with a pair of Segment Monitoring Paths (SMPs). Each SMP is identified by a 3-tuple consisting of a <SMP-DA,SMP-SA,SMP-VID> tuple. Each such tuple is represented by the textual convention `IEEE8021TeipsSmpid`, which is a fixed-length octet string containing the two MAC addresses and the VID value.

17.2.18.1 Using the TEIPS MIB to create MAs for Infrastructure Segments

IPS requires a mechanism to monitor the health of each Infrastructure Segment associated with an IPG. The CFM MA provides this mechanism.

Configuring an MA requires adding a row to the CFM MIB's StackTable. Two columns are used in the StackTable to define the Infrastructure Segment upon which the MA operates. These are the `IEEE8021ServiceSelectorType` column and the `IEEE8021ServiceSelectorValue` column. The first column defines how the value in the second column is to be interpreted. If the value of the first column is set to `segid(4)`, then the second column is interpreted as the external representation of a SEG-ID.

Thus, Infrastructure Segments, and their corresponding identifiers, configured in the `ieee8021TeipsV2SegTable` provide the SEG-ID values that are used as parameters to rowcreate operations for the `CFMStackTable` to create MAs that monitor the health of Infrastructure Segments.

Creating entries in the `CFMStackTable`, in turn, defines `MAID` values, represented as unsigned integers, that are used subsequently to configure the protected services.

17.2.18.2 Using the TEIPS MIB to create IPGs

IPGs are created by adding rows to the `ieee8021TeipsV2IpgTable`. Each entry in the table contains columns representing the Working and Protection Segment MAs associated with the IPG, the Port Number associated with each Infrastructure Segment MA, and a RowStatus column used to manage the creation and deletion of the IPG. The MAs are referred to by MAID and can be found in the `StackTable` of the CFM MIB managed objects. The value of the Port Number column is derived from the corresponding Infrastructure Segment MA.

17.2.18.3 Using the TEIPS MIB to query and configure IPGs

Each IPG has status and configuration information that can be managed. This information is located in the `ieee8021TeipsV2IpgConfigTable`. This table allows management stations to determine whether the Working Segment or Protection Segment is active, and it allows traffic to be switched by management command. It provides optional parameters for configuration of the waiting time before triggering a switchover and the time to restore after a failure condition has cleared.

17.2.19 Structure of the IEEE8021-SPB-MIB

The IEEE8021-SPB-MIB provides objects to configure both SPBV and SPBM as defined in Clause 27 and Clause 28. Table 17-25 describes the relationship between the SMIv2 objects defined in the MIB module in (17.7.19) and the variables and managed objects defined in Clause 12.

Table 17-25—IEEE8021-SPB-MIB structure

IEEE8021-SPB-MIB table/object	Reference
ieee8021SpbSys	12.25.1
ieee8021SpbSysAreaAddress	12.25.1.3.2, 12.25.1.3.3
ieee8021SpbSysId	12.25.1.3.3, Clause 3
ieee8021SpbSysControlAddr	12.25.1.3.3
ieee8021SpbSysName	12.25.1.3.3
ieee8021SpbSysBridgePriority	12.25.1.3.3, 13.26.3
ieee8021SpbmSysSPSourceId	12.25.1.3.3, Clause 3
ieee8021SpbvSysMode	12.25.1.3.3, Clause 3
ieee8021SpbmSysMode	12.25.1.3.3, Clause 3
ieee8021SpbSysDigestConvention	12.25.1.3.3, 28.4.3

Table 17-25—IEEE8021-SPB-MIB structure *(continued)*

IEEE8021-SPB-MIB table/object	Reference
ieee8021SpbMtidStaticTable	12.25.2
ieee8021SpbMtidStaticTableEntry	12.25.2.3.3
ieee8021SpbMtidStaticEntryMtid	12.25.1.3.2, 12.25.2.3.3, 28.12
ieee8021SpbMTidStaticEntryMtidOverload	12.25.2.3.3, 27.8.1
ieee8021SpbMtidStaticEntryRowStatus	12.25.2.3.3
ieee8021SpbTopIx	12.25.2.3.3
ieee8021SpbTopIxDynamicTable	12.25.3
ieee8021SpbTopIxDynamicTableEntry	12.25.3
ieee8021SpbTopIxDynamicEntryTopIx	12.25.3.1.2, 28.12
ieee8021SpbTopIxDynamicEntryAgreeDigest	12.25.3.1.3, 28.4
ieee8021SpbTopIxDynamicEntryMCID	12.25.3.1.3, 13.8
ieee8021SpbTopIxDynamicEntryAuxMCID	12.25.3.1.3, 28.9
ieee8021SpbEctStaticTable	12.25.4
ieee8021SpbEctStaticTableEntry	12.25.4
ieee8021SpbEctStaticEntryTopIx	12.25.4.1.2, 28.12
ieee8021SpbEctStaticEntryBaseVid	12.25.4.1.2, Clause 3
ieee8021SpbEctStaticEntryEctAlgorithm	12.25.4.1.2, Clause 3
ieee8021SpbvEctStaticEntrySpvid	12.25.4.1.2, Clause 3
ieee8021SpbEctStaticEntryRowStatus	12.25.4.1.2
ieee8021SpbEctDynamicTable	12.25.5
ieee8021SpbEctDynamicTableEntry	12.25.5
ieee8021SpbEctDynamicEntryTopIx	12.25.5.1.2, 12.25.5.1.3, 28.12
ieee8021SpbEctDynamicEntryBaseVid	12.25.5.1.2, 12.25.5.1.3, Clause 3
ieee8021SpbEctDynamicEntryMode	12.25.5.1.3, 28.12.4
ieee8021SpbEctDynamicEntryLocalUse	12.25.5.1.3, 28.12.4
ieee8021SpbEctDynamicEntryRemoteUse	12.25.5.1.3, 28.12.4
ieee8021SpbEctDynamicEntryIngressCheckDiscards	12.25.5.1.3
ieee8021SpbAdjStaticTable	12.25.6
ieee8021SpbAdjStaticTableEntry	12.25.6
ieee8021SpbAdjStaticEntryTopIx	12.25.6.1.2, 12.25.6.1.3, 28.12
ieee8021SpbAdjStaticEntryIfIndex	12.25.6.1.2, 12.25.6.1.3
ieee8021SpbAdjStaticEntryMetric	12.25.6.1.2, 12.25.6.1.3, 28.12.7
ieee8021SpbAdjStaticEntryIfAdminState	12.25.6.1.2, 12.25.6.1.3

Table 17-25—IEEE8021-SPB-MIB structure *(continued)*

IEEE8021-SPB-MIB table/object	Reference
ieee8021SpbAdjStaticEntryRowStatus	12.25.6.1.3
ieee8021SpbAdjDynamicTable	12.25.7
ieee8021SpbAdjDynamicTableEntry	12.25.7
ieee8021SpbAdjDynamicEntryTopIx	12.25.7.1.2, 12.25.7.1.3, 28.12
ieee8021SpbAdjDynamicEntryIfIndex	12.25.7.1.2, 12.25.7.1.3
ieee8021SpbAdjDynamicEntryPeerSysId	12.25.7.1.3, Clause 3
ieee8021SpbAdjDynamicEntryPort	12.25.7.1.3
ieee8021SpbAdjDynamicEntryIfOperState	12.25.7.1.3
ieee8021SpbAdjDynamicEntryPeerSysName	12.25.7.1.3
ieee8021SpbAdjDynamicEntryPeerAgreeDigest	12.25.7.1.3, 28.4
ieee8021SpbAdjDynamicEntryPeerMCID	12.25.7.1.3, 28.12.2, 27.4.1
ieee8021SpbAdjDynamicEntryPeerAuxMCID	12.25.7.1.3, 28.12.2
ieee8021SpbAdjDynamicEntryLocalCircuitID	12.25.7.1.3, 28.11
ieee8021SpbAdjDynamicEntryPeerLocalCircuitID	12.25.7.1.3, 28.11
ieee8021SpbAdjDynamicEntryPortIdentifier	12.25.7.1.3, 28.11, 14.2.7
ieee8021SpbAdjDynamicEntryPeerPortIdentifier	12.25.7.1.3, 28.11, 14.2.7
ieee8021SpbAdjDynamicEntryIsisCircIndex	12.25.7.1.3, 28.11
ieee8021SpbTopNodeTable	12.25.9
ieee8021SpbTopNodeTableEntry	12.25.9
ieee8021SpbTopNodeEntryTopIx	12.25.9.1.2, 12.25.9.1.3, 28.12
ieee8021SpbTopNodeEntrySysId	12.25.9.1.2, 12.25.9.1.3, Clause 3
ieee8021SpbTopNodeEntryBridgePriority	12.25.9.1.3, 13.26.3
ieee8021SpbmTopNodeEntrySPsourceID	12.25.9.1.3, Clause 3
ieee8021SpbTopNodeEntrySysName	12.25.9.1.3
ieee8021SpbTopEctTable	12.25.10
ieee8021SpbTopEctTableEntry	12.25.10
ieee8021SpbTopEctEntryTopIx	12.25.10.1.2, 12.25.10.1.3
ieee8021SpbTopEctEntrySysId	12.25.10.1.2, 12.25.10.1.3, Clause 3
ieee8021SpbTopEctEntryBaseVid	12.25.10.1.2, 12.25.10.1.3, Clause 3
ieee8021SpbTopEctEntryEctAlgorithm	12.25.10.1.3, Clause 3
ieee8021SpbTopEctEntryMode	12.25.10.1.3
ieee8021SpbvTopEctSysMode	12.25.10.1.3
ieee8021SpbvTopEctEntrySpvid	12.25.10.1.3

Table 17-25—IEEE8021-SPB-MIB structure *(continued)*

IEEE8021-SPB-MIB table/object	Reference
ieee8021SpbTopEctEntryLocalUse	12.25.10.1.3, 28.12.5
ieee8021SpbTopEdgeTable	12.25.11
ieee8021SpbTopEdgeTableEntry	12.25.11
ieee8021SpbTopEdgeEntryTopIx	12.25.11.1.2, 12.25.11.1.3, 28.12
ieee8021SpbTopEdgeEntrySysIdNear	12.25.11.1.2, 12.25.11.1.3, Clause 3
ieee8021SpbTopEdgeEntrySysIdFar	12.25.11.1.2, 12.25.11.1.3, Clause 3
ieee8021SpbTopEdgeEntryMetricNear2Far	12.25.11.1.3, 28.12.7
ieee8021SpbTopEdgeEntryMetricFar2Near	12.25.11.1.3, 28.12.7
ieee8021SpbmTopSrvTable	12.25.12
ieee8021SpbmTopSrvTableEntry	12.25.12
ieee8021SpbmTopSrvEntryTopIx	12.25.12.1.2, 12.25.11.1.3, 28.12
ieee8021SpbmTopSrvEntrySysId	12.25.12.1.2, 12.25.11.1.3, Clause 3
ieee8021SpbmTopSrvEntryIsid	12.25.12.1.2, 12.25.11.1.3, 28.12.10
ieee8021SpbmTopSrvEntryBaseVid	12.25.12.1.2, 12.25.11.1.3, 28.12.10
ieee8021SpbmTopSrvEntryIsidFlags	12.25.12.1.2, 12.25.11.1.3, 28.12.10
ieee8021SpbmTopSrvEntryMac	12.25.11.1.3, 28.12.10
ieee8021SpbvTopSrvTable	12.25.13
ieee8021SpbvTopSrvTableEntry	12.25.13
ieee8021SpbvTopSrvEntryTopIx	12.25.13.1.2, 12.25.13.1.3, 28.12
ieee8021SpbvTopSrvEntrySysId	12.25.13.1.2, 12.25.13.1.3, Clause 3
ieee8021SpbvTopSrvEntryMMac	12.25.13.1.2, 12.25.13.1.3, 28.12.9
ieee8021SpbvTopSrvEntryMMacFlags	12.25.13.1.3, 28.12.9
ieee8021SpbvTopSrvEntryBaseVid	12.25.13.1.3, Clause 3
ieee8021SpbmBsiStaticTable	12.25.8, 28.12.10
ieee8021SpbmBsiStaticTableEntry	12.25.8
ieee8021SpbmBsiStaticEntryIsid	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryBaseVid	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryTBit	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryRBit	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryTsBit	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryTieBreakMask	12.25.8.1, 12.25.8.2
ieee8021SpbmBsiStaticEntryRowStatus	—

Table 17-25—IEEE8021-SPB-MIB structure *(continued)*

IEEE8021-SPB-MIB table/object	Reference
dot1agCfmMepSpbmTable	12.14.7, 27.19
dot1agCfmMepSpbmEntry	12.14.7
dot1agCfmMepTransmitLbmSpbmDA	12.14.7.3
dot1agCfmMepTransmitLtmSpbmDA	12.14.7.4
dot1agCfmMepSpbmEspTable	12.14.5.3.2, 27.19.1
dot1agCfmMepSpbmEspEntry	12.14.5.3.2
dot1agCfmMepSpbmEspIndex	12.14.5.3.2
dot1agCfmMepSpbmEspEsp	12.14.5.3.2
dot1agCfmMepSpbmEspRowStatus	—
ieee8021PcrEctStaticTable	12.28.1
ieee8021PcrEctStaticTableEntry	12.28.1
ieee8021PcrEctStaticEntryTopIx	12.28.1.1.2
ieee8021PcrEctStaticEntryBaseVid	12.28.1.1.2
ieee8021PcrEctStaticEntryMrtBlueVid	12.28.1.1.2, 45.3.3, 45.3.4
ieee8021PcrEctStaticEntryMrtRedVid	12.28.1.1.2, 45.3.3, 45.3.4
ieee8021PcrEctStaticEntryRowStatus	12.28.2.1.3
ieee8021PcrTopEctTable	12.28.2
ieee8021PcrTopEctTableEntry	12.28.2
ieee8021PcrTopEctEntryTopIx	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntrySysId	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryBaseVid	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryMode	12.28.2.1.2, 12.28.2.1.3
ieee8021PcrTopEctEntryMrtBlueVid	12.28.2.1.3, 45.3.3, 45.3.4
ieee8021PcrTopEctEntryMrtRedVid	12.28.2.1.3, 45.3.3, 45.3.4

17.2.20 Structure of the IEEE8021-EVB-MIB

The IEEE8021-EVB-MIB provides objects to configure and manage an EVB station system or EVB Bridge system. Objects in this MIB module are arranged into subtrees. Each subtree is organized as a set of related objects. Where appropriate, the corresponding Clause 12 management reference is also included. Table 17-26 indicates the structure of the IEEE8021-EVB-MIB module.

Table 17-26—IEEE8021-EVB-MIB structure

IEEE8021-EVB-MIB table/object	References
ieee8021BridgeEvbNotifications subtree	
—	—
ieee8021BridgeEvbObjects subtree	
ieee8021BridgeEvbSys	12.26.1
ieee8021BridgeEvbSysType	—
ieee8021BridgeEvbSysNumExternalPorts	—
ieee8021BridgeEvbSysEvbLldpTxEnable	—
ieee8021BridgeEvbSysEvbLldpManual	—
ieee8021BridgeEvbSysEvbLldpGidCapable	—
ieee8021BridgeEvbSysEcpAckTimerExp	—
ieee8021BridgeEvbSysEcpMaxRetries	—
ieee8021BridgeEvbSysVdpDfltRsrcWaitDelayExp	—
ieee8021BridgeEvbSysVdpDfltReinitKeepAliveExp	—
ieee8021BridgeEvbSbpTable	12.26.2
ieee8021BridgeEvbSbpComponentID	—
ieee8021BridgeEvbSbpPortNumber	—
ieee8021BridgeEvbSbpLldpManual	—
ieee8021BridgeEvbSbpVdpOperRsrcWaitDelayExp	—
ieee8021BridgeEvbSbpVdpOperReinitKeepAliveExp	—
ieee8021BridgeEvbSbpVdpOperToutKeepAlive	—
ieee8021BridgeEvbSbpRowStatus	—
ieee8021BridgeEvbVsiDbTable	12.26.3
ieee8021BridgeEvbVsiComponentID	—
ieee8021BridgeEvbVsiPortNumber	—
ieee8021BridgeEvbVsiID	—
ieee8021BridgeEvbVsiTimeSinceCreate	—
ieee8021BridgeEvbVsiVdpOperCmd	—
ieee8021BridgeEvbVsiOperRevert	—

Table 17-26—IEEE8021-EVB-MIB structure *(continued)*

IEEE8021-EVB-MIB table/object	References
ieee8021BridgeEvbVsiOperHard	—
ieee8021BridgeEvbVsiOperReason	—
ieee8021BridgeEvbVsiMgrID (Deprecated)	—
ieee8021BridgeEvbVsiType	—
ieee8021BridgeEvbVsiTypeVersion	—
ieee8021BridgeEvbVsiMvFormat	—
ieee8021BridgeEvbVsiNumMACs	—
ieee8021BridgeEvbVDPMachineState	—
ieee8021BridgeEvbVDPCommandsSucceeded	—
ieee8021BridgeEvbVDPCommandsFailed	—
ieee8021BridgeEvbVDPCommandReverts	—
ieee8021BridgeEvbVsiMgrID16	—
ieee8021BridgeEvbVSIMvFormat	—
ieee8021BridgeEvbVsiDbMacTable	12.26.3
ieee8021BridgeEvbVsiComponentID	—
ieee8021BridgeEvbVsiPortNumber	—
ieee8021BridgeEvbVsiID	—
ieee8021BridgeEvbGroupID	—
ieee8021BridgeEvbVsiMac	—
ieee8021BridgeEvbVsiVlanId	—
ieee8021BridgeEvbUapConfigTable	12.26.4.1
ieee8021BridgePort	—
ieee8021BridgeEvbUapComponentId	—
ieee8021BridgeEvbUapPort	—
ieee8021BridgeEvbUapConfigIfIndex	—
ieee8021BridgeEvbUapCdcpAdminEnable	—
ieee8021BridgeEvbUapAdminCdcpRole	—
ieee8021BridgeEvbUapAdminCdcpChanCap	—
ieee8021BridgeEvbUapOperCdcpChanCap	—
ieee8021BridgeEvbUapAdminCdcpSVIDPoolLow	—
ieee8021BridgeEvbUapAdminCdcpSVIDPoolHigh	—
ieee8021BridgeEvbUapOperState	—
ieee8021BridgeEvbUapCdcpRemoteEnabled	—

Table 17-26—IEEE8021-EVB-MIB structure *(continued)*

IEEE8021-EVB-MIB table/object	References
ieee8021BridgeEvbUapCdcpRemoteRole	—
ieee8021BridgeEvbUapConfigRowStatus	—
ieee8021BridgeEvbCapConfigTable	12.26.4.2
ieee8021BridgeBridgePort	—
ieee8021BridgeEvbCapSchID	—
ieee8021BridgeEvbCapComponentId	—
ieee8021BridgeEvbCapIfIndex	—
ieee8021BridgeEvbCapPortNumber	—
ieee8021BridgeEvbCapSChannelID	—
ieee8021BridgeEvbCapAssociateSbpOrUrpCompID	—
ieee8021BridgeEvbCapAssociateSbpOrUrpPort	—
ieee8021BridgeEvbCapRowStatus	—
ieee8021BridgeEvbUrpTable	12.26.5
ieee8021BridgeEvbUrpComponentID	—
ieee8021BridgeEvbUrpPort	—
ieee8021BridgeEvbUrpIfIndex	—
ieee8021BridgeEvbUrpBindToIssPort	—
ieee8021BridgeEvbUrpLldpManual	—
ieee8021BridgeEvbUrpVdpOperRsrcWaitDelayExp	—
ieee8021BridgeEvbUrpVdpOperRespWaitDelay	—
ieee8021BridgeEvbUrpVdpOperReinitKeepAliveExp	—
ieee8021BridgeEvbUrpRowStatus	—
ieee8021BridgeEvbEcpTable	12.27.1
ieee8021BridgeEvbEcpComponentID	—
ieee8021BridgeEvbEcpPort	—
ieee8021BridgeEvbEcpOperAckTimerInitExp	—
ieee8021BridgeEvbecpOperMaxRetries	—
ieee8021BridgeEvbEcpTxFrameCount	—
ieee8021BridgeEvbEcpTxRetryCount	—
ieee8021BridgeEvbEcpFailures	—
ieee8021BridgeEvbEcpRxFrameCount	—
ieee8021BridgeEvbConformance subtree	
ieee8021BridgeEvbGroups	—

Table 17-26—IEEE8021-EVB-MIB structure *(continued)*

IEEE8021-EVB-MIB table/object	References
ieee8021BridgeEvbSysGroup	—
ieee8021BridgeEvbSbpConfigGroup	—
ieee8021BridgeEvbVsiDbGroup	—
ieee8021BridgeEvbUapConfigGroup	—
ieee8021BridgeEvbCapConfigGroup	—
ieee8021BridgeEvbUrpConfigGroup	—
ieee8021BridgeEvbsEcpConfigGroup	—
ieee8021BridgeEvbCompliances	—
ieee8021BridgeEvbbCompliance	—
ieee8021BridgeEvbsCompliance	—

17.2.21 Structure of the IEEE8021-ECMP-MIB

The IEEE8021-ECMP-MIB provides for configuration of flow filtering (44.2) on ports (CBPs and PNPs) and the configuration of ISIS-SPB advertisements specific to the ECMP ECT Algorithm (44.1.2). It also allows reading of FDB state and statistics related to ECMP and flow filtering. Table 17-27 indicates the relationship between the SMIv2 objects defined in the MIB module (17.7.21) and managed objects defined in Clause 12.

Table 17-27—IEEE8021-ECMP-MIB structure

IEEE8021-ECMP-MIB table/object	Reference
ieee8021QBridgeEcmpFdbTable	12.7.7.3, 8.8.3
(AUGMENTS ieee8021QBridgeTpFdbEntry)	—
ieee8021QBridgeEcmpFdbPortList	—
ieee8021EcmpFlowFilterCtlTable	12.16.5.4, 12.16.5.5, 44.2.2
ieee8021EcmpFlowFilterCtlVid	—
ieee8021EcmpFlowFilterCtlEnabled	—
ieee8021EcmpFlowFilterCtlHashGen	—
ieee8021EcmpFlowFilterCtlTtl	—
ieee8021EcmpEctStaticTable	12.25.14, 28.12.6.1
ieee8021EcmpEctStaticEntryTieBreakMask	—
ieee8021EcmpEctStaticEntryBridgePriority	—
ieee8021EcmpEctStaticEntryRowStatus	—
ieee8021EcmpTopSrvTable	12.25.12.1.3, 28.12.10
(AUGMENTS ieee8021SpbmTopSrvTableEntry)	—
ieee8021EcmpTopSrvEntryTsBit	—
ieee8021EcmpTopSrvEntryTieBreakMask	—
ieee8021QBridgePortVlanTtlStatisticsTable	12.6.1.1.3, 44.2.2.1
(AUGMENTS ieee8021QBridgePortVlanStatisticsEntry)	—
ieee8021QBridgeTpVlanPortTtlDiscards	—

17.2.22 Structure of the IEEE8021-ST-MIB

The IEEE8021-ST-MIB provides for configuration of scheduled traffic (8.6.8, 8.6.8.4) on ports. Table 17-28 indicates the relationship between the SMIv2 objects defined in the MIB module (17.7.22) and managed objects defined in 12.29.

Table 17-28—IEEE8021-ST-MIB structure

IEEE8021-ST-MIB table/object	Reference
ieee8021STMaxSDU subtree	
ieee8021STMaxSDUTable	Max SDU table, 8.6.8.4, 8.6.9, 12.29.1
ieee8021STTrafficClass*	Traffic Class
ieee8021STMaxSDU	queueMaxSDU, 8.6.8.4, 8.6.9, 12.29.1, 12.29.1.1.1
ieee8021TransmissionOverrun	TransmissionOverrun, 8.6.8.4, 8.6.9, 12.29.1, 12.29.1.1.2
ieee8021STParameters	
ieee8021STParametersTable	Scheduled Traffic parameter table, 8.6.8.4, 8.6.9, 12.29.1
ieee8021STGateEnabled	GateEnabled, 8.6.8.4, 8.6.9, 8.6.9.4.14, 12.29.1
ieee8021STAdminGateStates	AdminGateStates, 8.6.8.4, 8.6.9, 8.6.9.4.5, 12.29.1
ieee8021STOperGateStates	OperGateStates, 8.6.8.4, 8.6.9, 8.6.9.4.21, 12.29.1
ieee8021STAdminControlListLength	AdminControlListLength, 8.6.8.4, 8.6.9, 8.6.9.4.6, 12.29.1
ieee8021STOperControlListLength	OperControlListLength, 8.6.8.4, 8.6.9, 8.6.9.4.22, 12.29.1
ieee8021STAdminControlList	AdminControlList, 8.6.8.4, 8.6.9, 8.6.9.4.2, 12.29.1
ieee8021STOperControlList	OperControlList, 8.6.8.4, 8.6.9, 8.6.9.4.18, 12.29.1
ieee8021STAdminCycleTimeNumerator	Numerator—AdminCycleTime, 8.6.8.4, 8.6.9, 8.6.9.4.3, 12.29.1
ieee8021STAdminCycleTimeDenominator	Denominator—AdminCycleTime, 8.6.8.4, 8.6.9, 8.6.9.4.3, 12.29.1
ieee8021STOperCycleTimeNumerator	Numerator—OperCycleTime, 8.6.8.4, 8.6.9, 8.6.9.4.19, 12.29.1
ieee8021STOperCycleTimeDenominator	Denominator—OperCycleTime, 8.6.8.4, 8.6.9, 8.6.9.4.19, 12.29.1
ieee8021STAdminCycleTimeExtension	AdminCycleTimeExtension, 8.6.8.4, 8.6.9, 8.6.9.4.4, 12.29.1
ieee8021STOperCycleTimeExtension	OperCycleTimeExtension, 8.6.8.4, 8.6.9, 8.6.9.4.20, 12.29.1
ieee8021STAdminBaseTime	AdminBaseTime, 8.6.8.4, 8.6.9, 8.6.9.4.1, 12.29.1
ieee8021STOperBaseTime	OperBaseTime, 8.6.8.4, 8.6.9, 8.6.9.4.17, 12.29.1
ieee8021STConfigChange	ConfigChange, 8.6.8.4, 8.6.9, 8.6.9.4.7, 12.29.1
ieee8021STConfigChangeTime	ConfigChangeTime, 8.6.8.4, 8.6.9, 8.6.9.4.9, 12.29.1
ieee8021STTickGranularity	TickGranularity, 8.6.8.4, 8.6.9, 12.29.1
ieee8021STCurrentTime	CurrentTime, 8.6.8.4, 8.6.9, 8.6.9.4.10, 12.29.1
ieee802STConfigPending	ConfigPending, 8.6.9.4.8
ieee8021STSupportedListMax	SupportedListMax, 12.29.1.5

*This object is an INDEX of the table in which it resides.

17.2.23 Structure of the IEEE8021-Preemption-MIB

The IEEE8021-Preemption-MIB provides for configuration of frame preemption (6.7.2, 8.6.8) on ports. Table 17-29 indicates the relationship between the SMIv2 objects defined in the MIB module (17.7.23) and managed objects defined in 12.30.

Table 17-29—IEEE8021-Preemption-MIB structure

IEEE8021-Preemption-MIB table/object	Reference
ieee8021PreemptionParameterTable subtree	
ieee8021PreemptionParameterTable	Frame Preemption parameter table, 6.7.2, 12.30.1
ieee8021PreemptionPriority	Priority (Table index)
ieee8021FramePreemptionAdminStatus	framePreemptionAdminStatus, 6.7.2, 12.30.1
ieee8021PreemptionConfigTable	Frame Preemption configuration table, 6.7.2, 12.30.1
ieee8021FramePreemptionHoldAdvance	framePreemptionHoldAdvance, 6.7.2, 12.30.1, 12.30.1.2
ieee8021FramePreemptionReleaseAdvance	framePreemptionReleaseAdvance, 6.7.2, 12.30.1, 12.30.1.3
ieee8021FramePreemptionActive	framePreemptionActive, 6.7.2, 12.30.1, 12.30.1.4
ieee8021FramePreemptionHoldRequest	framePreemptionHoldRequest, 6.7.2, 12.30.1, 12.30.1.5

17.2.24 Structure of the IEEE8021-PSFP-MIB

The IEEE8021-PSFP-MIB provides for configuration of PSFP (8.6.5, 8.6.5.2, 8.6.10) on reception Ports. Table 17-30 indicates the relationship between the SMIv2 objects defined in the MIB module (17.7.24) and managed objects defined in 12.31.

Table 17-30—IEEE8021-PSFP-MIB structure

IEEE8021-PSFP-MIB table/object	Reference
ieee8021PSFPStreamFillterParameters subtree	
ieee8021PSFPStreamFilterTable	Stream Filter Instance Table, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPStreamFilterInstance	StreamFilterInstance, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPStreamHandleSpec	StreamHandleSpec, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPPrioritySpec	PrioritySpec, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPStreamGateInstanceID	StreamGateInstanceID, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPFilterSpecificationList [a]	MaxSDUSize, FlowMeterInstanceID, FlowMeterEnable, 8.6.5.2.1, 8.6.5.3, 12.31.2, 12.31.2.4, 12.31.2.6
ieee8021PSFPMatchingFramesCount	MatchingFramesCount, 8.6.5.2.1, 8.6.5.3, 12.31.2
ieee8021PSFPPassingFramesCount	PassingFramesCount, 8.6.5.2.1, 8.6.5.3, 8.6.5.4, 12.31.2

Table 17-30—IEEE8021-PSFP-MIB structure *(continued)*

IEEE8021-PSFP-MIB table/object	Reference
ieee8021PSFPNotPassingFramesCount	NotPassingFramesCount, 8.6.5.2.1, 8.6.5.3, 8.6.5.4, 12.31.2
ieee8021PSFPPassingSDUCount	PassingSDUCount, 8.6.5.2.1, 8.6.5.3, 8.6.5.3.1, 12.31.2
ieee8021PSFPNotPassingSDUCount	NotPassingSDUCount, 8.6.5.2.1, 8.6.5.3, 8.6.5.3.1, 12.31.2
ieee8021PSFPREDFramesCount	REDFramesCount, 8.6.5.2.1, 8.6.5.3, 8.6.5.5, 12.31.2
ieee8021PSFPStreamBlockedDueToOversizeFrameEnable	StreamBlockedDueToOversizeFrameEnable, 8.6.5.2.1, 8.6.5.3.1, 12.31.2
ieee8021PSFPStreamBlockedDueToOversizeFrame	StreamBlockedDueToOversizeFrame, 8.6.5.2.1, 8.6.5.3.1, 12.31.2
ieee8021PSFPStreamGateParameters	
ieee8021FPStPSreamGateTable	Stream Gate Instance Table, 8.6.5.2.1, 8.6.5.4, 12.31.3
ieee8021PSFPStreamGateInstance	StreamGateInstance, 8.6.5.2.1, 8.6.5.4, 12.31.3
ieee8021PSFPGateEnabled	StreamGateEnabled, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminGateStates	StreamGateAdminGateStates, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperGateStates	StreamGateOperGateStates, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminControlListLength	StreamGateAdminControlListLength, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperControlListLength	StreamGateOperControlListLength, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminControlList	StreamGateAdminControlList, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperControlList	StreamGateOperControlList, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminCycleTimeNumerator	StreamGateAdminCycleTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminCycleTimeDenominator	StreamGateAdminCycleTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperCycleTimeNumerator	StreamGateOperCycleTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperCycleTimeDenominator	StreamGateOperCycleTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminCycleTimeExtension	StreamGateAdminCycleTimeExtension, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPOperCycleTimeExtension	StreamGateOperCycleTimeExtension, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminBaseTime	StreamGateAdminBaseTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3

Table 17-30—IEEE8021-PSFP-MIB structure *(continued)*

IEEE8021-PSFP-MIB table/object	Reference
ieee8021PSFPOperBaseTime	StreamGateOperBaseTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPConfigChange	StreamGateConfigChange, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPConfigChangeTime	StreamGateConfigChangeTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPTickGranularity	StreamGateTickGranularity, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPCurrentTime	StreamGateCurrentTime, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPConfigPending	StreamGateConfigPending, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPConfigChangeError	StreamGateConfigChangeError, 8.6.5.2.1, 8.6.5.4, 8.6.10, 12.31.3
ieee8021PSFPAdminIPV	StreamGateAdminIPV, 8.6.5.2.1, 8.6.5.4, 12.31.3
ieee8021PSFPOperIPV	StreamGateOperIPV, 8.6.5.2.1, 8.6.5.4, 12.31.3
ieee8021PSFPGateClosedDueToInvalidRxEnable	StreamGateGateClosedDueToInvalidRxEnable, 8.6.5.2.1, 8.6.5.4
ieee8021PSFPGateClosedDueToInvalidRx	StreamGateGateClosedDueToInvalidRx, 8.6.5.2.1, 8.6.5.4
ieee8021PSFPGateClosedDueToOctetsExceededEnable	StreamGateGateClosedDueToOctetsExceededEnable, 8.6.5.2.1, 8.6.5.4
ieee8021PSFPGateClosedDueToOctetsExceeded	StreamGateGateClosedDueToOctetsExceeded, 8.6.5.2.1, 8.6.5.4
ieee8021PSFPFlowMeterParameters	
ieee8021PSFPFlowMeterTable	Flow Meter Instance Table, 8.6.5.2.1, 8.6.5.4, 12.31.4
ieee8021PSFPFlowMeterInstance	FlowMeterInstanceID, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterCIR	CIR, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterCBS	CBS, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterEIR	EIR, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterCF	CF, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterCM	CM, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterDropOnYellow	DropOnYellow, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterMarkAllFramesRedEnable	MarkAllFramesRedEnable, 8.6.5.2.1, 8.6.5.5, 12.31.4
ieee8021PSFPFlowMeterMarkAllFramesRed	MarkAllFramesRed, 8.6.5.2.1, 8.6.5.5, 12.31.4

Table 17-30—IEEE8021-PSFP-MIB structure *(continued)*

IEEE8021-PSFP-MIB table/object	Reference
ieee8021PSFPStreamParameters	
ieee8021PSFPStreamParameterTable	StreamParameterTable, 8.6.5.2.1, 12.31.1
ieee8021PSFPMaxStreamFilterInstances	MaxStreamFilterInstances, 8.6.5.2.1, 8.6.5.3, 12.31.1
ieee8021PSFPMaxStreamGateInstances	MaxStreamGateInstances, 8.6.5.2.1, 8.6.5.4, 12.31.1
ieee8021PSFPMaxFlowMeterInstances	MaxFlowMeterInstances, 8.6.5.2.1, 8.6.5.5, 12.31.1
ieee8021PSFPSupportedListMax	SupportedListMax, 8.6.5.2.1, 8.6.5.4, 12.31.1

[a] To allow the PSFP MIB originally specified in IEEE Std 802.1Q-2018 to manage systems conformant to this amendment, the encoding of a Maximum SDU size and a flow meter identifier in an ieee8021PSFPFilterSpecificationList has been retained.

17.2.25 Structure of the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB

The IEEE8021-TSN-REMOTE-MANAGEMENT-MIB module defines managed objects for remote management of TSN stream reservations (12.32).

Table 17-31—IEEE8021-TSN-REMOTE-MANAGEMENT-MIB structure

IEEE8021-TSN-REMOTE-MANAGEMENT-MIB table/object	Reference
ieee8021TsnRemoteMgmtBridgeDelayTable ieee8021BridgeTrafficClass	Bridge Delay, 12.32.1 traffic class (index, from IEEE8021-TC-MIB)
ieee8021TsnRemoteMgmtBridgeIngressPort	ingress Port (Table index)
ieee8021TsnRemoteMgmtBridgeEgressPort	egress Port (Table index)
ieee8021TsnRemoteMgmtBridgeIndependentDelayMin	independentDelayMin, 12.32.1.1
ieee8021TsnRemoteMgmtBridgeIndependentDelayMax	independentDelayMax, 12.32.1.1
ieee8021TsnRemoteMgmtBridgeDependentDelayMin	dependentDelayMin, 12.32.1.2
ieee8021TsnRemoteMgmtBridgeDependentDelayMax	dependentDelayMax, 12.32.1.2
ieee8021TsnRemoteMgmtPropagationDelayTable ieee8021BridgeBase Port	Propagation Delay, 12.32.2 Bridge Port (index, from IEEE8021-TC-MIB)
ieee8021TsnRemoteMgmtTxPropagationDelay	txPropagationDelay, 12.32.2.1

Table 17-31—IEEE8021-TSN-REMOTE-MANAGEMENT-MIB structure *(continued)*

IEEE8021-TSN-REMOTE-MANAGEMENT-MIB table/object	Reference
ieee8021TsnRemoteMgmtStaticTreesSupported	staticTreesSupported, 12.32.3.1
ieee8021TsnRemoteMgmtMsrpMrpExternalControlTable	12.32.4, Table 12-41
ieee8021TsnRemoteMgmtMsrpMrpExternalControl	externalControl, 12.32.4.1
ieee8021TsnRemoteMgmtMrpIndicationList	indicationList, 12.32.4.2
ieee8021TsnRemoteMgmtMrpIndicationListLength	indicationListLength, 12.32.4.3
ieee8021TsnRemoteMgmtMrpIndicationChangeCounter	indicationListLength, 12.32.4.4
ieee8021TsnRemoteMgmtMrpAdminRequestList	adminRequestList, 12.32.4.5
ieee8021TsnRemoteMgmtMrpAdminRequestListLength	adminRequestListLength, 12.32.4.6
ieee8021TsnRemoteMgmtMrpOperRequestList	operRequestList, 12.32.4.7
ieee8021TsnRemoteMgmtMrpOperRequestListLength	operRequestListLength, 12.32.4.8

17.3 MIB module relationships

In order to facilitate interoperable management of VLAN Bridges by remote means, 17.7 contains a complete set of SMIv2 MIB modules.

Some of these MIB modules have been derived from, and now replace, previous IETF MIB modules, as noted in Table 17-1. This was necessary because significant changes had to be made in these MIB modules, in particular the table indexing schemes, to support the evolution of VLAN Bridges. For example, Provider Backbone Bridging, described in Clause 26, supports multiple Bridge instances within a BEB. To avoid duplication of the base Bridge MIB modules within a PBB MIB module, the base Bridge modules have been reindexed to allow their use within a BEB. A BEB may have multiple I-components and zero or one B-components. A component identifier index, unique within a particular BEB, is used in the various MIB tables of these modules to distinguish between instances. In Bridges supporting multiple component or Bridge instances, the component identifier index is still present but is set to a default value of 1.

17.3.1 Relationship of the IEEE8021-TC-MIB to other MIB modules

Textual conventions (TCs) originally appeared in each of the MIB modules for IEEE Std 802.lQ produced by the IETF. However, with the transition of all modules for IEEE Std 802.1Q to this clause, it made sense to have a single module with all the TCs contained within it. Note that many of the original IETF TCs are still used in the various MIB modules for VLAN-Bridge management since they can be used unchanged.

These TCs in the IEEE8021-TC-MIB module, as well as many TCs from IETF MIB modules, are used by all of the MIB modules presented in this clause.

The component identifier (IEEE8021PbbComponentIdentifierTC) is defined in this module and is used as the syntax for component ID table indices in subsequent MIB modules.

17.3.2 Relationship of the IEEE8021-BRIDGE-MIB to other MIB modules

As described in Table 17-4 of 17.2.2, some IEEE 802.1D management objects have not been included in this MIB module because they overlap with objects in other MIB modules that are applicable to a Bridge implementing this MIB module.

17.3.2.1 Relationship to the SNMPv2-MIB

The SNMPv2-MIB [RFC3418] defines objects that are generally applicable to managed devices. These objects apply to the device as a whole, irrespective of whether the device’s sole functionality is bridging, or whether bridging is only a subset of the device’s functionality.

As explained in Table 17-4 of 17.2.2, full support for the IEEE 802.1D management objects requires that the SNMPv2-MIB objects sysDescr and sysUpTime be implemented. Note that compliance with the current SNMPv2-MIB module requires additional objects and notifications to be implemented, as specified in IETF RFC 3418.

17.3.2.2 Relationship to the IF-MIB

The IF-MIB [RFC2863], requires that any MIB that is an adjunct of the IF-MIB clarify specific areas within the IF-MIB. These areas were intentionally left vague in the IF-MIB in order to avoid over-constraining the MIB, thereby precluding management of certain media types.

The IF-MIB enumerates several areas that a media-specific MIB must clarify. Each of these areas is addressed in a following subclause. The implementor is referred to the IF-MIB in order to understand the general intent of these areas.

The IF-MIB [RFC2863] defines managed objects for managing network interfaces. A network interface is thought of as being attached to a *subnetwork*. Note that this term is not to be confused with *subnet*, which refers to an addressing partitioning scheme used in the Internet suite of protocols. The term *segment* is used in this clause to refer to such a subnetwork, whether it be an Ethernet LAN, a *ring*, a WAN link, or even an SDH virtual circuit.

As explained in 17.2.2, full support for the IEEE 802.1D management objects requires that the IF-MIB objects ifIndex, ifType, ifDescr, ifPhysAddress, and ifLastChange are implemented. Note that compliance to the current IF-MIB module requires additional objects and notifications to be implemented as specified in IETF RFC 2863.

Implicit in this BRIDGE-MIB is the notion of Bridge Ports (3.26). Each Bridge Port is associated with one interface of the *interfaces* subtree (one row in ifTable), and in most situations, each Bridge Port is associated with a different interface. However, there are situations in which multiple Bridge Ports are associated with the same interface. That is, for a given IF-MIB, interface refers to one of the interface points in the bridging architecture (in Figure 8-1), and that zero or more multiple interface table entries can thus be instantiated for a given Bridge Port. An example of such a situation would be several Bridge Ports each corresponding one-to-one with several Ethernet private lines (or SDH virtual circuits) but all on the same interface. Alternatively, there is the Link Aggregation (IEEE Std 802.1AX) case where there are many physical Ports for one Bridge Port.

Each Bridge Port is uniquely identified by a Port Number. A Port Number has no mandatory relationship to an interface number, but in the simple case, a Port Number will have the same value as the corresponding interface's interface number. As a result of limitations in the BPDU for STP, this standard [see item i) in 12.3] limits the maximum number of Bridge Ports to 4095. However, in the absence of spanning tree there is no restriction. As a result, Port Numbers are in the range (1..65 535) to allow correspondence to interface numbers—but the STP restriction must be adhered to if it is supported on a Bridge.

Discontinuities in the value of the counter on the Bridge Port can occur at reinitialization of the management system, and at other times as indicated by the value of ifCounterDiscontinuityTime object of the associated interface (if any).

Some entities perform other functionalities as well as bridging through the sending and receiving of data on their interfaces. In such situations, only a subset of the data sent/received on an interface is within the domain of the entity's bridging functionality. This subset is considered to be delineated according to a set of protocols, with some protocols being bridged, and other protocols not being bridged. For example, in an entity that exclusively performs bridging, all protocols would be considered as bridged, whereas in an entity that performs IP routing on IP datagrams and only Bridges other protocols, only the non-IP data would be considered as having been bridged.

Thus, this BRIDGE-MIB (and in particular, its counters) are applicable only to that subset of the data on an entity's interfaces that is sent/received for a protocol being bridged. All such data is sent/received via the Ports of the Bridge.

The BRIDGE MIB also defines a new interface type called an internal LAN (I-LAN). This interface is identified by an ifIndex and is intended to help manage internal associations between bridging components. The BRIDGE-MIB provides the ability to create and destroy I-LAN interfaces. When an I-LAN interface is created, a corresponding row is created in the ifTable. The ifType of this interface is 247.[29]

[29] IANA ifType registry is https://www.iana.org/assignments/ianaiftype-mib/ianaiftype-mib.

I-LAN interfaces support stacking through the ifStackTable. Through this mechanism, the I-LAN interface can create internal connections between components. For example, an I-LAN interface can connect two C-VLAN components in a system. To complete this process, the following steps are required:

a) Create C-VLAN component 1.
b) Create C-VLAN Port 1 on component 1.
c) Create a Bridge Port interface (ifType 209) identified by ifIndex 1 using a external mechanism.
d) Associate C-VLAN Port 1 on component 1 to Bridge Port interface 1.
e) Create an I-LAN interface identified with ifIndex 2.
f) Stack Bridge Port interface 1 on the I-LAN interface 2.
g) Create C-VLAN component 2.
h) Create C-VLAN Port 1 on component 2.
i) Create a Bridge Port interface (ifType 209) identified by ifIndex 3 using a external mechanism.
j) Associate C-VLAN Port 1 on component 2 to Bridge Port interface 3.
k) Stack Bridge Port interface 3 on the I-LAN interface 2.

The result of the previous configuration steps are displayed in the Figure 17-1.

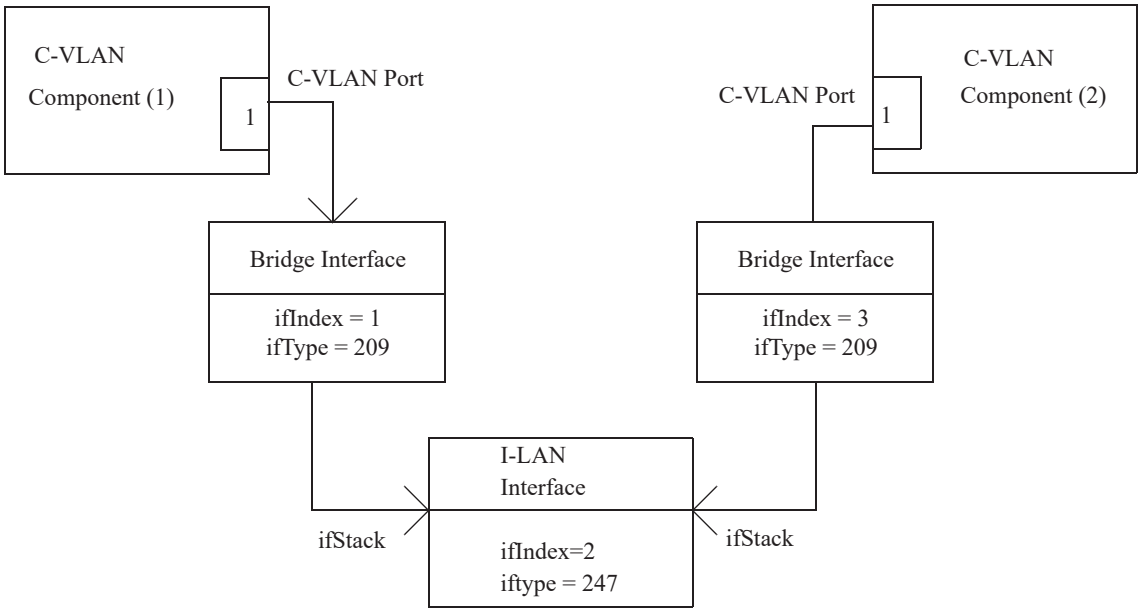


Figure 17-1—C-VLAN component internal LAN managed system

As a result, traffic can now be forwarded between C-VLAN component 1 and C-VLAN component 2 through the internal LAN.

17.3.2.3 FDB for IEEE 802.1D Bridges

The tables needed to explicitly manage the FDB for IEEE 802.1D Bridges have been removed from the IEEE8021-BRIDGE-MIB. There were separate tables for this function in the original IETF MIBs, but these duplicate tables in the IEEE8021-QBRIDGE MIB and are not needed.

As a result, single FDB implementations, like IEEE Std 802.1D, should just implement the ieee8021QBridgeTpFdbTable with an ieee8021QBridgeFdbId of 1, and setting any VID indices to 0.

17.3.3 Relationship of the IEEE8021-RSTP MIB to other MIB modules

The objects in the RSTP MIB supplement those defined in the BRIDGE MIB.

The original IETF BRIDGE-MIB [RFC1493] and its SMIv2-compliant version [RFC4188] have been replaced by 17.7.2. Besides using different prefix names for modules, an additional index was added to allow use of the RSTP MIB module in PBB.

17.3.4 Relationship of the IEEE8021-Q-BRIDGE-MIB to other MIB modules

17.3.4.1 Relationship to the IF-MIB

This standard assumes the interpretation of the Interfaces Subtree to be in accordance with the IF-MIB [RFC2863], which states that the interfaces table (ifTable) contains information on the managed resource's interfaces and that each sublayer below the internetwork layer of a network interface is considered an interface.

This standard does not make any assumption that within an entity, VIDs that are instantiated as an entry in dot1qVlanCurrentTable—either by management configuration through dot1qVlanStaticTable or by dynamic means (e.g., through MVRP)—are also represented by an entry in ifTable.

Where an entity contains higher-layer protocol entities (e.g., IP-layer interfaces that transmit and receive traffic to/from a VLAN), these should be represented by an interface that represents the protocol entity and an interface of ifType l2vlan (135) with the ifStackTable indicating the stacking relationship between the two entities.

17.3.4.1.1 ifStackTable

In addition, the IF-MIB [RFC2863] defines a table 'ifStackTable' for describing the relationship between logical interfaces within an entity. It is anticipated that implementors will use this table to describe the binding of (for example) Link Aggregation Group (LAG) interfaces to physical Ports, although the presence of VLANs makes the representation less than perfect for showing connectivity. The ifStackTable cannot represent the full capability of this standard, since this standard makes a distinction between VLAN bindings on *ingress* to and *egress* from a Port. These relationships may or may not be symmetrical; whereas, Interface MIB Evolution assumes a symmetrical binding for transmit and receive. This makes it necessary to define other manageable objects for configuring which Ports are in the member set for which VIDs.

17.3.4.1.2 ifRcvAddressTable

This table contains all MAC addresses, unicast, multicast, and broadcast, for which an interface will receive frames and forward them up to a higher-layer entity for local consumption. Note that this does not include addresses for data-link layer control protocols such as STP, RSTP, MSTP, MMRP, or MVRP. The format of the address, contained in ifRcvAddressAddress, is the same as for ifPhysAddress.

This table does not include unicast or multicast addresses that are accepted for possible forwarding out some other Port. This table is explicitly not intended to provide a Bridge address filtering mechanism.

17.3.4.2 Relationship to IEEE8021-BRIDGE-MIB

This subclause defines how objects in the IEEE8021-BRIDGE-MIB module should be represented for devices that implement the extensions. Some of the old objects are less useful in such devices, but must still be implemented for reasons of backwards compatibility.

17.3.4.2.1 ieee8021BridgeBase subtree

This subtree contains objects that are applicable to all types of Bridges. Interpretation of this subtree is unchanged.

17.3.4.2.2 ieee8021BridgeTp subtree

This subtree contains objects that describe the entity's state with respect to transparent bridging.

In a device operating with a single FDB, interpretation of this subtree is unchanged.

In a device supporting multiple FDBs, this subtree is interpreted as follows:

a) ieee8021BridgeTpLearnedEntryDiscards
The number of times that any of the FDBs became full.

b) ieee8021BridgeTpAgingTime
This applies to all FDBs.

c) ieee8021BridgeTpFdbTable
Report MAC addresses learned on each Port, regardless of which FDB they have been learned in. If an address has been learned in multiple databases on a single Port, report it only once. If an address has been learned in multiple databases on more than one Port, report the entry on any one of the valid Ports.

d) ieee8021BridgeTpPortTable
This table is Port-based and is not affected by multiple FDBs or multiple VIDs. The counters should include frames received or transmitted for all VIDs.

17.3.4.2.3 ieee8021BridgeStatic subtree

This optional subtree contains objects that describe the configuration of destination-address filtering.

In a device operating with a single FDB, interpretation of this subtree is unchanged.

In a device supporting multiple FDBs, this subtree is interpreted as follows:

a) ieee8021BridgeStaticTable
Entries read from this table include all static entries from all of the FDBs. Entries for the same MAC address and receive Port in more than one FDB must appear only once, since these are the indices of this table. This table should be implemented as read-only in devices that support multiple FDBs. Instead, write access should be provided through dot1qStaticUnicastTable and dot1qStaticMulticastTable, as defined in this standard.

17.3.4.2.4 Additions to the IEEE8021-BRIDGE-MIB

To supplement the BRIDGE-MIB, this module contains the following:

a) Support for multiple traffic classes and dynamic multicast filtering as per IEEE Std 802.1D.

b) Support for bridged VLANs as per IEEE Std 802.1Q.

c) Support for 64-bit versions of BRIDGE-MIB Port counters.

17.3.5 Relationship of the IEEE8021-PB-BRIDGE MIB to other MIB modules

To supplement the Q-BRIDGE-MIB, this module contains the following:

a) The Q-Bridge MIB directly supports VID translation. The original bidirectional VID translation of PB MIB is supported by the Q-Bridge MIB as well as separate ingress and egress VID translation.
b) Support for Provider Edge Bridges.

17.3.6 Relationship of the IEEE8021-MSTP-MIB to other MIB modules

The objects in the IEEE8021-MSTP-MIB supplement those defined in the IEEE8021-RSTP MIB.

17.3.7 Relationship of the IEEE8021-CFM-MIB to other MIB modules

17.3.7.1 Relationship to Interface MIB

Subclause 17.7.7 defines a CFM MIB module that supports 12.14 with the textual conventions imported from the TC MIB in 17.7.1. A system implementing the CFM MIB module in 17.7.7 shall also implement at least the System Group of the SNMPv2-MIB defined in IETF RFC 3418 and the Interfaces Group (the Interfaces MIB module, or IF-MIB) defined in IETF RFC 2863. The Interfaces Group has one conceptual row in a table for every interface in a system. 3.3 of IETF RFC 2863 defines hierarchical relationships among interfaces.

IETF RFC 2863 also requires that any MIB module that is an adjunct of the Interface Group clarify specific areas within the Interface MIB module. These areas were intentionally left vague in IETF RFC 2863 to avoid over-constraining the MIB, thereby precluding management of certain media types. These areas are clarified in other clauses that define the Bridge MIB modules. Even if a Bridge supports none of these, if it supports the CFM MIB module, and hence, the Interfaces Group, the clarifications from the other clauses shall be applied to the Interfaces Group. The relationship between IETF RFC 2863 and IETF RFC 3418 interfaces and Bridge Ports is also described in previous subclauses of 17.3. In addition, if both the CFM MIB module (17.7.7) and IEEE Std 802.1AX are supported, a Bridge shall

a) Assign each IEEE 802.1AX Port in the aggregation its own conceptual row in the IETF RFC 2863 IF-MIB.
b) Assign one conceptual row in the IETF RFC 2863 IF-MIB that references the aggregated Port. This may be the same as the interface identifying the Bridge Port. It shall not be the same as any of the IEEE 802.1AX Ports being aggregated.

17.3.7.2 IEEE8021-CFM-MIB and IEEE8021-CFM-V2-MIB

The inclusion of PBB (Clause 26) required the addition of additional indices to numerous tables in the CFM MIB. As a result, these tables are deprecated in the existing IEEE8021-CFM-MIB module and new reindexed tables are created in a second IEEE8021-CFM-V2-MIB module. Unchanged tables remain in the IEEE8021-CFM-MIB module. Specifically, groups with tables left unchanged are imported in the IEEE8021-CFM-V2-MIB module to appear in the compliance statement and new groups containing the new reindexed tables are added to the compliance statement.

The following tables are renamed:

dot1agPbbCfmStackTable
dot1agPbbCfmVlanTable
dot1agPbbCfmDefaultMdTable
dot1agPbbCfmConfigErrorListTable
dot1agPbbCfmMaCompTable

The new names are as follows:

ieee8021CfmStackTable
ieee8021CfmVlanTable
ieee8021CfmDefaultMdTable
ieee8021CfmConfigErrorListTable
ieee8021CfmMaCompTable

17.3.8 Relationship of the IEEE8021-PBB-MIB to other MIB modules

The IF-MIB, [RFC2863], requires that any MIB that is an adjunct of the IF-MIB clarify specific areas within the IF-MIB. These areas were intentionally left vague in the IF-MIB in order to avoid over-constraining the MIB, thereby precluding management of certain media types. The IF-MIB enumerates several areas that a media-specific MIB must clarify. Each of these areas is addressed in a following subclause. The implementor is referred to the IF-MIB in order to understand the general intent of these areas. The IF-MIB [RFC2863] defines managed objects for managing network interfaces.

A network interface is considered attached to a *subnetwork*. The term *segment* is used to refer to such a subnetwork, whether it be an Ethernet LAN, a *ring,* a WAN link, or even an SDH virtual circuit. Full support for PBB managed objects requires that the IF-MIB objects ifIndex, ifType, ifDescr, ifPhysAddress, and ifLastChange be implemented. Note that compliance to the current IF-MIB module requires additional objects and notifications to be implemented as specified in IETF RFC 2863.

The interpretation of the Interfaces Subtree is assumed to be in accordance with the IF-MIB, which states that the interfaces table (ifTable) contains information on the managed resource's interfaces and that each sublayer below the internetwork layer of a network interface is considered an interface. Specifically, in the PBB MIB module, the PIP index has been equated to an interface index (ifIndex). Therefore, when a PIP is created, a row is also created in the ifTable identified by the PIP's ifIndex. The ifType of this interface is 248.[30]

In addition, the IF-MIB defines a table 'ifStackTable' for describing the relationship between logical interfaces within an entity. The ifStackTable cannot represent the full capability of this standard, since this standard makes a distinction between VLAN bindings on *ingress* to and *egress* from a Port. These relationships may or may not be symmetrical; whereas, Interface MIB Evolution assumes a symmetrical binding for transmit and receive. This makes it necessary to define other manageable objects for configuring which Ports are in the member set for which VIDs.

A PIP supports stacking through the ifStackTable. For external PIP interfaces, a PIP can be stacked on an Ethernet interface (ifType 6). If the PIP is internal, it can be stacked on an I-LAN interface to create a connection between an I-component and a B-component. The following is an example of how this process is completed:

a) Create I-component 1.
b) Create VIP 1 on component 1.
c) Create a PIP identified by ifIndex 1.
d) Associate VIP 1 on component 1 to the PIP.
e) Create an I-LAN interface identified with ifIndex 2.
f) Stack PIP 1 on the I-LAN interface 2.
g) Create B-component 2.
h) Create CBP 1 on component 2.
i) Associate CBP 1 on component 2 to I-LAN interface 2.

[30] IANA ifType registry is https://www.iana.org/assignments/ianaiftype-mib/ianaiftype-mib.

The result of the previous configuration steps are displayed in Figure 17-2.

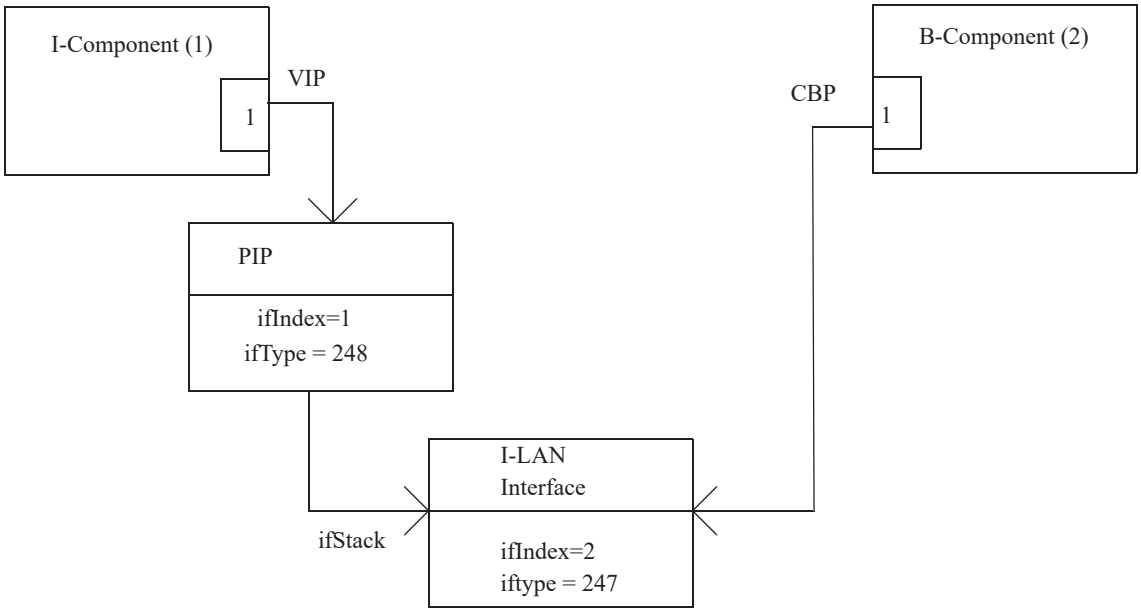


Figure 17-2—I/B-component internal LAN managed system

As a result, traffic can now be forwarded between I-component 1 and B-component 2 once a service is provisioned.

17.3.9 Relationship of the IEEE8021-DDCFM to other MIB modules

Subclause 17.7.9 defines the DDCFM MIB module that supports 12.17. A system implementing the DDCFM MIB module in 17.7.9 shall also implement at least the System Group of the SNMPv2-MIB defined in IETF RFC 3418 and Interfaces Group (the Interfaces MIB module, or IF-MIB) defined in IETF RFC 2863.

17.3.10 Relationship of the IEEE8021-PBBTE-MIB to other MIB modules

The IEEE8021-PBBTE-MIB is used to manage IB-BEBs that support additional PBB-TE functionality for the configuration of TESIs across provider backbone networks. The IEEE8021-PBBTE-MIB uses textual conventions and objects from the following MIB modules:

IEEE8021-TC-MIB
IEEE8021-BRIDGE-MIB
Q-BRIDGE-MIB
IEEE8021-Q-BRIDGE-MIB

The IEEE8021-PBBTE-MIB has the purpose of managing PBB-TE-specific functionality. As a PBB-TE IB-BEB is a specialized PBB IB-BEB with additional functionality, management of the system will also require that the system support the following Clause 17 MIB modules:

IEEE8021-BRIDGE-MIB
IEEE8021-CFM-MIB
IEEE8021-CFM-V2-MIB

IEEE8021-Q-BRIDGE-MIB
IEEE8021-MSTP-MIB
IEEE8021-PB-MIB
IEEE8021-PBB-MIB

Specifically, support of the IEEE-PBBTE-MIB requires that the system support the MIB and compliances in Table 17-31.

Table 17-31—PBB-TE required MIB compliances

MIB	Compliance
IEEE8021-PBB-MIB	ieee8021PbbWithPbbTeCompliance
IEEE8021-CFM-MIB	dot1agCfmWithPbbTeCompliance
IEEE8021-CFM-V2-MIB	

17.3.11 Relationship of the IEEE8021-TPMR MIB to other MIB modules

Subclause 17.7.11 defines a TPMR MIB module that supports the managed objects defined in 12.19. A system implementing the TPMR MIB module in 17.7.11 shall also implement at least the System Group of the SNMPv2-MIB defined in IETF RFC 3418 and the Interfaces Group (the Interfaces MIB module, or IF-MIB) defined in IETF RFC 2863. The Interfaces Group has one conceptual row in a table for every interface in a system. See Table 17-17 for the key objects from the System and Interfaces groups.

17.3.12 Relationship of the IEEE8021-FQTSS-MIB to other MIB modules

The IEEE8021-FQTSS-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the additional management functionality needed when the FQTSS, as defined in Clause 34, is supported by the Bridge. As support of the objects defined in the IEEE8021-FQTSS-MIB also requires support of the IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-FQTSS-MIB.

17.3.13 Relationship of the IEEE802-CN-MIB to other MIB modules

17.3.13.1 Interface MIB

Subclause 17.7.13 defines a Congestion Notification MIB (IEEE802-CN-MIB) module that supports congestion notification with the textual conventions imported from the TC MIB in 17.7.13. A system implementing the IEEE802-CN-MIB module in 17.7.13 shall also implement at least the System Group of the SNMPv2-MIB defined in IETF RFC 3418 and the Interfaces Group (the Interfaces MIB module, or IF-MIB) defined in IETF RFC 2863. The Interfaces Group has one conceptual row in a table for every interface in a system. 3.3 of IETF RFC 2863 defines hierarchical relationships among interfaces. IETF RFC 2863 also requires that any MIB module that is an adjunct of the Interface Group clarify specific areas within the Interface MIB module. These areas were intentionally left vague in IETF RFC 2863 to avoid over-constraining the MIB, thereby precluding management of certain media types. These areas are clarified in other clauses that define the MIB modules in this standard. Even if a system supports none of these, if it supports the IEEE802-CN-MIB module, and hence, the Interfaces Group, the clarifications from the other clauses shall be applied to the Interfaces Group. The relationship between IETF RFC 2863 and IETF RFC 3418 interfaces and ports is also described in previous subclauses of 17.3. In addition, if both the IEEE802-CN-MIB module (17.7.13) and IEEE Std 802.1AX are supported, a Bridge component or end station may

a) Assign each port in the aggregation its own conceptual row in the IETF RFC 2863 IF-MIB.
b) Assign one conceptual row in the IETF RFC 2863 IF-MIB that references the aggregated port. This can be the same as the interface identifying the port. It shall not be the same as any of the ports being aggregated.

17.3.13.2 IEEE8021-CFM-MIB and IEEE8021-CFM-V2-MIBs

Subclause 31.1 allows a system that supports either the dot1agCfmVlanTable from the IEEE8021-CFM-MIB module or the ieee8021CfmVlanTable from the IEEE8021-CFM-V2-MIB module to use those tables to select the vlan_identifier for a transmitted CNM.

17.3.14 Relationship of the IEEE8021-SRP-MIB to other MIB modules

The IEEE8021-SRP-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the management functionality needed when the SRP extensions, as defined in Clause 35, are supported by the Bridge. As support of these objects defined in the IEEE8021-SRP-MIB also requires support of the IEEE8021-TC-MIB, IEEE8021-BRIDGE-MIB, and IEEE8021-FQTSS-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-SRP-MIB.

17.3.15 Relationship of the IEEE8021-MVRPX-MIB to other MIB modules

The IEEE8021-MVRPX-MIB, because it adds variables to the ieee8021BridgeBasePortEntry in the IEEE8021-BRIDGE-MIB, depends upon that MIB. It also imports items from the SNMPv2-SMI, SNMPv2-TC, and SNMPv2-CONF MIBs, and requires the systemGroup of the SNMPv2-MIB for conformance.

17.3.16 Relationship of the IEEE8021-MIRP-MIB to other MIB modules

The IEEE8021-MIRP-MIB, because it extends the variables in the IEEE8021-PBB-MIB (17.7.8), depends upon that MIB. Because it adds a variable to the ieee8021BridgeBasePortEntry in the IEEE8021-BRIDGE-MIB, it also depends upon that MIB. It also imports items from the SNMPv2-SMI, SNMPv2-TC, SNMPv2-CONF, and Q-BRIDGE-MIB MIBs, and requires the systemGroup of the SNMPv2-MIB for conformance.

17.3.17 Relationship of the IEEE8021-PFC-MIB to other MIB modules

A system implementing the IEEE8021-PFC-MIB module (17.7.17) shall also implement at least the System Group of the SNMPv2-MIB defined in IETF RFC 3418 and the Interfaces Group (the Interfaces MIB module, or IF-MIB) defined in IETF RFC 2863. The Interfaces Group has one conceptual row in a table for every interface in a system. 3.3 of IETF RFC 2863 defines hierarchical relationships among interfaces. IETF RFC 2863 also requires that any MIB module that is an adjunct of the Interface Group clarify specific areas within the Interface MIB module. These areas were intentionally left vague in IETF RFC 2863 to avoid over constraining the MIB, thereby precluding management of certain media types. These areas are clarified in other clauses which define the MIB modules in this standard. Even if a system supports none of these, if it supports the PFC MIB module, and hence, the Interfaces Group, the clarifications from the other clauses shall be applied to the Interfaces Group. The relationship between IETF RFC 2863 and IETF RFC 3418 interfaces and ports is also described in previous subclauses of 17.3.

17.3.18 Relationship of the IEEE8021-TEIPS-MIB to other MIB modules

The IEEE8021-TEIPS-MIB is used to manage IB-BEBs and BCBs that support IPS functionality. The IEEE8021-TEIPS-MIB uses textual conventions and objects from the following MIB modules:

IEEE8021-TC-MIB
IEEE8021-BRIDGE-MIB

The IEEE8021-TEIPS-MIB has the purpose of managing IPS in PBB-TE Region (26.11). Thus, use of the IEEE8021-TEIPS-MIB requires that the system support the same set of MIB modules specified within 17.3.10 and requires the compliances described by Table 17-21.

17.3.19 Relationship of the IEEE8021-SPB-MIB to other MIB modules

The IEEE8021-SPB-MIB, because it provides mainly control plane functions and reuses VLANs in the Q-BRIDGE-MIB depends on that MIB. It also imports items from the SNMPv2-SMI, SNMPv2-TC, IF-MIB, and IEEE8021-TC-MIB, and requires SNMPv2-CONF for conformance.

PCR operations are based on ISIS-SPB sub-TLVs, with additional objects that support MRT operations.

17.3.20 Relationship of the IEEE8021-EVB-MIB to other MIB modules

The IEEE8021-EVB-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the management functionality needed for EVB (5.23, 5.24), as defined in Clause 40, Clause 41, Clause 42, and Clause 43. As support of the objects defined in the IEEE8021-EVB-MIB also requires support of the IEEE8021-TC-MIB and IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-EVB-MIB.

17.3.21 Relationship of the IEEE8021-ECMP-MIB to other MIB modules

The IEEE8021-ECMP-MIB extends SPBM functionality and therefore is closely related to the IEEE8021-SPB-MIB and IEEE8021-PBB-MIB. For example, it includes configuration for an optional ISIS-SPB sub-TLV for the ECMP ECT Algorithm (28.12.6.1) and configuration for flow filtering on PNPs and CBPs (44.2.2).

Because it provides control functions related to VIDs, it depends on the Q-BRIDGE-MIB. It also augments tables defined in the IEEE8021-Q-BRIDGE-MIB (adding the ability to read the FDB Port Map for an individual address and adding TTL discard statistics). It also imports items from the SNMPv2-SMI, SNMPv2-TC, and IEEE8021-TC-MIB and requires SNMPv2-CONF for conformance.

17.3.22 Relationship of the IEEE8021-ST-MIB to other MIB modules

The IEEE8021-ST-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the additional management functionality needed when the scheduled traffic extensions, as defined in 8.6.8.4, are supported by the Bridge. As support of the objects defined in the IEEE8021-ST-MIB also requires support of the IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-ST-MIB.

17.3.23 Relationship of the IEEE8021-Preemption-MIB to other MIB modules

The IEEE8021-Preemption-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the additional management functionality needed when the frame preemption extensions are supported by the Bridge. As support of the objects defined in the IEEE8021-Preemption-MIB also requires support of the IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-Preemption-MIB.

17.3.24 Relationship of IEEE8021-PSFP-MIB to other MIB modules

The IEEE8021-PSFP-MIB provides objects that extend the core management functionality of a Bridge, as defined by the IEEE8021-BRIDGE-MIB (17.7.2), in order to support the additional management functionality needed when the PSFP extensions, as defined in 8.6.5.2.1 and 8.6.10, are supported by the Bridge. As support of the objects defined in the IEEE8021-PSFP-MIB also requires support of the IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-PSFP-MIB.

17.3.25 Relationship of IEEE8021-TSN-REMOTE-MANAGEMENT-MIB to other MIB modules

The IEEE8021-TSN-REMOTE-MANAGEMENT-MIB provides objects that support management of TSN stream reservations by providing Bridge transit delay and Bridge Port propagation delay information, by allowing a remote manager to determine whether static trees are supported (12.32.3), and provides additional control over MSRP attribute propagation. As support of the objects defined in the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB also requires support of the IEEE8021-BRIDGE-MIB, the provisions of 17.3.2 apply to implementations claiming support of the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB.

17.4 Security considerations

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example, by using IPsec), there is no control about who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in these MIB modules.

It is recommended that implementers consider the security features as provided by the SNMPv3 framework (see IETF RFC 3410 (2002), section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is not recommended. Instead, it is recommended to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of these MIB modules is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

17.4.1 Security considerations of the IEEE8021-TC-MIB

This module does not define any management objects. Instead, it defines a set of textual conventions that may be used by other MIB modules to define management objects. Meaningful security considerations are contained in the following subclauses that describe security considerations for other MIB modules that define management objects with a SYNTAX of any of these textual conventions.

17.4.2 Security considerations of the IEEE8021-BRIDGE-MIB

There are a number of management objects defined in the IEEE8021-BRIDGE-MIB module that have a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

The following tables and objects in the IEEE8021-BRIDGE-MIB can be manipulated to interfere with the operation of priority classes. This could, for example, be used to force a reinitialization of state machines, thus causing network instability. Another possibility would be for an attacker to override established policy on Port priorities, thus giving a user (or an attacker) unauthorized preferential treatment.

ieee8021TrafficClassesEnabled
ieee8021GmrpStatus
ieee8021PortPriorityTable
ieee8021UserPriorityRegenTable
ieee8021TrafficClassTable
ieee8021PortGarpTable
ieee8021PortGmrpTable

a) The writable object ieee8021BridgeTpAgingTime controls how fast dynamically-learned forwarding information is aged out. Setting this object to a large value may simplify FDB overflow attacks. Setting this object to too small a value may compromise the throughput of the network by causing excessive flooding.

b) The writable ieee8021BridgeStaticTable provides a filtering mechanism controlling to which Ports frames originating from a specific source may be forwarded. Write access to this table can be used to turn provisioned filtering off or to add filters to prevent rightful use of the network.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These tables and objects and their sensitivity/vulnerability are described as follows:

— The objects ieee8021DeviceCapabilities and ieee8021PortCapabilitiesTable in the IEEE8021-P-BRIDGE-MIB could be used by an attacker to determine which attacks might be useful to attempt against a given device.

— The readable objects defined in the IEEE8021-BRIDGE-MIB module provide information about the topology of a bridged network and the attached active stations. The addresses listed in the ieee8021BridgeTpFdbTable usually reveal information about the manufacturer of the MAC hardware, which can be useful information for mounting other specific attacks.

— The two notifications, newRoot and topologyChange, are emitted during spanning tree computation and may trigger management systems to inspect the status of Bridges and to recompute internal topology information. Hence, forged notifications may cause management systems to perform unnecessary computations and to generate additional SNMP traffic directed to the Bridges in a network. Therefore, forged notifications may be part of a denial of service attack.

17.4.3 Security considerations of the IEEE8021-SPANNING-TREE MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following writable objects could be misused to cause network delays and spanning tree instabilities:

ieee8021SpanningTreeVersion
ieee8021SpanningTreeRstpTxHoldCount
ieee8021SpanningTreeRstpPortProtocolMigration
ieee8021SpanningTreeRstpPortAdminEdgePort
ieee8021SpanningTreeRstpPortAdminPathCost
ieee8021SpanningTreeRstpPortAdminPointToPoint

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These tables and objects and their sensitivity/vulnerability are described below:

ieee8021SpanningTreeVersion could be read by an attacker to identify environments containing applications or protocols that are potentially sensitive to RSTP mode.

The writable objects

ieee8021SpanningTreePriority
ieee8021SpanningTreeBridgeMaxAge
ieee8021SpanningTreeBridgeHelloTime
ieee8021SpanningTreeBridgeForwardDelay
ieee8021SpanningTreePortPriority
ieee8021SpanningTreePortEnable
ieee8021SpanningTreePortPathCost

influence the spanning tree protocol. Unauthorized write access to these objects can cause the spanning tree protocol to compute other default topologies or it can change the speed in which the spanning tree protocol reacts to failures.

17.4.4 Security considerations of the IEEE8021-Q-BRIDGE-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following tables and objects in the IEEE8021-Q-BRIDGE-MIB could be manipulated to interfere with the operation of VLANs. This could, for example, be used to force a reinitialization of state machines to cause network instability, or to change the forwarding and filtering policies.

ieee8021GvrpStatus
ieee8021ForwardAllTable
ieee8021StaticUnicastTable
ieee8021StaticMulticastTable

ieee8021VlanStaticTable
ieee8021PortVlanTable
ieee8021LearningConstraintsTable
ieee8021ProtocolGroupTable
ieee8021ProtocolPortTable

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These tables and objects and their sensitivity/vulnerability are described below.

The following read-only tables and objects in the IEEE8021-Q-BRIDGE-MIB could be used by an attacker to determine which attacks might be useful to attempt against a given device, could be used by an attacker to detect whether their attacks are being blocked or filtered, or could be used to understand the logical topology of the network.

ieee8021MaxVlanID
ieee8021MaxSupportedVlans
ieee8021NumVlans
ieee8021FdbTable
ieee8021TpFdbTable
ieee8021TpPortGroupTable
ieee8021VlanCurrentTable
ieee8021PortVlanStatisticsTable

17.4.5 Security considerations of the IEEE8021-PB-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following tables and objects in the PB-MIB could be manipulated to interfere with the operation of VLANs. This could, for example, be used to force a reinitialization of state machines to cause network instability, or to change the forwarding and filtering policies.

ieee8021PbProviderBridgePortTable
ieee8021PbVidTranslationTable
ieee8021PbCVidRegistrationTable
ieee8021PbEdgePortTable
ieee8021PbInternalInterfaceTable

17.4.6 Security considerations of the IEEE8021-MSTP-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

Writable objects that could be misused to cause network delays and spanning tree instabilities include the following:

ieee8021CistEnableBPDURx
ieee8021CistEnableBPDUTx
ieee8021CistPortAdminEdgePort
ieee8021CistPortMacEnabled
ieee8021MstpPortPriority
ieee8021MstpPortPathCost

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These tables and objects and their sensitivity/vulnerability are described below:

ieee8021SpanningTreeVersion could be read by an attacker to identify environments containing applications or protocols that are potentially sensitive to RSTP mode.

17.4.7 Security considerations of the IEEE8021-CFM-MIB

It is expected that, in some provider networks, management access to a Bridge can be granted, by an organization that owns and is responsible for the normal operations of the Bridge, to another organization that needs to configure and manage CFM entities in that Bridge. For example, a Provider could sell a service to a customer that connects sites in cities thousands of kilometers apart. That Provider might not have a physical presence in all of those cities (or any of them, for that matter) and therefore would need to contract with other Providers to supply a number of interconnected PBNs that together are able to offer the service to the customer. The relationship between the Provider and Owner is not necessarily cordial; there can be personal or financial incentives for misbehavior.

To support this scenario, the MIB module in 17.7.7 defines the Maintenance Domain table—dot1agCfmMdTable. Each row (dot1agCfmMdEntry) in this table corresponds to one Maintenance Domain managed object (12.14.5). A Maintenance Domain managed object can be created, read, and written by the Bridge's Owner. More limited access to that object can be granted to another Provider, who thereby becomes that Maintenance Domain's administrator. Associated with each row in the Maintenance Domain table are any number of rows (dot1agCfmMaNetEntry and dot1agCfmMaCompEntry) in the MA tables—dot1agCfmMaNetTable and dot1agCfmMaCompTable. Each of the paired rows in these two tables corresponds to a Maintenance Association managed object (12.14.6). A Maintenance Domain administrator has the ability to create and alter these rows. Additional MIB tables are defined in 17.7.7 that correspond to the Maintenance Domain list managed object (12.14.1), the CFM Stack managed object (12.14.2), and the Default MD Level managed object (12.14.3), all of which can be used by an Owner of the Bridge, but not by a Maintenance Domain administrator.

The SNMPv3 framework (IETF STD 62) defines a securityName, which provides for secure identification of a user (or group of users) via an SNMPv3 Security Model. For ease of reference in this present standard, the "Owner" of a system (in particular, a Bridge) is defined as a user whose "MIB view" includes READ-WRITE access to the System Group of the SNMPv2-MIB (IETF RFC 3418). A Management Domain administrator is then a user whose MIB view includes more limited access to the Maintenance Domain managed object, and full READ-WRITE access to its subordinate Maintenance Association managed objects (12.14.6), each of which is a pair of rows (dot1agCfmMaNetEntry and dot1agCfmMaCompEntry) in the two tables—dot1agCfmMaNetTable and dot1agCfmMaCompTable.

A Bridge can support IETF STD 62 (SNMPv3) in order to provide a secure means for confining access by Management Domain administrators to their corresponding Maintenance Association managed objects, and

to prevent inappropriate access to the rest of the Bridge's management objects. If the SNMPv3 framework is not implemented in a Bridge, an Owner is defined, imprecisely, as an administrator of the Bridge, and a Management Domain administrator (even less precisely) as an administrator of one Management Domain.

Therefore, it is recommended that the implementors consider the security features as provided by the SNMPv3 framework, including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy). Specifically, a Bridge can use the User-Based Security Model, IETF RFC 3414, and/or the View-Based Access Control Model, IETF RFC 3415, for controlling access to the CFM managed objects. It is then a customer/user responsibility to ensure that the SNMP agent giving access to an instance of this MIB is properly configured to give access to the objects only to those principals (users) that have legitimate rights to GET or SET (change/create/delete) them.

The control of access by Providers to other MIB modules, for example, the Interface Group, is not specified by this standard.

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. Table 17-32 lists the MIB tables and objects and their sensitivity/vulnerability.

Table 17-32—Sensitive managed objects: tables and notifications

Table or object	Reason for sensitivity to security considerations
dot1agCfmDefaultMdTable dot1agCfmVlanTable	The integrity of the spanning tree(s) running in a network is dependent on certain configuration parameters, especially Static VLAN Registration Entries (8.8.2). The assignment of VIDs to particular service instances, and hence to MAs, is controlled by the administrator responsible for the integrity of the spanning tree, namely the Owner of the Bridge.
dot1agCfmMdTable dot1agCfmMaNetTable dot1agCfmMaCompTable dot1agCfmVlanTable dot1agCfmMaMepListTable dot1agCfmMepTable dot1agCfmMepDbTable dot1agCfmLtrTable dot1agCfmFaultAlarm	The business relationships among the various Maintenance Domain administrators, and between them and the Owner of the Bridge, are not defined by this standard. The ability of one Maintenance Domain administrator to identify another, or even detect the presence of another Maintenance Domain administrator, in the same Bridge, may jeopardize those business relationships. The CFM MIB module separates objects by Maintenance Domain so that the Bridge Owner can ensure that management by one Maintenance Domain administrator does not conflict with management by another.

There is no detailed list in this standard of all vulnerable objects with a MAX-ACCESS clause of read-write or read-create and of the security threats associated to their intentional or unintentional manipulation by write actions. The reason is that this standard takes the approach that objects within a maintenance domain are protected as if in a "walled garden," accessible only by administrators authorized for the respective Maintenance Domains. See Figure 12-1 for an illustration of this concept.

The only exceptions to this approach are the read-create MIB objects that define the maintenance domains themselves and their capabilities. The vulnerabilities associated with these objects are shown in Table 17-33.

Table 17-33—Sensitive managed objects: variables in dot1agCfmMdTable

Object	Reason for sensitivity to security considerations
dot1agCfmMdFormat dot1agCfmMdName	An intentional or accidental write operation on these objects may lead to the modification of the identifiers of the Maintenance Domains and would impact the capacity of existing administrators to identify and manage the entities within those Maintenance Domains.
dot1agCfmMdMdLevel	An intentional or accidental write operation on this object may impact the CFM operations on the Maintenance Domain by altering the MD Level associated with the Maintenance Domain.
dot1agCfmMdMhfCreation	An intentional or accidental write operation on this object may impact the capabilities for creating MIP Half Functions (MHFs) in the Maintenance Domain.

17.4.8 Security considerations of the IEEE8021-PBB-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described next.

The following tables and objects in the PBB MIB could be manipulated to interfere with the operation of PBBs. This could, for example, be used to force a reinitialization of state machines to cause network instability, or changing the forwarding and filtering policies. The following are vulnerable writable objects from the IEEE8021-PBB-MIB:

ieee8021PbbVipISid
ieee8021PbbPipVipMap

In addition, the following are vulnerable tables from the IEEE8021-PBB-MIB:

ieee8021PbbCBPServiceMappingTable
ieee8021PbbPipPriorityTable
ieee8021PbbVipToPipMappingTable
ieee8021PbbCbpTable

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

The following read-only tables and objects in this MIB could be used by an attacker to determine which attacks might be useful to attempt against a given device, or could be used to understand the logical topology of the network:

ieee8021PbbBackboneEdgeBridgeAddress
ieee8021PbbVipPipIfIndex
ieee8021PbbISidToVipComponentId
ieee8021PbbISidToVipPort

17.4.9 Security considerations of the IEEE8021-DDCFM-MIB

There are a number of management objects defined in DDCFM MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. Table 17-34 lists the MIB tables and objects and their sensitivity/vulnerability.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. Table 17-35 lists the MIB tables and objects that are sensitive to read.

Table 17-34—Sensitive managed objects (of DDCFM): tables and notifications

Table or object	Reason for sensitivity to security considerations
ieee8021DdcfmRr	Once created and activated, ieee8021DdcfmRr can intercept selected data frames traversing through a Bridge interface, and send its copy encapsulated in RFM header to a specific destination within the maintenance domain. The action can create extra traffic within the maintenance domain.
ieee8021DdcfmDr	Once created and activated, ieee8021DdcfmDr will decapsulate received SFM and send the decapsulated data frame to location specified by the data frame's destination_address. This action practically injects specific traffic into the network.
ieee8021DdcfmSFMOriginator	Once created and activated, ieee8021DdcfmSFMOriginator injects SFMs into the maintenance domain. However, if the corresponding ieee8021DdcfmDr is not activated, the received SFMs are dropped. Therefore, ieee8021DdcfmSFMOriginator is less sensitive than the corresponding ieee8021DdcfmDr.

Table 17-35—Sensitive managed objects (of DDCFM) for read

Table or object	Reason for sensitivity to security considerations
ieee8021DdcfmRFMReceiver	Once created, ieee8021DdcfmRFMReceiver can receive the RFM, which encapsulate actual data frame that could be sensitive and need to be protected. It is very important to control the GET operation on this object.

17.4.10 Security considerations of the IEEE8021-PBBTE-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following tables and objects in the PBB MIB could be manipulated to interfere with the operation of IB PBBs. This could, for example, be used to force a reinitialization of state machines to cause network instability, or changing the forwarding and filtering policies. The following are all the writable objects from the IEEE8021-PBB-MIB:

ieee8021PbbTeProtectionGroupListWorkingMA
ieee8021PbbTeProtectionGroupListProtectionMA
ieee8021PbbTeProtectionGroupListRowStatus
ieee8021PbbTeTesiComponent
ieee8021PbbTeTesiBridgePort
ieee8021PbbTeProtectionGroupConfigCommandAdmin
ieee8021PbbTeProtectionGroupConfigWTR
ieee8021PbbTeProtectionGroupConfigHoldOff
ieee8021PbbTeProtetcionGroupConfigNotifyEnable
ieee8021PbbTeProtectionGroupISidGroupId
ieee8021PbbTeProtectionGroupISidRowStatus
ieee8021PbbTeBridgeStaticForwardAnyUnicastTable
ieee8021PbbTeBridgeStaticForwardAnyUnicastEgressPorts
ieee8021PbbTeBridgeStaticForwardAnyUnicastForbiddenPorts

17.4.11 Security considerations of the IEEE8021-TPMR-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following object in the SNMPv2-MIB could be manipulated to interfere with the operation of a management system and its ability to recognize and manage a TPMR device.

sysName

The following object in the SNMPv2-MIB could be manipulated to interfere with the operation of a management system and its ability to recognize and manage a TPMR Port.

ifName

The following objects in the TPMR-MIB could be manipulated to interfere with the operation of MSP on a TPMR Port and, for example, be used to cause network instability.

ieee8021TpmrMspLinkNotify
ieee8021TpmrMspLinkNotifyWait
ieee8021TpmrMspLinkNotifyRetry
ieee8021TpmrMspMacNotify
ieee8021TpmrMspMacNotifyTime
ieee8021TpmrMspMacRecoverTime

17.4.12 Security considerations of the IEEE8021-FQTSS-MIB

There are a number of management objects defined in the IEEE8021-FQTSS-MIB module that have a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than notaccessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

The following tables and objects in the IEEE8021-FQTSS-MIB can be manipulated to interfere with the operation of the forwarding and queuing mechanisms in a manner that would be detrimental to the transmission of time-sensitive streams:

ieee8021FqtssDeltaBandwidth
ieee8021FqtssAdminIdleSlopeMs
ieee8021FqtssAdminIdleSlopeLs
ieee8021FqtssClassMeasurementInterval
ieee8021FqtssSrClassId
ieee8021FqtssTxSelectionAlgorithmID
ieee8021FqtssPriorityRegenOverride

a) ieee8021FqtssDeltaBandwidth can be manipulated to reduce the amount of bandwidth available to a given SR class.
b) ieee8021FqtssAdminIdleSlopeMs and ieee8021FqtssAdminIdleSlopeLs can be manipulated to change the overall amount of bandwidth available to stream traffic on a Port, in a network where SRP is not used for stream reservations.
c) ieee8021FqtssClassMeasurementInterval can be manipulated to change the measurement interval that is used, together with TSpec, to calculate reserved bandwidth.
d) ieee8021FqtssSrClassId can be manipulated to change the priority mapping of a SRclassID to a priority. This can impact the behavior of Streams.
e) ieee8021FqtssTxSelectionAlgorithmID can be manipulated in order to apply the wrong transmission selection algorithm to a traffic class that was being used by stream traffic.
f) ieee8021FqtssPriorityRegenOverride can be manipulated to disrupt stream traffic within an SRP domain with non-stream traffic entering from outside the SRP domain boundary.

17.4.13 Security considerations of the IEEE8021-CN-MIB

There are a number of management objects defined in the IEEE8021-MIRP-MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described in the paragraphs that follow.

Improper manipulation of certain tables and objects can result in the misidentification of the boundaries of CNDs (30.6). Any such errors can result in the following problems:

a) Frames not originated through an RP (31.2.2.2) can pass through CPs (31.1.1). The inability to throttle these frames via CNMs (33.3) can cause legitimate, RP-originated frames to experience unacceptably high loss rates.
b) Frames not originating through an RP (31.2.2.2) can pass through queues in the bridged network that are not CPs (31.1.1), where they can encounter uncontrolled congestion. This can cause those frames to experience unacceptably high loss rates.
c) The CN-TAG (30.5) in a data frame or CNM can be improperly discarded. This can cause that CNM, or a CNM resulting from the data frame, to be discarded by the end station that sourced the frame. As a result, that flow, and all flows passing through the same CPs, can experience unacceptably high loss rates.
d) The CN-TAG in a data frame or CNM can be improperly retained. This can result in a failure of two end stations to communicate, because the receiving end station is unable to process frames with CN-TAGs.

The following tables and objects in the IEEE8021-MIRP-MIB can cause such CND boundary identification errors:

ieee8021CnGlobalMasterEnable
ieee8021CnComPriDefModeChoice
ieee8021CnComPriAdminDefenseMode
ieee8021CnComPriCreation
ieee8021CnComPriLldpInstanceChoice
ieee8021CnComPriLldpInstanceSelector
ieee8021CnComPriRowStatus
ieee8021CnPortPriDefModeChoice
ieee8021CnPortPriAdminDefenseMode
ieee8021CnPortPriLldpInstanceChoice
ieee8021CnPortPriLldpInstanceSelector

Improper manipulation of certain other objects can result in assigning a data frame or CNM to the incorrect priority. This can result in the affected data streams experiencing loss rates that are either higher or lower than expected by the network administrator. Lower than expected loss rates for one data stream can cause higher than expected loss rates for other streams. These affects are typically, but not universally, less severe than the loss rate anomalies caused by CND boundary misidentification. The following variables can cause improper priority assignment:

ieee8021CnGlobalCnmTransmitPriority
ieee8021CnComPriAlternatePriority
ieee8021CnPortPriAlternatePriority

Improper manipulation of the remainder of the read-write and read-create objects can cause the congestion notification algorithm to operate in ways not intended by the network administrator. This can result in excessively high data frame loss rates and/or low link utilization rates. These variables are the following:

ieee8021CnCpQueueSizeSetPoint
ieee8021CnCpFeedbackWeight
ieee8021CnCpMinSampleBase
ieee8021CnCpMinHeaderOctets
ieee8021CnRpPortPriMaxRps
ieee8021CnRpgEnable
ieee8021CnRpgTimeReset
ieee8021CnRpgByteReset
ieee8021CnRpgThreshold
ieee8021CnRpgMaxRate
ieee8021CnRpgAiRate
ieee8021CnRpgHaiRate
ieee8021CnRpgGd
ieee8021CnRpgMinDecFac
ieee8021CnRpgMinRate

Unintended access to any of the readable tables or variables in the IEEE8021-MIRP-MIB alerts the reader that congestion notification is configured, and (for all tables and variables except those in the ieee8021CnGlobalTable and ieee8021CnCpidToInterfaceTable) on which priority value or values congestion notification is configured. This information can suggest to an attacker what applications are being run, and thus suggest application-specific attacks, or to enable the attacker to detect whether their attacks are successful. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

17.4.14 Security considerations of the IEEE8021-SRP-MIB

The purpose of MSRP is to create reservations for various types of data streams, including audio/video (AV) content. Access to the objects within the IEEE8021-SRP-MIB module, whether they have MAX-ACCESS of read-write, read-create, or read-only, may reveal sensitive information in some network environments. Very serious health and safety situations could arise if MSRP was involved in configuring network resources for an emergency public safety announcement and the MSRP behavior of the bridged network was allowed to be modified unexpectedly.

With these considerations in mind it is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly even encrypt their values when sending them over the network via SNMP.

The following tables and objects in the IEEE8021-SRP-MIB can be manipulated to interfere with the operation of the stream reservation mechanisms in a manner that would be detrimental to the transmission of the associated stream data:

ieee8021SrpBridgeBaseMsrpEnabledStatus
ieee8021SrpBridgeBaseMsrpTalkerPruning
ieee8021SrpBridgeBaseMsrpMaxFanInPorts
ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize
ieee8021SrpBridgeBaseMsrpTalkerVlanPruning
ieee8021SrpBridgePortMsrpEnabledStatus
ieee8021SrpBridgePortSrPvid
ieee8021SrpBridgeBaseMsrpTalkerPruningPerPort

a) ieee8021SrpBridgeBaseMsrpEnabledStatus can be manipulated to enable or disable MSRP operations for the entire Bridge.
b) ieee8021SrpBridgeBaseMsrpTalkerPruning can be manipulated to stop the propagation of Talker attributes if Listeners are not configured to support Talker Pruning.
c) ieee8021SrpBridgeBaseMsrpMaxFanInPorts can be manipulated to set the number of ingress Ports supporting streaming down to one, which would stop Talkers streams from coming in on any other Port.
d) ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize can be manipulates to set a frame size that is so large or so small that it causes the Bridge to calculate unreasonable maximum latency.
e) ieee8021SrpBridgeBaseMsrpTalkerVlanPruning can be manipulated to change the behavior of a Bridge regarding Talker declarations. This can either restrict Talker declarations in an unintended way or cause Talker declarations to be forwarded on unintended Ports.
f) ieee8021SrpBridgePortMsrpEnabledStatus can be manipulated to enable or disable MSRP on a particular Port, perhaps allowing sensitive stream data to be sent to unacceptable devices.
g) ieee8021SrpBridgePortSrPvid can be manipulated to move Streams to a VLAN that has been blocked by management, thus disabling reception of the Stream by one or more Listeners.
h) ieee8021SrpBridgeBaseMsrpTalkerPruningPerPort can be manipulated to disable MAC address pruning per Port, causing Talker declarations to be forwarded on unintended Ports.

ieee8021SrpBridgePortSrPvid can be manipulated to move Streams to a VLAN that has been blocked by management, thus disabling reception of the Stream by one or more Listeners.

17.4.15 Security considerations of the IEEE8021-MVRPX-MIB

The objects in IEEE8021-MVRPX-MIB could be manipulated to interfere with the operation of PBBs. Setting ieee8021MvrpxPortNewOnly, ieee8021MvrpxPortMvrpNewPropagated, or ieee8021MvrpxPortXmitZero to the wrong value could cause New messages to be transmitted when they

should not be or suppressed when they should be transmitted. This can result in the FDB being flushed either too often or not at all, or in lost or spurious VLAN registrations. Extra New messages waste resources in the Bridge's supervisory processor and can cause unnecessary flooding of data frames to unknown destinations, and lost New messages can prevent connectivity until the entries in the FDB time out. Lost or spurious VLAN registrations can cause the loss of connectivity for particular VLANs, or waste system resources transporting data frames to parts of the network where they are not needed.

17.4.16 Security considerations of the IEEE8021-MIRP-MIB

The following tables and objects in the IEEE8021-MIRP-MIB could be manipulated to interfere with the operation of PBBs. They could, for example, prevent Multiple I-SID Registration Protocol Data Units (MIRPDUs) from reaching their intended destinations, or cause them to reach unintended destinations. The former could result in temporary loss of service due to MAC address entries being timed out, instead of being flushed. The latter could result in excessive computation time taken by the PIPs or I-components unnecessarily receiving the MIRPDUs. The following are vulnerable writable objects from the IEEE8021-MIRP-MIB:

ieee8021MirpV2PortTable
ieee8021MirpV2PortEnabledStatus
ieee8021PbbMirpEnableStatus
ieee8021PbbMirpBvid
ieee8021PbbMirpDestSelector
ieee8021PbbMirpPnpEnable
ieee8021PbbMirpPnpPortNumber

17.4.17 Security considerations of the IEEE8021-PFC-MIB

One management object defined in the IEEE8021-PFC-MIB module has a MAXACCESS clause of read-write. Such object can be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. The management object is:

PFCLinkDelayAllowance

Improper setting of this management object can result in improper network operations. If the value of this management object is too high, then PFC can be invoked excessively, negatively impacting the link bandwidth. If the value of this management object is too low, then PFC can be invoked too late and frame loss can occur.

17.4.18 Security considerations of the IEEE8021-TEIPS-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described below.

The following tables and objects in the TEIPS-MIB could be manipulated to interfere with the operation of PBBs. This could, for example, be used to force a reinitialization of state machines to cause network instability or to change the forwarding and filtering policies. The following are all the writable objects from the IEEE8021-TEIPS-MIB:

ieee8021TeipsV2Ipgid
ieee8021TeipsV2IpgWorkingMA
ieee8021TeipsV2IpgProtectionMA
ieee8021TeipsV2TesiId

ieee8021TeipsV2CandidatePsMA
ieee8021TeipsV2IpgConfigWTR
ieee8021TeipsV2IpgConfigHoldOff
ieee8021TeipsV2IpgConfigMWTR

17.4.19 Security considerations of the IEEE8021-SPB-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These tables and objects and their sensitivity/vulnerability are described next.

ieee8021SpbMtidStaticEntryMtid

The following tables and objects in the SPB-MIB could be manipulated to interfere with the operation of Shortest Path Bridges. This could, for example, be used to misconfigure the network to cause loss of connectivity, or misconnect traffic. The following are vulnerable writable objects from the IEEE8021-SPB-MIB:

ieee8021SpbSys
ieee8021SpbSysAreaAddress
ieee8021SpbSysId
ieee8021SpbSysControlAddr
ieee8021SpbSysName
ieee8021SpbSysBridgePriority
ieee8021SpbMtidStaticTable
ieee8021SpbMtidStaticTableEntry
ieee8021SpbMTidStaticEntryMtidOverload
ieee8021SpbmBsiStaticTable
dot1agCfmMepSpbmEspTable
ieee8021PcrEctStaticTable

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. The following read-only tables with there respective objects in this MIB could be used by an attacker to understand the logical topology of the network:

ieee8021SpbEctDynamicTable
ieee8021SpbAdjDynamicTable
ieee8021SpbTopNodeTable
ieee8021SpbTopEctTable
ieee8021SpbTopEdgeTable
ieee8021PcrTopEctTable

17.4.20 Security considerations of the IEEE8021-EVB-MIB

The purpose of EVB is to coordinate VSIs within an EVB station with a data center network (DCN). In this environment the EVB station and the EVB Bridge may be under different management authorities. Access to the objects within the IEEE8021-EVB-MIB module of the EVB Bridge by the EVB station and access to objects within the IEEE8021-EVB-MIB module of the EVB station by the EVB Bridge may therefore need to be restricted.

Access to the objects within the IEEE8021-EVB-MIB module, whether they have MAX-ACCESS of read-write, read-create, or read-only, can reveal sensitive information in some network environments. Very serious health and safety situations could arise if EVB systems were involved in configuring network resources for an emergency public safety announcement and the EVB Bridge system behavior of the bridged network was allowed to be modified unexpectedly.

With these considerations in mind, it is thus important to control all types of access (including GET and/or NOTIFY) to these objects. SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example, by using IPsec), there is no control about who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

It is recommended that implementers consider the security features as provided by the SNMPv3 framework (see IETF RFC 3410 (2002), section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is not recommended. Instead, it is recommended to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to the principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

There are a number of management objects defined in IEEE8021-EVB-MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. Table 17-36 describes the tables and objects and their sensitivities/vulnerabilities.

Table 17-36—Sensitive managed objects (of EVB): tables and notifications

Table or object	Reason for sensitivity to security considerations
evbSysEvbLldpTxEnable evbSysEvbLldpManual evbSysEvbLldpGidCapable	The EVB TLV exchange controls how the VDP, ECP, and reflective relay parameters are set. These parameters allow manual configurations of the EVB parameters, which can be used to disable the operation of these protocols.
ieee8021BridgeEvbSysEcpAckTimer ieee8021BridgeEvbSysEcpMaxRetires	The ECP timer and retry count are set to provide reliable delivery of control frames. Incorrect settings can cause failures of the control protocols.
ieee8021BridgeEvbSysVdpDfltRsrcWaitDelay	The VDP resource timer determines the time required by the system to locate a profile. Setting this time too short may make VDP requests always fail.
ieee8021BridgeEvbSbpRowStatus ieee8021BridgeEvbUapRowStatus ieee8021BridgeEvbCapRowStatus ieee8021BridgeEvbUrpRowStatus	These variables allow creations of new ports on an EVB Bridge or EVB station. Inappropriate use of these may allow unauthorized interception of data.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. Table 17-37 provides the identity of VSIs and the addresses used to access them that could be used to identify the user application and what addresses can be used to interfere with or intercept their traffic.

Table 17-37—Sensitive managed objects (of EVB) for read

Table	Reason for sensitivity to security considerations
ieee8021BridgeEvbVsiDbTable	The VSI database provides a list of all operating VSIs along with their primary system keys. This information may be used to spy on the operating applications and the activity associated with each application.
ieee8021BridgeEvbVsiDbMacTable	The VSI MAC table provides the network addresses associated with operating applications. This information may be used in system attacks.

17.4.21 Security considerations of the IEEE8021-ECMP-MIB

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write and/or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These objects and their sensitivity/vulnerability are described next.

The following objects in the IEEE8021-ECMP-MIB could be manipulated to interfere with the operation of ECMP networks. These could, for example, be used to misconfigure the network to cause loss of connectivity or undesirable path selection. The following are vulnerable writable objects from the IEEE8021-ECMP-MIB:

ieee8021EcmpFlowFilterCtlTtl
ieee8021EcmpEctStaticEntryBridgePriority
ieee8021EcmpEctStaticEntryRowStatus

17.4.22 Security considerations of the IEEE8021-ST-MIB

There are a number of management objects defined in the IEEE8021-ST-MIB module that have a MAX-ACCESS clause of read-write. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

The following tables and objects in the IEEE8021-ST-MIB can be misconfigured to interfere with the operation of the forwarding and queuing mechanisms in a manner that would be detrimental to the transmission of scheduled traffic:

ieee8021STMaxSDU
ieee8021STGateEnabled
ieee8021STAdminGateStates
ieee8021STAdminControlListLength
ieee8021STAdminControlList
ieee8021STAdminCycleTimeNumerator
ieee8021STAdminCycleTimeDenominator
ieee8021STAdminCycleTimeExtension
ieee8021STAdminBaseTime
ieee8021STConfigChange
ieee8021STConfigChangeTime

a) ieee8021STMaxSDU can be misconfigured to affect the ability of a Port to transmit frames of greater than a given SDU size.
b) ieee8021STGateEnabled can be misconfigured to enable/disable scheduled traffic processing.
c) ieee8021STAdminGateStates can be misconfigured to affect the gate states of a Port on startup.

d) ieee8021STAdminControlListLength, ieee8021STAdminControlList, ieee8021STAdminCycleTimeNumerator, ieee8021STAdminCycleTimeDenominator, ieee8021STAdminCycleTimeExtension, ieee8021STAdminBaseTime, ieee8021STConfigChange, and ieee8021STConfigChangeTime can be misconfigured to affect the traffic schedule for the Port.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not accessible) can be considered sensitive or vulnerable in some network environments. Thus it is important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to encrypt the values of these objects when sending them over the network via SNMP.

17.4.23 Security considerations of the IEEE8021-Preemption-MIB

There is one management object defined in the IEEE8021-Preemption-MIB module that has a MAX-ACCESS clause of read-write. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

The following tables and objects in the IEEE8021-Preemption-MIB can be manipulated to interfere with the operation of the forwarding and queuing mechanisms in a manner that would be detrimental to the transmission of frames:

ieee8021FramePreemptionAdminStatus

a) Misconfiguration of the ieee8021FramePreemptionAdminStatus object can lead to the degradation of the quality of service for the application on the port at the respective traffic class that is wrongly preempted, or to the saturation of the priority queues on the port because of preemptable traffic classes receiving express processing.

17.4.24 Security considerations of the IEEE8021-PSFP-MIB

There are a number of management objects defined in the IEEE8021-PSFP-MIB module that have a MAX-ACCESS clause of read-write or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

The following tables and objects in the IEEE8021-PSFP-MIB can be misconfigured to interfere with the operation of the forwarding and queuing mechanisms in a manner that would be detrimental to the operation of PSFP:

ieee8021PSFPStreamHandleSpec
ieee8021PSFPPrioritySpec
ieee8021PSFPStreamGateInstanceID
ieee8021PSFPFilterSpecificationList
ieee8021PSFPStreamBlockedDueToOversizeFrameEnable
ieee8021PSFPStreamBlockedDueToOversizeFrame
ieee8021PSFPGateEnabled
ieee8021PSFPAdminGateStates
ieee8021PSFPAdminControlListLength
ieee8021PSFPAdminControlList
ieee8021PSFPAdminCycleTimeNumerator
ieee8021PSFPAdminCycleTimeDenominator

ieee8021PSFPAdminCycleTimeExtension
ieee8021PSFPAdminBaseTime
ieee8021PSFPConfigChange
ieee8021PSFPConfigChangeTime
ieee8021PSFPAdminIPV
ieee8021PSFPOperIPV
ieee8021PSFPGateClosedDueToInvalidRxEnable
ieee8021PSFPGateClosedDueToInvalidRx
ieee8021PSFPGateClosedDueToOctetsExceededEnable
ieee8021PSFPGateClosedDueToOctetsExceeded
ieee8021PSFPFlowMeterInstance
ieee8021PSFPFlowMeterCIR
ieee8021PSFFlowMeterCBS
ieee8021PSFPFlowMeterEIR
ieee8021PSFPFlowMeterCF
ieee8021PSFPFlowMeterCM
ieee8021PSFPFlowMeterDropOnYellow
ieee8021PSFPFlowMeterMarkAllFramesRedEnable
ieee8021PSFPFlowMeterMarkAllFramesRed

a) ieee8021PSFPStreamHandleSpec, ieee8021PSFPPrioritySpec, ieee8021PSFPStreamGateInstanceID, and ieee8021PSFPFilterSpecificationList can be misconfigured to adversely affect the policing functions that are applied to received frames.
b) ieee8021PSFPGateEnabled can be misconfigured to enable/disable scheduled traffic processing.
c) ieee8021PSFPAdminGateStates can be misconfigured to affect the gate state of a stream filter on startup.
d) ieee8021PSFPAdminControlListLength, ieee8021PSFPAdminControlList, ieee8021PSFPAdminCycleTimeNumerator, ieee8021PSFPAdminCycleTimeDenominator, ieee8021PSFPAdminCycleTimeExtension, ieee8021PSFPAdminBaseTime, ieee8021PSFPConfigChange, and ieee8021PSFPConfigChangeTime can be misconfigured to affect the filter schedule for the Port.
ieee8021PSFPFlowMeterInstance, ieee8021PSFPFlowMeterCIR, ieee8021PSFFlowMeterCBS, ieee8021PSFPFlowMeterEIR, ieee8021PSFPFlowMeterCF, ieee8021PSFPFlowMeterCM, ieee8021PSFPFlowMeterDropOnYellow, ieee8021PSFPFlowMeterMarkAllFramesRedEnable, ieee8021PSFPFlowMeterMarkAllFramesRed, ieee8021PSFPGateClosedDueToInvalidRxEnable, ieee8021PSFPGateClosedDueToInvalidRx, ieee8021PSFPGateClosedDueToOctetsExceededEnable, ieee8021PSFPGateClosedDueToOctetsExceeded, ieee8021PSFPStreamBlockedDueToOversizeFrameEnable, and ieee8021PSFPStreamBlockedDueToOversizeFrame can be misconfigured to adversely affect the way that flow metering operates.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not accessible) can be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (including GET and/or NOTIFY) to these objects and possibly to encrypt the values of these objects when sending them over the network via SNMP.

17.4.25 Security considerations of the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB

There are a number of management objects defined in the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB module that have a MAX-ACCESS clause of read-write or read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

The following tables and objects in the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB can be misconfigured to interfere with the operation of the forwarding and queuing mechanisms in a manner that would be detrimental to the connectivity, delay, and jitter provided to TSN streams and other network traffic:

ieee8021TsnRemoteMgmtMsrpMrpExternalControl

17.5 Dynamic component and Port creation

17.5.1 Overview of the dynamically created Bridge entities

The IEEE Bridge MIBs allow for the possibility of Bridge components and Bridge Ports to be created under the control of management operations. This functionality is optional. Compliant Bridges need not support this functionality or may tie the creation of components and Ports to the insertion or extraction of system hardware. This subclause outlines the rules and table interactions used by management stations to create soft configurable dynamic components and Ports on those systems that support this functionality.

A Bridge component contains, at a minimum, a collection of Bridge Ports, a relay unit that forwards and filters frames that travel between Ports, and managed objects to control the operation of the component. Certain types of components may contain other objects. These will be addressed later in this subclause in component-specific text.

Bridge components are the Owners of Bridge Ports, so components must be created before components can be populated with Ports.

The tables that are indexed by a single component ID index are as follows:

ieee8021BridgeBaseTable
ieee8021QBridgeTable
ieee8021QBridgeNextFreeLocalVlanTable
ieee8021QBridgeLearningConstraintDefaultTable
ieee8021CistTable
ieee8021MstConfigIdTable
ieee8021CfmVlanTable

17.5.1.1 Components

A component contains a relay function whose purpose is to move frames between interfaces to the relay called a Bridge Port or an Edge Relay Port. Different types of components are provided in this standard that are used to construct different types of Bridges.

17.5.1.2 Bridge Ports

A Bridge Port or Edge Relay Port is a frame source or sink directly attached to the relay function of a Bridge component.

17.5.1.3 Internal LAN connections

A BEB is composed of zero or one B-component and zero or more I-components. When the BEB has both a B-component and some I-components, the PIPs and CBPs of these I-components are connected by internal LAN connections. There needs to be a way to specify the interconnections between the PIPs on the I-component and the CBP on the B-component. This is done via the ieee8021BridgeILanIfTable defined in the IEEE8021-BRIDGE-MIB.

Essentially, this table allows for the creation of a new “interface” to represent the connection and then the ifStackTable is used to specify the interconnection.

These interconnections are used in multi-component Bridges, such as:

Provider Edge Bridges
BEBs

EVB stations
EVB Bridges

to specify the relationship between two interfaces in the following manner:

Two Port interfaces are interconnected if the invocation of a request operation at one of the interfaces causes an indication operation with the same parameters to happen at the other interface.

17.5.1.4 Provider Instance Ports (PIPs)

Even though it is not a Bridge Port, the creation of PIPs on I-components are discussed as part of the Bridge Port creation logic for I-components.

17.5.2 Component creation

A component is created by making an entry in the ieee8021BridgeBaseTable with the ieee8021BridgeBaseComponentType set to the proper value. Components can also be created indirectly by making entries in other system-specific tables, which then automatically create entries in the ieee8021BridgeBaseTable.

A Bridge component consists of a relay function and related Bridge Ports or Edge Relay Ports. The component type determines if the relay operates on untagged, C-tagged, or S-tagged frames. It also determines which specific type(s) of Bridge Ports or Edge Relay Ports may be created on the component.

17.5.2.1 MAC Bridge component creation

The MAC Bridge component has no specific component creation rules.

17.5.2.2 C-VLAN component creation

C-VLAN components are used in the following different types of Bridges:

a) C-VLAN Bridges
b) Provider Edge Bridges
c) EVB Bridges

Provider Edge Bridge C-VLAN components are created implicitly by the creation of a CEP on the S-VLAN component of the Provider Edge Bridge. C-VLAN components that belong to customer Bridges or to EVB Bridges are created by a management station performing a row-create on the component table or by implicit action such as the insertion of blades into a system.

17.5.2.3 S-VLAN component creation

S-VLAN components are used in three different ways in Bridges. The first is as the S-VLAN component of an S-VLAN Bridge or Provider Edge Bridge or the foundation for an I-component or B-component. The second is as a Port-mapping S-VLAN component in a Provider Edge Bridge. The third is as a Port-mapping S-VLAN component in an EVB station or an EVB Bridge.

Provider Edge Bridge Port-mapping S-VLAN components are created implicitly by the creation of a RCAP on the primary S-VLAN component of the Provider Edge Bridge.

EVB Bridge and EVB station Port-mapping S-VLAN components are created implicitly by the creation of an Uplink Access Port (UAP) on an ISS of an EVB Bridge or an EVB station. For an EVB Bridge the ISS is

allocated to a Bridge Port of the primary C-VLAN component. On an EVB station the ISS has no permanent Bridge Port or Edge Relay Port assignment.

17.5.2.4 B-component creation

The B-component has no specific component creation rules.

17.5.2.5 I-component creation

The I-component has no specific component creation rules.

17.5.2.6 ER creation

ERs of an EVB station are created implicitly by the creation of a URP, or actions such as the insertion of blades into a system or the installation of a software driver on the EVB station.

17.5.2.7 T-component creation

The T-component has no specific component creation rules.

17.5.3 Port creation

This subclause discusses how Ports of each relevant Port type are created on each relevant component type.

The general procedure is for the network administrator to perform an SNMP row-create operation on a table specific to the type of Port being created. If the operation succeeds, an entry will be implicitly created in the ieee8021BridgeBasePortTable by the agent.

The specific details are outlined in the 17.5.3.1 through 17.5.3.7.

17.5.3.1 Port creation on MAC Bridge components

MAC Bridge components are used in MAC Bridges. Creation of a Port on a MAC Bridge component requires specifying the component and Port index in the ieee8021BridgeCreatableBaseBridgeGroup table.

The type of the component referred to by the component ID parameter must be dBridgeComponent.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBaseComponentId	- Implementation Specific
ieee8021BridgeBasePort	- Implementation Specific
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit customerVlanPort(0) must be set
ieee8021BridgeBasePortType	- dBridgePort(8)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.2 Port creation on C-VLAN components

C-VLAN components support several different types of Bridge Ports. These are C-VLAN Ports, CEPs, PEPs, and SBPs.

A C-VLAN component that is not part of a Provider Edge Bridge may have C-VLAN Ports. A C-VLAN component that is part of a Provider Edge Bridge must have exactly 1 CEP and any number of PEPs.

The only type of Ports that may be created by operating on the C-VLAN component that is not part of an EVB Bridge are the C-VLAN Ports. On an EVB Bridge it is possible to create both C-VLAN Bridge Ports and SBPs.

CEPs are created by a management action on the S-VLAN component of a Provider Edge Bridge. From a management perspective, these entities are managed through the S-VLAN component or via management operations specific to the Provider Edge Bridge.

PEPs, together with the associated CNP and the internal connection between them, are created by performing row-create operations for a C-VID in the ieee8021PbCvidRegistrationTable and the corresponding S-VID in the ieee8021PbEdgePortTable.

17.5.3.2.1 Creating C-VLAN Ports

C-VLAN Ports are created by performing a row-create operation on the ieee8021QBridgeCVlanPortTable for a C-VLAN component that is configured to act as a VLAN Bridge. The required columns are the component ID and the Port Number to use for the newly created Port.

The type of the component referred to by the component ID parameter must be cVlanComponent configured for Q-Bridge operation.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per QBridgeCVlanPortTable
ieee8021BridgeBasePort	- As per QBridgeCVlanPortTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit customerVlanPort(0) must be set
ieee8021BridgeBasePortType	- customerVlanPort(2)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.2.2 Creating SBPs

SBPs are created by performing a row-create operation on the ieee8021BridgeEvbSbpConfigTable for a C-VLAN component that is configured to act as an EVB Bridge. The required columns are the component ID and the Port Number to use for the newly created Port.

The type of the component referred to by the component ID parameter is a cVlanComponent configured for Q-Bridge operation.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per ieee8021BridgeEvbSbpConfigTable
ieee8021BridgeBasePort	- As per ieee8021BridgeEvbSbpConfigTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset at creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset at creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific: bit *Station-facing Bridge Port* (8) is set
ieee8021BridgeBasePortType	- Station-facing Bridge Port (8)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.2.3 Creating CEPs

CEPs are created by doing a RowStatus create operation on the CEP table belonging to the PEB.

17.5.3.2.4 Creating PEPs

PEPs, together with the associated CNP and the internal connection between them, are created by performing row-create operations for a C-VID in the ieee8021PbCvidRegistrationTable and the corresponding S-VID in the ieee8021PbEdgePortTable. See the discussion on provisioning a C-tagged service interface in 17.6.1.2.

17.5.3.3 Port creation on S-VLAN components

S-VLAN components are the S-VLAN component of an S-VLAN Bridge or Provider Bridges. There are several different types of Ports that may be created on S-VLAN components. These are PNPs, CNPs, CEPs, RCAPs, and UAPs.

17.5.3.3.1 Creating PNPs

A PNP on an S-VLAN component works pretty much the same way as a customerVlanPort on a C-VLAN component except that the VID value used for forwarding and filtering decisions must come from an S-TAG and not a C-TAG.

Creating a PNP on a Provider Bridge is done by adding an entry to the ieee8021PbPnpTable specifying the componentId and Port Number.

ieee8021BridgeBasePortComponentId	- Component to which the new Port belongs
ieee8021BrdigeBasePort	- Port Number for the new Port

The type of the component referred to by the component ID parameter must be sVlanComponent.

This will cause an implicit entry in the ieee8021QBridgePortVlan table associated with the S-VLAN component.

The Component ID must refer to the S-VLAN component of a Provider Edge Bridge and the Port Number must refer to the Port Number of the PNP associated with that S-VLAN component.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per PbPnpTable
ieee8021BridgeBasePort	- As per PbPnpTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action

ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit providerNetworkPort(1) must be set
ieee8021BridgeBasePortType	- providerNetworkPort(3)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.3.2 Creating CNPs

There are two variants on the creation of CNPs. CNPs are either internal or external. Internal CNPs are directly connected to either a PEP on a C-VLAN component or a PAP on a Port-mapping S-VLAN component of a PEB and provide a C-tagged or Port-based service interface, respectively. External CNPs are connected to an external customer system and provide either a Port-based or S-tagged service interface.

a) Creating an external CNP.

The external CNP is used to provide a Port-based or S-tagged service interface to customer of the PBN.

Creating an external CNP requires specifying the component ID and Bridge Port Number of the Port to be created. This is done by creating an entry in the ieee8021PbCnpTable.

This creates a new entry in the ieee8021QBridgePortVlanTable for the provider Bridge's S-VLAN component.

This operation also created a new entry in the ieee8021BridgeBasePortTable.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per PbCnpTable
ieee8021BridgeBasePort	- As per PbCnpTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit customerNetworkPort(2) must be set
ieee8021BridgeBasePortType	- customerNetworkPort(4)
ieee8021BridgeBasePortExternal	- Implementation Specific

b) Creating an internal CNP.

The internal CNP is used to provide a C-tagged service interface or a Port-based RCSI to the customer of a PBN.

An internal CNP, together with the associated PEP and the internal connection between them, is created by performing row-create operations for an S-VID in the ieee8021PbEdgePortTable and the corresponding C-VID in the ieee8021PbCvidRegistrationTable. See the discussion on provisioning a C-tagged service interface in 17.6.1.2. An internal CNP together with the associated PAP and the internal connection between them are created by configuring a Port-based RCSI, that is, performing a row-create operation on the ieee8021PbInternalInterfaceTable with an ieee8021PbIiInternalPortType of customerNetworkPort.

Internal CNPs are not directly manageable.

17.5.3.3.3 Creating a CEP

CEPs are created either by doing a row-create operation on the Provider Edge Bridge's CEP table or as a side effect of mapping an external S-VID on a RCAP to a C-tagged RCSI. The ieee8021PbCepTable contains the following columns:

ieee8021BridgeBasePortComponentId - S-VLAN component ID that "owns" the CEP
ieee8021BridgeBasePort - The Port Number of the CEP on the S-VLAN component.
ieee8021PbCepCComponentId - C-VLAN component read only index cross-ref for entity MIB
ieee8021PbCepCepPortNumber - C-VLAN component Port read-only index cross-ref for entity MIB
ieee8021PbCepRowStatus - Controls the creation and deletion of the Port

Note that the C-VLAN component containing the newly created CEP does not appear in the IEEE 802.1 Bridge MIB's list of components. So ieee8021PbCepCComponentId and the ieee8021PbCepCepPortNumber, are index values that are not further interpreted by any IEEE 802.1 MIB. These index values, if present, can be used in an implementation-dependent manner to allow management stations to cross reference entries in other MIBs, such as the IETF's entity MIB, back to the information managed by the IEEE MIBs.

The newly created Port will be added to the Port list of the S-VLAN component of the Provider Edge Bridge.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId - As per CustomerEdgePortTable
ieee8021BridgeBasePort - As per CustomerEdgePortTable
ieee8021BridgeBasePortIfIndex - Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards - Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards - Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties - Implementation Specific
ieee8021BridgeBasePortTypeCapabilities - Implementation Specific bit customerEdgePort(3) must be set
ieee8021BridgeBasePortType - customerEdgePort(5)
ieee8021BridgeBasePortExternal - Implementation Specific

17.5.3.3.4 Creating an RCAP

RCAPs are created by doing a row-create operation on the Provider Edge Bridge's RCAP table. The ieee8021PbRcapTable contains the following columns:

ieee8021BridgeBasePortComponentId - primary S-VLAN component ID that "owns" the RCAP
ieee8021BridgeBasePort - The Port Number of the RCAP on the primary S-VLAN component.
ieee8021PbRcapSComponentId - Port-mapping S-VLAN component read only index cross-ref for entity MIB
ieee8021PbRcapRcapPortNumber - Port-mapping S-VLAN component Port read-only index cross-ref for entity MIB
ieee8021PbRcapRowStatus - Controls the creation and deletion of the Port

Note that the Port-mapping S-VLAN component containing the newly created RCAP does not appear in the IEEE 802.1 Bridge MIB's list of components. So ieee8021PbRcapSComponentId and the

ieee8021PbRcapRcapPortNumber, are index values that are not further interpreted by any IEEE 802.1 MIB. These index values, if present, can be used in an implementation-dependent manner to allow management stations to cross reference entries in other MIBs, such as the IETF's entity MIB, back to the information managed by the IEEE MIBs.

The newly created Port will be added to the Port list of the primary S-VLAN component of the Provider Edge Bridge.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per RcapTable
ieee8021BridgeBasePort	- As per RcapTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit remoteCustomerAccessPort(7) must be set
ieee8021BridgeBasePortType	- remoteCustomerAccessPort(9)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.3.5 Creating an Uplink Access Port (UAP)

UAPs are created by doing a row-create operation on the EVB Bridge's or EVB station's ieee8021BridgeEvbUapConfigTable. The required column is the ISS Port Number to use for the newly created Port. The ComponentID and PortNumber are specified if the system chooses to build an implicit ieee8021BridgeBasePortTable entry. The ieee8021BridgeEvbUapConfigTable contains the following columns:

ieee8021BridgeEvbUapIssPortNumber
ieee8021BridgeEvbUapComponentId
ieee8021BridgeEvbUapPortNumber
ieee8021BridgeEvbUapCdcpAdminEnable
ieee8021BridgeEvbUapAdminCDCPRole
ieee8021BridgeEvbUapAdminCDCPChanCap
ieee8021BridgeEvbUapOperCDCPChanCap
ieee8021BridgeEvbUapAdminCDCPSVIDPoolLow
ieee8021BridgeEvbUapAdminCDCPSVIDPoolHigh
ieee8021BridgeEvbUapOperState
ieee8021BridgeEvbUapCdcpRemoteEnabled
ieee8021BridgeEvbUapCdcpRemoteRole
ieee8021BridgeEvbUapConfigRowStatus

The optional implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per ieee8021BridgeEvbUapConfigTable
ieee8021BridgeBasePort	- As per ieee8021BridgeEvbUapConfigTable UapPortNumber
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific

ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific: bit *Uplink Access Port* (9) is set
ieee8021BridgeBasePortType	- Uplink Access Port
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.4 Port creation on B-components

B- and I-components are the two components that constitute a BEB (see Clause 26). These components provide what is generally known as “MAC in MAC” transport of Ethernet frames.

Ports on these BEB components are created using 12.16 managed objects.

17.5.3.4.1 Creating PNPs

A B-component is an S-VLAN component with one or more CBPs. A B-component may be a component of a BEB. PNP creation on a B-component follows the same logic used to create a PNP on an S-VLAN component.

Creating a PNP on a BEB is done by adding an entry to the ieee8021PbPnpTable specifying the componentId and Port Number.

ieee8021BridgeBasePortComponentId	- Component to which the new Port belongs
ieee8021BridgeBasePort	- Port Number for the new Port

The type of the component referred to by the component ID parameter must be sVlanComponent.

As a PNP is a Port on a B-component, which is a type of S-VLAN component, the act of creating a PNP causes entries to be made in the ieee8021QBridgePortVlanTable and the ieee8021BridgeBasePortTable.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per PbPnpTable
ieee8021BridgeBasePort	- As per PbPnpTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit providerNetworkPort(1) must be set
ieee8021BridgeBasePortType	- providerNetworkPort(3)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.4.2 Creating CBPs

Creating a CBP on a B-component is done by creating an entry in the ieee8021PbbCbpTable with the following column values:

ieee8021BridgeBasePortComponentId	- Component number of the B-component
ieee8021BridgeBasePort	- Port Number for the newly created Port

As a CBP is a Port on a B-component, which is a type of S-VLAN component, the act of creating a PNP causes entries to be made in the ieee8021QBridgePortVlanTable and the ieee8021BridgeBasePortTable.

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per PbbCbpTable
ieee8021BridgeBasePort	- As per PbbCbpTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit customerBackbonePort(4) must be set
ieee8021BridgeBasePortType	- customerBackbonePort(6)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.5 Port creation on I-components

Creating a Bridge Port on an I-component works the same way as creating a Port on a B-component with the exception that the rules for determining the legality of the Port type are different.

Creating PIPs works in a manner analogous to the creation of a Bridge Port, but as PIPs are not Bridge Ports the details are somewhat different.

17.5.3.5.1 Creating CNPs

The CNP is used to provide a Port-based or S-tagged service interface to customer of the PBBN.

Creating a CNP of requires specifying the I-component ID and Bridge Port Number of the Port to be created. This is done by creating an entry in the ieee8021PbCnpTable. This creates a new entry in the ieee8021QBridgePortVlanTable for the provider Bridge's I-component. This operation also created a new entry in the ieee8021BridgeBasePortTable. The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per QBridgePortVlanTable
ieee8021BridgeBasePort	- As per QBridgePortVlanTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit (2) must be set
ieee8021BridgeBasePortType	- customerNetworkPort(4)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.5.3.5.2 Creating VIPs

The creation of VIP starts with the creation of an entry in the ieee8021PbbVipTable with the following columns set:

ieee8021BridgeBasePortComponentId	- Component Number of I-component
ieee8021BridgeBasePort	- As appropriate
ieee8021PbbVipRowStatus	- Probably either createAndGo or createAndWait

An entry will be created in the ieee8021PbbVipTable with the following columns set:

ieee8021PbbVipPipIfIndex	- 0

ieee8021PbbVipISid	- 1
ieee8021PbbVipDefaultDstBMAC	- 00-1E-83-00-00-01
ieee8021PbbVipRowStatus	- “Active”

As a VIP is a Port on a I-component, which is a type of S-VLAN component, the act of creating a VIP causes entries to be made in the ieee8021QBridgePortVlanTable and the ieee8021BridgeBasePortTable.The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per QBridgePortVlanTable
ieee8021BridgeBasePort	- As per QBridgePortVlanTable
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific bit virtualInstancePort must be set
ieee8021BridgeBasePortType	- virtualInstancePort
ieee8021BridgeBasePortExternal	- Implementation Specific

Note that before becoming operational, the VIP must be assigned to a PIP and must be assigned to a service by setting an I-SID value. Furthermore, the mapping tables must be set up in a consistent basis.

17.5.3.5.3 Creating PIPs

PIPs are not Bridge Ports, but they are necessary parts of the internal operation of a BEB. They share many characteristics of Bridge Ports, simply because both PIPs and Bridge Ports are interfaces that transfer MAC frames, but are not connected to a MAC relay function.

PIPs are created using a BEB managed object. This object maps to the ieee8021PbbPipTable in the PBB MIB module. An entry needs to be created in the table with the following attributes:

ieee8021PbbPipIfIndex	- A previously unallocated ifIndex value
ieee8021PbbPipBMACAddress	- Implementation Default or specified value
ieee8021PbbPipName	- Implementation Default or specified value
ieee8021PbbPipIComponentId	- I-component index to which this PIP belongs
ieee8021PbbPipVipMap	- Empty Mapping

Note that before the operation can occur on this PIP, it may be necessary to modify the B-MAC address value of the PIP, especially in the case where local MAC addresses are used in the PBBN.

17.5.3.6 Required post creation operations

Before a Bridge Port is ready for operational use, the Bridge Port must be associated with an entity that acts as a frame source and frame sink. For a Bridge with or without the dynamic Port creation capability, this will likely be an ISS. For a Bridge with dynamic Port creation, it will be an ISS.

Most Bridge Ports manage this association by using the ieee8021BridgeBasePortIfIndex column in the ieee8021BridgeBasePort table. It is system dependent if the ieee8021BridgeBasePortIfIndex column in the ieee8021BridgeBasePort table needs to be filled in with the appropriate ifIndex for the newly created Bridge Port. Systems that enforce a specific mapping between Bridge Port Numbers and physical interfaces may have the agent automatically fill in this field and the association may not be modifiable.

The association for CEPs is managed by the ieee8021PbCepTable.

The association between PEPs and CNPs for PEBs is managed implicitly by the creation of the PEP/CNP pair by adding a CEP to the member set of an S-VID.

The association between PAPs and CNPs for PEBs is managed implicitly by the creation of a PAP/CNP pair by mapping an external S-VID on a RCAP to a Port-based RCSI. The association between PAPs and CEPs for PEBs is managed implicitly by the creation of a PAP/CEP pair by mapping an external S-VID on a RCAP to a C-tagged RCSI.

The association between PIPs and CBPs is managed by the internal LAN table (ieee8021BridgeILanIfTable).

Additionally, for Ports on elements of Provider Bridges and PBBs, instances in service tables must be created before the Ports are capable of passing frames according to the relevant clauses of this standard and subsequent amendments.

17.5.3.7 Port creation on ERs

Creating a URP implicitly creates the ER itself. When a URP is created it is not necessarily bound to an ISS. The operating environment of the EVB system may choose to bind the URP to either an S-channel or to an ISS when it chooses. The ER may be created with a DRP or it may dynamically create them on demand from the operating environment.

Creating a DRP on an ER works the same way as creating a Port on a C-VLAN-aware component (17.5.3.2) with the exception that the rules for determining the legality of the Port type are different.

17.5.3.7.1 Creating DRPs

DRPs are created by performing a row-create operation on the ieee8021EvbPortTable for an ER. The required columns are the component ID and the Port Number to use for the newly created DRP.

17.5.3.7.2 Creating URPs

URPs are created by performing a row-create operation on the ieee8021BridgeEvbUrpConfigTable of an EVB station. The required columns are the component ID and the Port Number to use for the newly created Port.

The implicitly constructed ieee8021BridgeBaseTable entry will have the following fields filled in:

ieee8021BridgeBaseComponentId	- As per ieee8021BridgeEvbUrpConfigTabl
ieee8021BridgeBaseBridgeAddress	- As per ieee8021BridgeEvbUrpConfigTabl
ieee8021BridgeBaseNumPorts	- Implementation Specific Action
ieee8021BridgeBaseComponentType	- Type edge relay
ieee8021BridgeBaseDeviceCapabilities	- Implementation Specific
ieee8021BridgeBaseTrafficClassesEnabled	- Implementation Specific
ieee8021BridgeBaseMmrpEnabledStatus	- Implementation Specific
ieee8021BridgeBaseRowStatus	

The implicitly constructed ieee8021BridgeBasePortTable entry will have the following fields filled in:

ieee8021BridgeBasePortComponentId	- As per ieee8021BridgeEvbUrpConfigTabl
ieee8021BridgeBasePort	- As per ieee8021BridgeEvbUrpConfigTabl
ieee8021BridgeBasePortIfIndex	- Implementation Specific Action
ieee8021BridgeBasePortDelayExceededDiscards	- Statistic, reset to 0 by creation

ieee8021BridgeBasePortMtuExceededDiscards	- Statistic, reset to 0 by creation
ieee8021BridgeBasePortCapabilties	- Implementation Specific
ieee8021BridgeBasePortTypeCapabilities	- Implementation Specific: bit Uplink Relay Port(10) is set
ieee8021BridgeBasePortType	- Uplink Relay Port (10)
ieee8021BridgeBasePortExternal	- Implementation Specific

17.6 MIB operations for service interface configuration

This subclause outlines, on a per-service interface basis, the MIB operations that a Provider must perform to configure each type of service interface. The clause is organized into two broad subclauses. The first subclause explains how service interfaces for Provider networks (Clause 15, Clause 16, etc.), are configured. The second subclause explains how service interfaces for Provider Backbone Networks (Clause 25, Clause 26, etc.), are configured. Both of these subclauses have the same substructure. First, a description of the MIB operations that are service interface type independent, and secondly a description of the service type MIB operations organized in a per-service type manner.

17.6.1 Provisioning PBN service interfaces

This clause assumes that the components and Ports, if dynamic, have been created, although there may be some notes on the parameters used for Port creation on a per-service basis, if there are restrictions. This subclause describes the MIB operations needed to configure service interfaces for PBN equipment.

Table 17-38 lists the parameters required for each of the service interface types that can be used to interface to a provider network. These parameter names are used in subsequent clauses as values to be entered in the appropriate MIB tables.

Table 17-38—Provider Bridge service interface parameters

Parameter	Description	Customer service interface type		
		Port-based	C-tagged	S-tagged
ComponentID	ID of the S-VLAN component	Mandatory	Mandatory	Mandatory
Port Number	Bridge Port Number that Receives Customer Frames	CNP Port Number	CEP Port Number	CNP Port Number
RelaySVid	S-VID value used within the provider network	Mandatory	Mandatory	Mandatory
CVid	C-VID value used to identify frames to be transported by the specified service	Not needed	Mandatory	Not needed
LocalSVid	S-VID value used to identify the frames to be transported by the service	Not needed	Not Needed	Optional: if not specified, the RelaySVid value is used
Default CVID value	C-VID value to be used for frames received from the Provider Network without C-TAGs	Not needed	Mandatory	Not needed
Default Priority Value	Priority value to be used for frames received from the Provider Network without C-TAGs	Not needed	Mandatory	Not needed

17.6.1.1 Provisioning a Port-based service interface

This subclause describes the MIB operations needed to provision a Port-based service interface.

Creating a Port-based service on a CNP requires manipulation of the Port member sets of the ieee8021QBridgeVlanStaticTable. One must manipulate the Port member sets for the row with the following index values:

ieee8021QBridgeVlanStaticComponentId	- ComponentId
ieee8021QBridgeVlanStaticVlanIndex	- RelaySVid

The CNP must be added to the PortList specified by the ieee8021QBridgeVlanStaticEgressPorts column of this row and must be added to the PortList specified by the ieee8021QBridgeVlanStaticUntaggedPorts column of this row.

One may, or may not, wish to allow the customer to specify priorities for the arriving customer traffic. In either case one must set the ieee8021QBridgePortAcceptableFrameTypes column of the entry in the ieee8021QBrigePortVlanTable indexed by:

ieee8021BridgeBasePortComponentId	- ComponentId
ieee8021BridgeBasePort	- PortNumber

to admitUntaggedAndPriority and set the ieee8021QBridgePortIngressFiltering column to TRUE to ensure that customers may not “spoof” the provider network by sending S-tagged frames to the CNP.

17.6.1.2 Provisioning a C-tagged service interface

This subclause describes the MIB operations needed to provision a C-tagged service interface.

The CEP must be added to the Port member set of each S-VID on the S-VLAN component of the Provider Edge Bridge that is to provide service for the CEP. This is done by modifying the ieee8021QBridgeVlanStaticTable ieee8021QBridgeStaticEgressPorts PortList whose matching index column values are as follows:

ieee8021QBridgeVlanStaticComponentId	- ComponentId
ieee8021QBridgeVlanStaticVlanIndex	- RelaySVid

Adding the CEP to the member set of an S-VID implies the existence of a CNP on the S-VLAN component that is internally connected to a PEP on the C-VLAN component. Enabling the CEP to send and receive frames from the service instance identified by the RelaySVid requires creating a linkage between the S-VID, the CNP, the PEP, and a C-VID. This is accomplished by configuring the ieee8021PbEdgePortTable and ieee8021PbCVidRegistrationTable.

Each S-VID value that is associated with a provider service instance accessed through the CEP requires that an entry be made in the ieee8021PbEdgePortTable. An entry in this table maps an S-VID to a CNP and associates that CNP with a specific PEP. The CNP is identified by the CEP port number and the S-VID that form the index values for the table. The contents of the table entry identify the PEP by specifying the C-VID value used as the PVID for that PEP (as well as providing other configuration parameters for that PEP). A CNP is implicitly created by the first entry identifying a given PEP (i.e., the first entry that contains a given C-VID value). In some cases it is useful to create multiple entries to map multiple S-VIDs to the same CNP. Two or more entries map to the same CNP if the C-VID value identifying the PVID of the PEP is the same (the other values of the entry should be the same as well). This many-to-one mapping of S-VIDs to CNP/PEP pairs can be used to configure asymmetric VLANs for supporting rooted-multipoint connectivity (F.1.3.2). The table entry with the following index values:

ieee8021BridgeBasePortComponentId	- ComponentId
ieee8021BridgeBasePort	- PortNumber
ieee8021PAbEdgePortSVid	- RelaySVid

needs to have the following columns set:

ieee8021PbEdgePortPVID	- DefaultCVid
ieee8021PbEdgePortDefaultUserPriority	- DefaultPriority
ieee8021PbEdgePortAcceptableFrameType	- As Desired
ieee8021PbEdgePortEnableIngressFiltering	- As Desired

Each C-VID value that is to be mapped to a provider service instance requires that an entry be made in the ieee8021PbCvidRegistrationTable. An entry in this table maps a C-VID to a PEP and associates that PEP with a specific CNP. The PEP is identified by the CEP port number and the C-VID that form the index values for the table. The contents of the table entry identify the CNP by specifying the S-VID value used as the PVID for that CNP (as well as providing member set and untagged set information for the C-VID). A PEP is implicitly created by the first entry identifying a given CNP (i.e., the first entry that contains a given S-VID value). In some cases it is useful to create multiple entries to map multiple C-VIDs to the same PEP. Two or more entries map to the same PEP if the S-VID value identifying the PVID of the CNP is the same. This many-to-one mapping of C-VIDs to PEP/CNP pairs can be used to support bundling multiple C-VLANs into a single service instance. The table entry with the following index values:

ieee8021BridgeBasePortComponentId	- ComponentId
ieee8021BridgeBasePort	- PortNumber
ieee8021PbCVidRegistrationCVid	- CVid

needs to have the following columns set:

ieee8021PbCVidRegistrationSVid	- RelaySVid
ieee8021PbCVidRegistrationUntaggedPep	- As Desired
ieee8021PbCVidRegistrationUntaggedCep	- As Desired

17.6.1.3 Provisioning an S-tagged service interface

This subclause describes the MIB operations needed to provision an S-tagged service interface.

Creating an S-tagged-based service interface requires manipulation of the Port member sets of the CNP entry in the ieee8021QBridgeVlanStaticTable. One must manipulate the Port member sets for the row with the following index values:

ieee8021QBridgeVlanStaticComponentId	- ComponentId
ieee8021QBridgeVlanStaticVlanIndex	- RelaySVid

The CNP must be added to the PortList specified by the ieee8021QBridgeVlanStaticEgressPorts column of this row. The CNP must not be in the PortList specified by the ieee8021QBrdigeVlanStaticUntaggedPorts column of this row as this service requires S-TAGS in all frames.

If the Provider wishes to use separate S-TAG values for the customer and provider S-VLAN spaces, then the entry in the ieee8021PbVidTranslationTable indexed by the following:

ieee8021BridgeBasePortComponentId	- ComponentId
ieee8021bridgeBasePort	- PortNumber
ieee8021PbVidTranslationLocalVid	- LocalSVid

must be created or changed so that the ieee8021PvVidTranslationRelayVid column is set to the RelaySVid.

17.6.2 Provisioning Backbone Bridged Network service interfaces

This subclause describes the MIB operations needed to provision service interfaces on PBBNs. In particular, this subclause assumes that the provider backbone network service instance exists and that the following information is available:

The I-SID value that identifies the correct backbone service instance is known.

At any BEB that is to have a service interface map customer data to a backbone service instance, given the I-SID, the following information can be determined:

— The Component ID of the B-component that contains the appropriate PNP used to access the service instance.
— The Port number of the PNP.
— The B-VID value used to transport that service over the Backbone Core.
— The DA used to transport the frame over the Backbone Core. Either a default MAC address, or the service MAC address.

Furthermore, the core of the network is assumed to be operationally correct. That is, if a frame is presented to the Backbone Core by a BEB with the proper B-VID value and proper Backbone Destination MAC address (B-DA) at the proper PNP, then the frame will arrive at the appropriate VIP(s). This can be achieved by statically configuring the member sets of the BCBs or by configuring the network such that dynamic address and VLAN registration protocols ensure that the Core Bridges Port member sets and FDBs are set appropriately.

Provisioning a service interface in a BEB to access a backbone service interface requires configuring two components. The first is the I-component. The I-component determines the backbone service instance to which customer data is mapped. The second component is the B-component. The B-component determines how the backbone service instance is forwarded over the PBBN core. Thus, the I-component determines the I-SID value, and thus the backbone service instance, to which the customer data belongs and the B-component determines the B-VID and B-DA values that will be used by the relay functions of the BCBs to determine the forwarding path through the core network used by the customer’s data.

In the case of an I-tagged service interface, the service interface used by the customer is configured on the CBP of a BEB and the physical interconnection between the backbone network and the customer network is between the CBP of a provider managed B-component and the PIP of a customer managed I-component.

To simplify the discussion of service interface provisioning, this subclause first discusses interface type-independent provisioning of the B-component, and then service interface-independent provisioning of the I-component. Following that discussion, interface type-specific configuration is discussed. This type-specific configuration consists of instructions on how to determine the parameters needed by the service independent configuration of both the I- and B-components along with the provisioning of service-specific tables in the I- and B-components.

Table 17-39 lists the parameters required to provision each type of service interface per Clause 25. The parameters are used in the descriptions of the MIB table operations needed to configure each service in the following subclauses.

Table 17-39—PBB service interface parameters

Parameter	Description	Service interface type			
		Port-based	Unbundled one-to-one S-tagged	Bundled many-to-one or all-to-one S-tagged	I-tagged service interface
IComponentID	Component ID of the I-component of a BEB	Mandatory	Mandatory	Mandatory	Not needed
BComponentID	Component ID of the B-component of a BEB	Mandatory	Mandatory	Mandatory	Mandatory
CBPPortNumber	Port number of a Customer Backbone Port	Mandatory	Mandatory	Mandatory	Mandatory
BackboneSid	I-SID value used between the PIP and CBP	Mandatory	Mandatory	Mandatory	Mandatory
MappingType	Used for point-to-multipoint services where ingress or egress limiting is needed	Optional	Optional	Optional	Optional
DefaultDestAddress	MAC address to use as the backbone DA	Optional: if not specified, the service default address is used	Optional: if not specified, the service default address is used	Optional: if not specified, the service default address is used	Optional: if not specified, the service default address is used
B-Vid	Backbone VID that identifies the VLAN to transport the service over the backbone	Optional: if not specified, the default B-VLAN is used	Optional: f not specified, the default B-VLAN is used	Optional: if not specified, the default B-VLAN is used	Optional: if not specified, the default B-VLAN is used
LocalSID	I-SID value to be used in the backbone network.	Optional: if not specified, the BackboneSID value is used	Optional: if not specified, the BackboneSID value is used	Optional: if not specified, the BackboneSID value is used	Optional: if not specified, the BackboneSID value is used
PCPSpec	Priority Code Point encoding and decoding specifications	Optional: note that separate values may be required for the I- and B-components	Optional: note that separate values may be required for the I- and B-components	Optional: note that separate values may be required for the I- and B-components	Not needed
LocalSVid	S-TAG value that designates traffic at the CNP, if different from the RelaySVid	Not needed	Optional: RelaySVid used if not specified	Optional: RelaySVid used if not specified	Not needed

Table 17-39—PBB service interface parameters *(continued)*

Parameter	Description	Service interface type			
		Port-based	Unbundled one-to-one S-tagged	Bundled many-to-one or all-to-one S-tagged	I-tagged service interface
RelaySVid	S-TAG value used within the I-component to identify traffic belonging to a particular service instance	Mandatory	Mandatory	Mandatory	Not needed
VIPPortNumber	Port number of the VIP	Mandatory	Mandatory	Mandatory	Not needed
PIPIndex	Identifier of the PIP to which the VIP belongs	Mandatory	Mandatory	Mandatory	Not needed
VIP-SID	ISID value used by a VIP	Mandatory	Mandatory	Mandatory	Not needed
adminPointToPointMAC	Indicates if the service is a point-to-point service	Optional	Optional	Optional	Optional
CNPPortNumber	The Bridge Port number of a CNP on an I-component	Mandatory	Mandatory	Mandatory	Not needed

17.6.2.1 Service type-independent provisioning of the B-component

All frames that are transmitted over a PBBN service instance ultimately start at a CBP. Thus part of provisioning any service interface requires configuration of the CBP. This is done with the ieee8021PbbCBPServiceMappingTable.

Provisioning this portion of the service interface is straightforward. One needs to add a row to the ieee8021PbbCBPServiceMappingTable whose columns are set to the values specified in the required parameters. Furthermore, one may need to ensure that both the CBP and PNP belong to the member set of the B-VID if dynamic configuration of VIDs is not supported.

17.6.2.2 Service type-independent provisioning of the I-component

The I-component needs to be configured when either Port-based or S-tagged service interfaces are configured. Traffic belonging to an I-tagged service interface does not transit the I-component; hence there is no configuration of the I-component for that service. The I-component's provisioning is more service interface dependent than the provisioning of the B-component. However, some of the logic needed to provision the I-component does not depend upon the service being provisioned. In particular the configuration of the ieee8021PbbVIPTable and the ieee8021PbbPipTable is provisioned almost identically for both Port-based and S-tagged service instances.

17.6.2.2.1 Configuring the ieee8021PbbVipTable

Traffic for both Port-based and S-tagged services interfaces transitions a VIP on the I-component The particular VIP over with the traffic transits determines the backbone service instance, and thus the I-SID value for the traffic. A VIP must be created for each service instance for which the I-component forwards traffic. Bundled services interfaces map multiple customer S-VIDs to a single service instance. Generally, when creating a service the first step is to create the VIP that will carry this service. This is done by creating a row in the ieee8021PbbVipTable. The following columns must be set in the table:

ieee8021BridgeBasePortComponentId	- set to IComponentId
ieee8021BridgeBasePort	- set to VIPPortNum
ieee8021PbbVipISid	- set to the VIP-SID (which may be localSID or backboneSID depending on the use of I-SID translation at the B-component)

As a side effect of this row creation, a row will be created in the ieee8021PbbISidToVipTable. Essentially, this table implements the inverse mapping, taking an I-SID value to the VIP that is the local endpoint of the service instance.

17.6.2.2.2 Configuring the ieee8021PbbPipTable

For Port-based, unbundled service interfaces, and for the first S-VID allocated to a bundled service, then the VIP used for the service must be configured to use the appropriate PIP. Use the IComponentID and PIPIndex to select a row in this table. Set the bit corresponding to the VIPPortNum in the appropriate MAP column of that row to 1. This adds the VIP to the PIP and, as a side effect, sets the ieee8021PbbVipPipIfindex column in the ieee8021PbbVipTable.

17.6.2.3 Service-dependent provisioning for an I-tagged service interface

The I-tagged service interface of a PBBN allows a customer to attach directly to a CBP of a B-component of a BEB allowing the customer to transport frames that already possess an I-TAG. A scenario for this is when the customer is also a backbone provider and is purchasing transport across another Provider's network. Another scenario is when an access network provides an I-tagged interface. The I-tagged service interface is defined in 25.5

The provisioning is accomplished by using the parameter values of Table 17-7 and applying the procedures outlined in 17.6.2.1 to provision the B-component.

17.6.2.4 Service-dependent provisioning a Port-based service interface

The Port-based service interface of a PBBN causes all of the traffic arriving at the CNP of the I-component of a BEB to mapped to a single backbone service instance. The Port-based interface of a PBBN provides the same customer service as a Port-based service interface of a PBN. The implementation of this service interface in a PBBN is defined in 25.3.

17.6.2.4.1 Configuring the B-component

Given the PIP, one uses the I-LAN table to find the B-component and CBP that the traffic for this service will transit. This gives us the following two parameters:

BComponentId—B-component ID for the CBP
CBPPortNumber—Port number of the CBP on this B-component

These two service parameters found from the I-LAN table along with the remainder of the parameters defined in Table 17-5 are used to configure the B-component as outlined in 17.6.2.1. As a side effect of configuring the CBP via the ServiceMapping table, the ieee8021PbbVipDefaultDstBMAC column is set in the ieee8021PbbVipTable.

17.6.2.4.2 Configuring the Port operating modes and I-component VID

The first step is to configure the I-component VID used to interconnect the VIP with the CNP. This is done by creating an entry in the ieee8021QBridgeVlanStaticTable with the columns set to the following values:

ieee8021QBridgeVlanStaticComponentId	- IcomponentId
ieee8021QBridgeVlanStaticVlanIndex	- IcompPVid
ieee8021QBridgeVlanStaticName	- Something administratively convenient
ieee8021QBridgeVlanStaticEgressPorts	- Port List containing just the VIP and the CNP
ieee8021QBridgeVlanStaticUntaggedPorts	- PortList containing just the VIP and the CNP

This sets the VIP and the CNP to be the only Ports present on the new I-component PVID. Furthermore, they are both set for untagged traffic. Thus, traffic arriving at one Port will be relayed to the other Port without any S-TAGs.

The final step is to configure the ingress filtering on both the VIP and CNP. This is done by modifying their entries in the ieee8021QBridgePortVlanTable. For both of these Ports, the following columns in the table must be set:

ieee8021QBridgePortAcceptableFrameTypes	- acceptUntaggedAndPriority
ieee8021QBridgePortIngressFiltering	- TRUE
ieee8021QBridgePVid	- IcompPVid

17.6.2.5 Service-dependent provisioning for an S-tagged service interfaces

This subclause describes the MIB operations specific to S-tagged service interface provisioning. Configuration is done in a manner similar to Port-based services. The configuration differences are largely confined to different configurations of the CNP and VIP Port member sets, tagging, and ingress filtering.

The parameters for an S-tagged service interface are similar to those for a Port-based service interface.

17.6.2.5.1 Configuring the B-component

If the service interface to be created is unbundled, or if the service interface is bundled and the newly configured service interface is the first S-VID value to be transported on this Backbone I-SID, then the B-component will need to be configured.

The first step is to find the B-component ID and CBP for the traffic. Given the PIP, one uses the I-LAN table to find the B-component and CBP that the traffic for this service interface will transit. This gives us the following two parameters:

BComponentId—B-component ID for the CBP
CBPPortNumber—Port number of the CBP on this B-component

These, together with the BackboneSid, DefaultDestAddress, and BVid value can be used to configure the B-component as per the previous instructions. As a side effect of configuring the CBP via the ServiceMapping table, the ieee8021PbbVipDefaultDstBMAC column is set in the ieee8021PbbVipTable.

17.6.2.5.2 Configuring the I-component for S-tagged service interfaces

These service interfaces are configured by creating one or more static VLANs on the I-component whose S-VIDs are the values specified as the S-VID parameters to the service. For a one-to-one service, exactly one S-VID value is specified. For a many-to-one or all-to-one service, multiple S-VID values are specified. This is done by creating an entry in the ieee8021QBridgeVlanStaticTable with the columns set to the following values:

ieee8021QBridgeVlanStaticComponentId	- IcomponentId
ieee8021QBridgeVlanStaticVlanIndex	- S-VID
ieee8021QBridgeVlanStaticName	- Something administratively convenient
ieee8021QBridgeVlanStaticEgressPorts	- Port List containing just the VIP and the CNP

For the one-to-one service set:

ieee8021QBridgeVlanStaticUntaggedPorts	- PortList containing just the VIP

For the many-to-one or all-to-one service:

ieee8021QBridgeVlanStaticUntaggedPorts	- Null set

For the unbundled one-to-one service, the VIP and CNP are set to be the only Ports that are members of the I-component's VLAN identified by S-VID. Adding the VIP to the set of untagged Ports means that the data will be sent to the CBP on the B-component untagged.

For the bundled many-to-one or all-to-one service interfaces, the VIP may be in the member set of more than one S-VID. This is the mechanism by which multiple CNP services, identified by S-VID, are mapped to the same I-SID value. Furthermore, unlike the unbundled service, the VIP is not a member of the untagged egress set of the S-VID.

17.7 MIB modules[31, 32]

In this subclause, certain terms (e.g., “SHOULD” and “MUST”) denote requirements terminology according to the usage specified in IETF RFC 2119, as is customary for IETF MIB module definitions. In the MIB modules definitions below, if any discrepancy between the DESCRIPTION text and the corresponding definition in any other part of this standard occur, the definitions outside this subclause take precedence.

17.7.1 Definitions for the IEEE8021-TC-MIB module

```
IEEE8021-TC-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- TEXTUAL-CONVENTIONs MIB for IEEE 802.1
-- ============================================================

IMPORTS
    MODULE-IDENTITY, Unsigned32, org
        FROM SNMPv2-SMI -- RFC 2578
    TEXTUAL-CONVENTION
        FROM SNMPv2-TC; -- RFC 2579

ieee8021TcMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "Textual conventions used throughout the various IEEE 802.1 MIB
         modules.

         Unless otherwise indicated, the references in this MIB
         module are to IEEE Std 802.1Q-2022.

         Copyright (C) IEEE (2022).
         This version of this MIB module is part of IEEE Std 802.1Q;
         see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            Updating of definition of IEEE8021PbbIngressEgress
            New identifier types for new SPBM MA types"
```

[31] *Copyright release for MIBs:* Users of this standard may freely reproduce the MIB modules in this standard so that they can be used for their intended purpose.

[32] An ASCII version of this MIB module is attached to the PDF version of this standard, and can be obtained by Web browser from the IEEE 802.1 Website at https://1.ieee802.org/mib-modules/.

```
    REVISION     "201202150000Z" -- February 15, 2012
    DESCRIPTION
         "Modified IEEE8021BridgePortType textual convention to
          include stationFacingBridgePort,
          uplinkAccessPort, and uplinkRelayPort types."

    REVISION     "201108230000Z" -- August 23, 2011
    DESCRIPTION
         "Modified textual conventions  to support the IEEE 802.1
          MIBs for PBB-TE Infrastructure Protection Switching."

    REVISION     "201104060000Z" -- April 6, 2011
    DESCRIPTION
         "Modified textual conventions  to support Remote Customer
          Service Interfaces."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."


    REVISION     "200811180000Z" -- November 18, 2008
    DESCRIPTION
         "Added textual conventions needed to support the IEEE 802.1
          MIBs for PBB-TE.  Additionally, some textual conventions were
          modified for the same reason."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
         "Initial version."
    ::= { org ieee(111) standards-association-numbers-series-standards(2)
          lan-man-stds(802) ieee802dot1(1) 1 1 }

ieee802dot1mibs OBJECT IDENTIFIER
    ::= { org ieee(111) standards-association-numbers-series-standards(2)
          lan-man-stds(802) ieee802dot1(1) 1 }

-- ================================================================
-- Textual Conventions
-- ================================================================

IEEE8021PbbComponentIdentifier ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PB or PBB.  Each
        virtual Bridge instance is called a component.  In simple
        situations where there is only a single component the default
        value is 1.  The component is identified by a component
        identifier unique within the BEB and by a MAC address unique
        within the PBBN.  Each component is associated with a Backbone
        Edge Bridge (BEB) Configuration managed object."
    REFERENCE "12.3 l)"
    SYNTAX       Unsigned32 (1..4294967295)

IEEE8021PbbComponentIdentifierOrZero ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PB or PBB.  In simple
        situations where there is only a single component the default
        value is 1.  The component is identified by a component
        identifier unique within the BEB and by a MAC address unique
        within the PBBN.  Each component is associated with a Backbone
        Edge Bridge (BEB) Configuration managed object.

        The special value '0' means 'no component identifier'.  When
        this TC is used as the SYNTAX of an object, that object must
        specify the exact meaning for this value."
```

```
    REFERENCE "12.3 l)"
    SYNTAX       Unsigned32 (0 | 1..4294967295)

IEEE8021PbbServiceIdentifier ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The service instance identifier is used at the Customer
        Backbone Port of a PBB to distinguish a service instance
        (Local-SID). If the Local-SID field is supported, it is
        used to perform a bidirectional 1:1 mapping between the
        Backbone I-SID and the Local-SID. If the Local-SID field
        is not supported, the Local-SID value is the same as the
        Backbone I-SID value."
    REFERENCE "12.16.3, 12.16.5"
    SYNTAX       Unsigned32 (256..16777214)

IEEE8021PbbServiceIdentifierOrUnassigned ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The service instance identifier is used at the Customer
        Backbone Port of a PBB to distinguish a service instance
        (Local-SID). If the Local-SID field is supported, it is
        used to perform a bidirectional 1:1 mapping between the
        Backbone I-SID and the Local-SID. If the Local-SID field
        is not supported, the Local-SID value is the same as the
        Backbone I-SID value.

        The special value of 1 indicates an unassigned I-SID."
    REFERENCE "12.16.3, 12.16.5"
    SYNTAX       Unsigned32 (1|256..16777214)

IEEE8021PbbIngressEgress ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "A 2 bit selector that determines if frames on this VIP may
        ingress to the PBBN but not egress the PBBN, egress to the
        PBBN but not ingress the PBBN, or both ingress and egress
        the PBBN."
    REFERENCE "12.16.3, 12.16.5"
    SYNTAX       BITS {
                     ingress(0),
                     egress(1)
                 }

IEEE8021PriorityCodePoint ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "Bridge ports may encode or decode the PCP value of the
        frames that traverse the port. This textual convention
        names the possible encoding and decoding schemes that
        the port may use.  The priority and drop_eligible
        parameters are encoded in the Priority Code Point (PCP)
        field of the VLAN tag using the Priority Code Point
        Encoding Table for the Port, and they are decoded from
        the PCP using the Priority Code Point Decoding Table."
    REFERENCE "12.6.2.6"
    SYNTAX       INTEGER {
                     codePoint8p0d(1),
                     codePoint7p1d(2),
                     codePoint6p2d(3),
                     codePoint5p3d(4)
                 }

IEEE8021BridgePortNumber ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "An integer that uniquely identifies a Bridge Port, as
        specified in 17.3.2.2.
        This value is used within the spanning tree
```

```
        protocol to identify this port to neighbor Bridges."
    REFERENCE "17.3.2.2"
    SYNTAX       Unsigned32 (1..65535)

IEEE8021BridgePortNumberOrZero ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "An integer that uniquely identifies a Bridge Port. The value
        0 means no port number, and this must be clarified in the
        DESCRIPTION clause of any object defined using this
        TEXTUAL-CONVENTION."
    REFERENCE "17.3.2.2"
    SYNTAX       Unsigned32 (0..65535)

IEEE8021BridgePortType ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "A port type.  The possible port types are:

             customerVlanPort(2) - Indicates a port is a
                 C-tag-aware port of an enterprise VLAN-aware Bridge.

             providerNetworkPort(3) - Indicates a port is an S-tag-
                 aware port of a Provider Bridge or Backbone Edge
                 Bridge used for connections within a PBN or PBBN.

             customerNetworkPort(4) - Indicates a port is an S-tag-
                 aware port of a Provider Bridge or Backbone Edge
                 Bridge used for connections to the exterior of a
                 PBN or PBBN.

             customerEdgePort(5) - Indicates a port is a C-tag-
                 aware port of a Provider Bridge used for connections
                 to the exterior of a PBN or PBBN.

             customerBackbonePort(6) - Indicates a port is a I-tag-
                 aware port of a Backbone Edge Bridge's B-component.

             virtualInstancePort(7) - Indicates a port is a virtual
                 S-tag-aware port within a Backbone Edge Bridge's
                 I-component that is responsible for handling
                 S-tagged traffic for a specific backbone service
                 instance.

             dBridgePort(8) - Indicates a port is a VLAN-unaware
                 member of an IEEE 802.1D Bridge.

             remoteCustomerAccessPort (9) - Indicates a port is an
                 S-tag-aware port of a Provider Bridge used for
                 connections to remote customer interface LANs
                 through another PBN.

             stationFacingBridgePort (10) - Indicates a port of a
                 Bridge that supports the EVB status parameters
                 (40.4) with an EVBMode parameter value of
                 EVB Bridge.

             uplinkAccessPort (11) - Indicates a port on a
                 Port-mapping S-VLAN component that connects an EVB
                 Bridge with an EVB station.

             uplinkRelayPort (12) - Indicates a port of an edge relay
                 that supports the EVB status parameters (40.4)
                 with an EVBMode parameter value of EVB station."
    REFERENCE   "40.4, 12.13.1.1, 12.13.1.2, 12.16, 12.16.1.1.3
                 12.16.2.1, 12.26"
    SYNTAX       INTEGER {
                     none(1),
                     customerVlanPort(2),
                     providerNetworkPort(3),
                     customerNetworkPort(4),
```

```
                    customerEdgePort(5),
                    customerBackbonePort(6),
                    virtualInstancePort(7),
                    dBridgePort(8),
                    remoteCustomerAccessPort(9),
                    stationFacingBridgePort(10),
                    uplinkAccessPort(11),
                    uplinkRelayPort(12)
                    }

IEEE8021VlanIndex ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "A value used to index per-VLAN tables: values of 0 and
        4095 are not permitted.  If the value is between 1 and
        4094 inclusive, it represents an IEEE 802.1Q VLAN-ID with
        global scope within a given bridged domain (see VlanId
        textual convention).  If the value is greater than 4095,
        then it represents a VLAN with scope local to the
        particular agent, i.e., one without a global VLAN-ID
        assigned to it.  Such VLANs are outside the scope of
        IEEE 802.1Q, but it is convenient to be able to manage them
        in the same way using this MIB."
    REFERENCE   "9.6"
    SYNTAX      Unsigned32 (1..4094|4096..4294967295)

IEEE8021VlanIndexOrWildcard ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "A value used to index per-VLAN tables.  The value 0 is not
        permitted, while the value 4095 represents a 'wildcard'
        value.  An object whose SYNTAX is IEEE8021VlanIndexOrWildcard
        must specify in its DESCRIPTION the specific meaning of the
        wildcard value.  If the value is between 1 and
        4094 inclusive, it represents an IEEE 802.1Q VLAN-ID with
        global scope within a given bridged domain (see VlanId
        textual convention).  If the value is greater than 4095,
        then it represents a VLAN with scope local to the
        particular agent, i.e., one without a global VLAN-ID
        assigned to it.  Such VLANs are outside the scope of
        IEEE 802.1Q, but it is convenient to be able to manage them
        in the same way using this MIB."
    REFERENCE   "9.6"
    SYNTAX      Unsigned32 (1..4294967295)

IEEE8021MstIdentifier ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, an MSTID, i.e., a value used to identify
        a spanning tree (or MST) instance.  In the PBB-TE environment
        the value 4094 is used to identify VIDs managed by the PBB-TE
        procedures."
    SYNTAX      Unsigned32 (1..4094)

IEEE8021ServiceSelectorType ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "A value that represents a type (and thereby the format)
        of a IEEE8021ServiceSelectorValue.  The value can be one of
        the following:

        ieeeReserved(0)   Reserved for definition by IEEE 802.1
                          recommend to not use zero unless
                          absolutely needed.
        vlanId(1)         12-Bit identifier as described in IEEE Std 802.1Q.
        isid(2)           24-Bit identifier as described in IEEE Std 802.1ah.
        tesid(3)          32 Bit identifier as described below.
        segid(4)          32 Bit identifier as described below.
        path-tesid(5)     32 Bit identifier as described below.
```

```
        group-isid(6)     24 Bit identifier as described below.
        ieeeReserved(7)  Reserved for definition by IEEE Std 802.1

        To support future extensions, the IEEE8021ServiceSelectorType
        textual convention SHOULD NOT be subtyped in object type
        definitions.  It MAY be subtyped in compliance statements in
        order to require only a subset of these address types for a
        compliant implementation.

        The tesid is used as a service selector for MAs that are present
        in Bridges that implement PBB-TE functionality.  A selector of
        this type is interpreted as a 32 bit unsigned value of type
        IEEE8021PbbTeTSidId.  This type is used to index the
        ieee8021PbbTeTeSiEspTable to find the ESPs that comprise the TE
        Service Instance named by this TE-SID value.

        The segid is used as a service selector for MAs that are present
        in Bridges that implement IPS functionality.  A selector of
        this type is interpreted as a 32 bit unsigned value of type
        IEEE8021TeipsSegid.  This type is used to index the
        Ieee8021TeipsSegTable to find the SMPs that comprise the
        Infrastructure Segment named by this segid value.

        The path-tesid is used as a service selector for SPBM path MAs.
        A selector of this type is interpreted as a 32 bit unsigned value
        corresponding to the MA index dot1agCfmMaIndex. This type is used
        to index the dot1agCfmMepSpbmEspTable to find the ESPs that
        comprise the SPBM path associated with an SPBM path MA.

        The group-isid is used as a service selector for SPBM group MAs.
        A selector of this type is interpreted as a 24 bit unsigned value
        corresponding to the I-SID associated with an SPBM group MA.

        Implementations MUST ensure that IEEE8021ServiceSelectorType
        objects and any dependent objects (e.g.,
        IEEE8021ServiceSelectorValue objects) are consistent.  An
        inconsistentValue error MUST be generated if an attempt to
        change an IEEE8021ServiceSelectorType object would, for
        example, lead to an undefined IEEE8021ServiceSelectorValue value."
    SYNTAX      INTEGER {
                    vlanId(1),
                    isid(2),
                    tesid(3),
                    segid(4),
                    path-tesid(5),
                    group-isid(6),
                    ieeeReserved(7)
                }

IEEE8021ServiceSelectorValueOrNone ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "An integer that uniquely identifies a generic MAC Service,
         or none.  Examples of service selectors are a VLAN-ID
         (IEEE 802.1Q) and an I-SID (IEEE Std 802.1ah).

         An IEEE8021ServiceSelectorValueOrNone value is always
         interpreted within the context of an
         IEEE8021ServiceSelectorType value.  Every usage of the
         IEEE8021ServiceSelectorValueOrNone textual convention is
         required to specify the IEEE8021ServiceSelectorType object
         that provides the context.  It is suggested that the
         IEEE8021ServiceSelectorType object be logically registered
         before the object(s) that use the
         IEEE8021ServiceSelectorValueOrNone textual convention, if
         they appear in the same logical row.

         The value of an IEEE8021ServiceSelectorValueOrNone object
         must always be consistent with the value of the associated
         IEEE8021ServiceSelectorType object.  Attempts to set an
         IEEE8021ServiceSelectorValueOrNone object to a value
```

```
        inconsistent with the associated
        IEEE8021ServiceSelectorType must fail with an
        inconsistentValue error.

        The special value of zero is used to indicate that no
        service selector is present or used.  This can be used in
        any situation where an object or a table entry MUST either
        refer to a specific service, or not make a selection.

        Note that a MIB object that is defined using this
        TEXTUAL-CONVENTION SHOULD clarify the meaning of
        'no service' (i.e., the special value 0), as well as the
        maximum value (i.e., 4094, for a VLAN ID)."
    SYNTAX       Unsigned32 (0 | 1..4294967295)

IEEE8021ServiceSelectorValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "An integer that uniquely identifies a generic MAC Service.
         Examples of service selectors are a VLAN-ID (IEEE 802.1Q)
         and an I-SID (IEEE Std 802.1ah).

         An IEEE8021ServiceSelectorValue value is always interpreted
         within the context of an IEEE8021ServiceSelectorType value.
         Every usage of the IEEE8021ServiceSelectorValue textual
         convention is required to specify the
         IEEE8021ServiceSelectorType object that provides the context.
         It is suggested that the IEEE8021ServiceSelectorType object
         be logically registered before the object(s) that use the
         IEEE8021ServiceSelectorValue textual convention, if they
         appear in the same logical row.

         The value of an IEEE8021ServiceSelectorValue object must
         always be consistent with the value of the associated
         IEEE8021ServiceSelectorType object.  Attempts to set an
         IEEE8021ServiceSelectorValue object to a value inconsistent
         with the associated IEEE8021ServiceSelectorType must fail
         with an inconsistentValue error.

         Note that a MIB object that is defined using this
         TEXTUAL-CONVENTION SHOULD clarify the
         maximum value (i.e., 4094, for a VLAN ID)."
    SYNTAX       Unsigned32 (1..4294967295)

IEEE8021PortAcceptableFrameTypes ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
        "Acceptable frame types on a port."
    REFERENCE   "12.10.1.3, 12.13.2.3, 12.13.2.4"
    SYNTAX      INTEGER {
                    admitAll(1),
                    admitUntaggedAndPriority(2),
                    admitTagged(3)
                }

IEEE8021PriorityValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "An IEEE 802.1Q user priority value."
   REFERENCE   "12.13.2.3"
    SYNTAX      Unsigned32 (0..7)

IEEE8021PbbTeProtectionGroupId ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The PbbTeProtectionGroupId identifier is used to distinguish
         protection group instances present in the B Component of
         an IB-BEB."
    REFERENCE "12.18.2"
```

```
    SYNTAX       Unsigned32 (1..429467295)

IEEE8021PbbTeEsp ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
       "This textual convention is used to represent the logical
        components that constitute the 3-tuple that identifies an
        Ethernet Switched Path.  The 3-tuple consists of a
        destination MAC address, a source MAC address and a VID.
        Bytes (1..6) of this textual convention contain the
        ESP-MAC-DA, bytes (7..12) contain the ESP-MAC-SA, and bytes
        (13..14) contain the ESP-VID."
    REFERENCE "3.86"
    SYNTAX OCTET STRING ( SIZE(14))

IEEE8021PbbTeTSidId ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS current
    DESCRIPTION
       "This textual convention is used to represent an identifier
        that refers to a TE Service Instance.  Note that, internally
        a TE-SID is implementation dependent.  This textual convention
        defines the external representation of TE-SID values."
    REFERENCE
        "3.275"
    SYNTAX  Unsigned32 (1..42947295)

IEEE8021PbbTeProtectionGroupConfigAdmin ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "This textual convention is used to represent administrative
        commands that can be issued to a protection group.  The value
        noAdmin(1) is used to indicate that no administrative action
        is to be performed."
    REFERENCE "26.10.3.3.5
               26.10.3.3.6
               26.10.3.3.7
               12.18.2.3.2"
    SYNTAX    INTEGER {
                 clear(1),
                 lockOutProtection(2),
                 forceSwitch(3),
                 manualSwitchToProtection(4),
                 manualSwitchToWorking(5)
              }

IEEE8021PbbTeProtectionGroupActiveRequests ::= TEXTUAL-CONVENTION
   STATUS current
   DESCRIPTION
       "This textual convention is used to represent the status of
        active requests within a protection group."
    REFERENCE
       "12.18.2.1.3 d)"
   SYNTAX   INTEGER {
                noRequest(1),
                loP(2),
                fs(3),
                pSFH(4),
                wSFH(5),
                manualSwitchToProtection(6),
                manualSwitchToWorking(7)
            }

IEEE8021TeipsIpgid ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
        "The TEIPS IPG identifier is used to distinguish
         IPG instances present in a PBB."
    REFERENCE "12.24.1.1.3 a)"
    SYNTAX       Unsigned32 (1..429467295)
```

```
IEEE8021TeipsSegid ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS current
    DESCRIPTION
       "This textual convention is used to represent an
        identifier that refers to an Infrastructure Segment.
        Note that, internally a SEG-ID implementation
        dependent.  This textual convention defines the
        external representation of SEG-ID values."
    REFERENCE
        "26.11.1"
    SYNTAX  Unsigned32 (1..42947295)

IEEE8021TeipsSmpid ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
       "This textual convention is used to represent the logical
        components that constitute the 3-tuple that identifies a
        Segment Monitoring Path (SMP).  The 3-tuple consists of a
        destination MAC address, a source MAC address and a VID.
        Bytes (1..6) of this textual convention contain the
        SMP-MAC-DA, bytes (7..12) contain the SMP-MAC-SA, and bytes
        (13..14) contain the SMP-VID."
    REFERENCE "26.11.1"
    SYNTAX OCTET STRING ( SIZE(14))

IEEE8021TeipsIpgConfigAdmin ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
        "This textual convention is used to represent administrative
        commands that can be issued to an IPG.  The value
        clear(1) is used to indicate that no administrative action
        is to be performed."
    REFERENCE "12.24.2.1.3 h)"
    SYNTAX    INTEGER {
                 clear(1),
                 lockOutProtection(2),
                 forceSwitch(3),
                 manualSwitchToProtection(4),
                 manualSwitchToWorking(5)
              }

IEEE8021TeipsIpgConfigActiveRequests ::= TEXTUAL-CONVENTION
   STATUS current
   DESCRIPTION
       "This textual convention is used to represent the status of
        active requests within an IPG."
    REFERENCE
       "12.24.2.1.3 d)"
   SYNTAX   INTEGER {
                noRequest(1),
                loP(2),
                fs(3),
                pSFH(4),
                wSFH(5),
                manualSwitchToProtection(6),
                manualSwitchToWorking(7)
            }

END
```

17.7.2 Definitions for the IEEE8021-BRIDGE-MIB module

```
IEEE8021-BRIDGE-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- Bridge MIB for IEEE 802.1Q devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE,
    Integer32, Counter64
        FROM SNMPv2-SMI
    RowStatus, MacAddress, TruthValue, TimeInterval
        FROM SNMPv2-TC
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF
    ifIndex, InterfaceIndexOrZero, ifGeneralInformationGroup
        FROM IF-MIB
    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber, IEEE8021PriorityCodePoint,
    IEEE8021BridgePortType, IEEE8021PriorityValue,
    IEEE8021PbbComponentIdentifierOrZero,
    IEEE8021BridgePortNumberOrZero
        FROM IEEE8021-TC-MIB
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    systemGroup
        FROM SNMPv2-MIB
    ;

ieee8021BridgeMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        IEEE Std 802.1Q.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION  "Published as part of IEEE Std 802.1Q 2014 revision.
                  Cross references updated and corrected."

    REVISION     "201208100000Z" -- August 10, 2012
    DESCRIPTION  "Added an enumeration for tComponent in
                  ieee8021BridgeBaseComponentType
```

```
                as part of IEEE Std 802.1Q Cor-2."

    REVISION     "201202150000Z" -- February 15, 2012
    DESCRIPTION  "Extended ieee8021BridgeBaseComponentType to
                  include erComponent and
                  ieee8021BridgeBasePortTypeCapabilities to include
                  stationFacingBridgePort, uplinkAccessPort and
                  uplinkRelayPort.
                  Added tables ieee8021BridgeBaseIfToPortTable and
                  ieee8021BridgePortTable
                  as part of IEEE Std 802.1Qbg."

    REVISION     "201104060000Z" -- April 6, 2011
    DESCRIPTION  "Modifications to support Remote Customer Service
                  Interfaces."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION  "Minor edits to contact information etc. as part of
                  2011 revision of IEEE Std 802.1Q."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION  "Initial revision, derived from RFC 4188."
    ::= { ieee802dot1mibs 2 }

-- ============================================================
-- subtrees in the Bridge MIB
-- ============================================================

ieee8021BridgeNotifications
    OBJECT IDENTIFIER ::= { ieee8021BridgeMib 0 }

ieee8021BridgeObjects
    OBJECT IDENTIFIER ::= { ieee8021BridgeMib 1 }

ieee8021BridgeConformance
    OBJECT IDENTIFIER ::= { ieee8021BridgeMib 2 }

ieee8021BridgeBase
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 1 }
ieee8021BridgeTp
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 2 }
ieee8021BridgePriority
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 3 }
ieee8021BridgeMrp
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 4 }
ieee8021BridgeMmrp
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 5 }
ieee8021BridgeInternalLan
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 6 }
ieee8021BridgeDot1d
    OBJECT IDENTIFIER ::= { ieee8021BridgeObjects 7 }

-- ============================================================
-- the ieee8021BridgeBase subtree
-- ============================================================
-- Implementation of the ieee8021BridgeBase subtree is mandatory
-- for all Bridges.
-- ============================================================

-- ============================================================
-- the ieee8021BridgeBaseTable
-- ============================================================
ieee8021BridgeBaseTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeBaseEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains generic information about every
        Bridge component.  All writable objects in this table
        MUST be persistent over power up restart/reboot."
    REFERENCE   "12.4.1"
    ::= { ieee8021BridgeBase 1 }
```

```
ieee8021BridgeBaseEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeBaseEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information for each Bridge
        component."
    INDEX  { ieee8021BridgeBaseComponentId }
    ::= { ieee8021BridgeBaseTable 1 }

Ieee8021BridgeBaseEntry ::=
    SEQUENCE {
        ieee8021BridgeBaseComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021BridgeBaseBridgeAddress
            MacAddress,
        ieee8021BridgeBaseNumPorts
            Integer32,
        ieee8021BridgeBaseComponentType
            INTEGER,
        ieee8021BridgeBaseDeviceCapabilities
            BITS,
        ieee8021BridgeBaseTrafficClassesEnabled
            TruthValue,
        ieee8021BridgeBaseMmrpEnabledStatus
            TruthValue,
        ieee8021BridgeBaseRowStatus
            RowStatus
    }

ieee8021BridgeBaseComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgeBaseEntry 1 }

ieee8021BridgeBaseBridgeAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The MAC address used by this Bridge when it is
        referred to in a unique fashion.  It is recommended
        that this be the numerically smallest MAC address of
        all ports that belong to this Bridge.  However, it is
        only required to be unique.  When concatenated with
        ieee8021SpanningTreePriority, a unique BridgeIdentifier
        is formed, which is used in the Spanning Tree Protocol.

        This object may not be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.4.1.1.3 a)"
    ::= { ieee8021BridgeBaseEntry 2 }

ieee8021BridgeBaseNumPorts OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "ports"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of ports controlled by this bridging
        entity."
    REFERENCE   "12.4.1.1.3 c)"
```

```
    ::= { ieee8021BridgeBaseEntry 3 }

ieee8021BridgeBaseComponentType OBJECT-TYPE
    SYNTAX      INTEGER {
                    iComponent(1),
                    bComponent(2),
                    cVlanComponent(3),
                    sVlanComponent(4),
                    dBridgeComponent(5),
                    erComponent (6),
                    tComponent (7)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the component type(s) of this Bridge.  The
        following component types are possible:

            iComponent(1) - An S-VLAN component of a Backbone
                Edge Bridge that performs encapsulation of customer
                frames.

            bComponent(2) - An S-VLAN component of a Backbone
                Edge Bridge that bundles backbone service instances
                into B-VLANs.

            cVlanComponent(3) - A C-VLAN component of an
                enterprise VLAN Bridge or of a Provider Bridge used
                to process C-tagged frames.

            sVlanComponent(4) - An S-VLAN component of a
                Provider Bridge.

            dBridgeComponent(5) - A VLAN unaware component of an
                IEEE 802.1Q Bridge.

            erComponent (6) - An Edge Relay component of an EVB Station.

            tComponent (7) - A TPMR component in a Backbone Edge Bridge.

        This object may not be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.3 m)"
    ::= { ieee8021BridgeBaseEntry 4 }

ieee8021BridgeBaseDeviceCapabilities OBJECT-TYPE
    SYNTAX      BITS {
        dot1dExtendedFilteringServices(0),
        dot1dTrafficClasses(1),
        dot1qStaticEntryIndividualPort(2),
        dot1qIVLCapable(3),
        dot1qSVLCapable(4),
        dot1qHybridCapable(5),
        dot1qConfigurablePvidTagging(6),
        dot1dLocalVlanCapable(7)
    }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the optional parts of IEEE Std 802.1Q
        that are implemented by this device and are manageable
        through this MIB.  Capabilities that are allowed on a
        per-port basis are indicated in
        ieee8021BridgeBasePortCapabilities.

        dot1dExtendedFilteringServices(0),
                            -- can perform filtering of
                            -- individual multicast addresses
                            -- controlled by MMRP.
```

```
        dot1dTrafficClasses(1),
                              -- can map priority to
                              -- multiple traffic classes.
        dot1qStaticEntryIndividualPort(2),
                              -- dot1qStaticUnicastReceivePort &
                              -- dot1qStaticMulticastReceivePort
                              -- can represent non-zero entries.
        dot1qIVLCapable(3),   -- Independent VLAN Learning (IVL).
        dot1qSVLCapable(4),   -- Shared VLAN Learning (SVL).
        dot1qHybridCapable(5),
                              -- both IVL & SVL simultaneously.
        dot1qConfigurablePvidTagging(6),
                              -- whether the implementation
                              -- supports the ability to
                              -- override the default PVID
                              -- setting and its egress status
                              -- (VLAN-Tagged or Untagged) on
                              -- each port.
        dot1dLocalVlanCapable(7)
                              -- can support multiple local
                              -- Bridges, outside of the scope
                              -- of IEEE 802.1Q defined VLANs.

        This object may not be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.10.1.1.3 b)"
    ::= { ieee8021BridgeBaseEntry 5 }

ieee8021BridgeBaseTrafficClassesEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value true(1) indicates that Traffic Classes are
        enabled on this Bridge.  When false(2), the Bridge
        operates with a single priority level for all traffic.

        This object may be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { true }
    ::= { ieee8021BridgeBaseEntry 6 }

ieee8021BridgeBaseMmrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative status requested by management for
        MMRP.  The value true(1) indicates that MMRP should
        be enabled on this device, in all VLANs, on all ports
        for which it has not been specifically disabled.  When
        false(2), MMRP is disabled, in all VLANs and on all
        ports, and all MMRP packets will be forwarded
        transparently.  This object affects both Applicant and
        Registrar state machines.  A transition from false(2)
        to true(1) will cause a reset of all MMRP state
        machines on all ports.

        This object may be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { true }
    ::= { ieee8021BridgeBaseEntry 7 }
```

```
ieee8021BridgeBaseRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The object indicates the status of an entry, and is used
        to create/delete entries.

        The following objects MUST be set prior to making a new
        entry active:
            ieee8021BridgeBaseBridgeAddress
            ieee8021BridgeBaseComponentType
            ieee8021BridgeBaseDeviceCapabilities
        It is recommended that these three objects not be allowed
        to be modified while the corresponding instance of
        ieee8021BridgeBaseRowStatus object is active(1).

        The following objects are not required to be set before
        making a new entry active (they will take their defaults),
        and they also may be modified while the corresponding
        instance of this object is active(1):
            ieee8021BridgeBaseTrafficClassesEnabled
            ieee8021BridgeBaseMmrpEnabledStatus

        The value of this object and all corresponding instances
        of other objects in this table MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021BridgeBaseEntry 8 }

-- ============================================================
-- The Generic Bridge Port Table
-- ============================================================
ieee8021BridgeBasePortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeBasePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains generic information about every
        port that is associated with this Bridge.  Transparent,
        and source-route ports are included."
    REFERENCE   "12.4.2"
    ::= { ieee8021BridgeBase 4 }

ieee8021BridgeBasePortEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeBasePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current

    DESCRIPTION
        "A list of objects containing information for each port
         of the Bridge."
    INDEX  { ieee8021BridgeBasePortComponentId,
             ieee8021BridgeBasePort }
    ::= { ieee8021BridgeBasePortTable 1 }

Ieee8021BridgeBasePortEntry ::=
    SEQUENCE {
        ieee8021BridgeBasePortComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021BridgeBasePort
            IEEE8021BridgePortNumber,
        ieee8021BridgeBasePortIfIndex
            InterfaceIndexOrZero,
        ieee8021BridgeBasePortDelayExceededDiscards
            Counter64,
        ieee8021BridgeBasePortMtuExceededDiscards
            Counter64,
        ieee8021BridgeBasePortCapabilities
            BITS,
        ieee8021BridgeBasePortTypeCapabilities
            BITS,
        ieee8021BridgeBasePortType
```

```
            IEEE8021BridgePortType,
        ieee8021BridgeBasePortExternal
            TruthValue,
        ieee8021BridgeBasePortAdminPointToPoint
            INTEGER,
        ieee8021BridgeBasePortOperPointToPoint
            TruthValue,
        ieee8021BridgeBasePortName
            SnmpAdminString
    }

ieee8021BridgeBasePortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgeBasePortEntry 1 }

ieee8021BridgeBasePort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The port number of the port for which this entry
        contains Bridge management information."
    REFERENCE   "12.4.2.1"
    ::= { ieee8021BridgeBasePortEntry 2 }

ieee8021BridgeBasePortIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The value of the instance of the IfIndex object,
         defined in the IF-MIB, for the interface corresponding
         to this port, or the value 0 if the port has not been
         bound to an underlying frame source and sink.

         It is an implementation specific decision as to whether this object
         may be modified if it has been created or if 0 is a legal value.

         The underlying IfEntry indexed by this column MUST be persistent
         across reinitializations of the management system."
    ::= { ieee8021BridgeBasePortEntry 3 }

ieee8021BridgeBasePortDelayExceededDiscards OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of frames discarded by this port due
        to excessive transit delay through the Bridge.  It
        is incremented by both transparent and source
        route Bridges.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3 f)"
    ::= { ieee8021BridgeBasePortEntry 4 }

ieee8021BridgeBasePortMtuExceededDiscards OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
```

```
    STATUS      current
    DESCRIPTION
        "The number of frames discarded by this port due
        to an excessive size.  It is incremented by both
        transparent and source route Bridges.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3 g)"
    ::= { ieee8021BridgeBasePortEntry 5 }

ieee8021BridgeBasePortCapabilities OBJECT-TYPE
    SYNTAX      BITS {
        dot1qDot1qTagging(0),
        dot1qConfigurableAcceptableFrameTypes(1),
        dot1qIngressFiltering(2)
    }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Indicates the parts of IEEE 802.1Q that are
        optional on a per-port basis, that are implemented by
        this device, and that are manageable through this MIB.

        dot1qDot1qTagging(0), -- supports IEEE 802.1Q VLAN tagging of
                              -- frames and MVRP.
        dot1qConfigurableAcceptableFrameTypes(1),
                              -- allows modified values of
                              -- dot1qPortAcceptableFrameTypes.
        dot1qIngressFiltering(2)
                              -- supports the discarding of any
                              -- frame received on a Port whose
                              -- VLAN classification does not
                              -- include that Port in its Member
                              -- set."
    REFERENCE   "12.10.1.1.3 c)"
    ::= { ieee8021BridgeBasePortEntry 6 }

ieee8021BridgeBasePortTypeCapabilities OBJECT-TYPE
    SYNTAX      BITS {
                    customerVlanPort(0),
                    providerNetworkPort(1),
                    customerNetworkPort(2),
                    customerEdgePort(3),
                    customerBackbonePort(4),
                    virtualInstancePort(5),
                    dBridgePort(6),
                    remoteCustomerAccessPort(7),
                    stationFacingBridgePort (8),
                    uplinkAccessPort (9),
                    uplinkRelayPort(10)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Indicates the capabilities of this port.  The corresponding
         instance of ieee8021BridgeBasePortType can potentially take
         any of the values for which the corresponding bit in this
         object is 1.  The possible port types are as follows:

             customerVlanPort(0) - Indicates the port can be a C-TAG-
                 aware port of an enterprise VLAN-aware Bridge.

             providerNetworkPort(1) - Indicates the port can be an
                 S-TAG-aware port of a Provider Bridge or Backbone
                 Edge Bridge used for connections within a PBN or
                 PBBN.

             customerNetworkPort(2) - Indicates the port can be an
```

```
                S-TAG-aware port of a Provider Bridge or Backbone
                Edge Bridge used for connections to the exterior of
                a PBN or PBBN.

            customerEdgePort(3) - Indicates the port can be a C-TAG-
                aware port of a Provider Bridge used for connections
                to the exterior of a PBN or PBBN.

            customerBackbonePort(4) - Indicates the port can be a
                I-TAG-aware port of a Backbone Edge Bridge's
                B-component.

            virtualInstancePort(5) - Indicates the port can be a
                virtual S-TAG-aware port within a Backbone Edge
                Bridge's I-component that is responsible for
                handling S-tagged traffic for a specific backbone
                service instance.

            dBridgePort(6) - Indicates the port can be a VLAN-unaware
                member of an IEEE 802.1Q Bridge.

            remoteCustomerAccessPort(7) - Indicates the port can be an
                S-TAG-aware port of a Provider Bridge capable of providing
                Remote Customer Service Interfaces.

            stationFacingBridgePort(8) - Indicates the station-facing
                Bridge Port in a EVB Bridge.

            uplinkAccessPort(9)  -  Indicates the uplink access port
                in an EVB Bridge or EVB station.

            uplinkRelayPort (10)  - Indicates the uplink relay port
                in an EVB station."

    REFERENCE   "40.4, 12.13.1.1, 12.13.1.2, 12.16,
                 12.16.2.1, 12.26"
    ::= { ieee8021BridgeBasePortEntry 7 }

ieee8021BridgeBasePortType OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortType
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The port type.  This value MUST be persistent over power up
         restart/reboot."
    REFERENCE   "40.4, 12.13.1.1, 12.13.1.2, 12.16,
                 12.16.2.1, 12.26"
    ::= { ieee8021BridgeBasePortEntry 8 }

ieee8021BridgeBasePortExternal OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A boolean indicating whether the port is external.  A value of
        true(1) means the port is external.  A value of false(2) means
        the port is internal."
    REFERENCE   "12.4.2.1"
    ::= { ieee8021BridgeBasePortEntry 9 }

ieee8021BridgeBasePortAdminPointToPoint OBJECT-TYPE
    SYNTAX      INTEGER {
                    forceTrue(1),
                    forceFalse(2),
                    auto(3)
                }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
         "For a port running spanning tree, this object represents the
         administrative point-to-point status of the LAN segment
         attached to this port, using the enumeration values of
```

```
            IEEE Std 802.1AC.  A value of forceTrue(1) indicates
            that this port should always be treated as if it is
            connected to a point-to-point link.  A value of
            forceFalse(2) indicates that this port should be treated as
            having a shared media connection.  A value of auto(3)
            indicates that this port is considered to have a
            point-to-point link if it is an Aggregator and all of its
            members are aggregatable, or if the MAC entity
            is configured for full duplex operation, either through
            auto-negotiation or by management means.  Manipulating this
            object changes the underlying adminPointToPointMAC.

            For a VIP, the adminPointToPointMAC parameter controls
            the mechanism by which the Default Backbone Destination
            parameter for the VIP is determined.  For a backbone
            service instance that includes only 2 VIPs, the value
            may be set to forceTrue(1) which permits dynamic learning
            of the Default Backbone Destination parameter.  For a
            backbone service instance that includes more than 2 VIPs,
            the value MUST be set to ForceFalse(2) or auto(3).

            When this object is set to forceTrue(1) for a VIP, the
            Default Backbone Destination parameter is modified by
            the subsequent M_UNITDATA.indications as specified in
            6.10.1 (and described in 26.4.1).  Whenever the parameter
            is set to forceFalse(2) or auto(3), the value for the
            Default Backbone Destination parameter is set to the
            Backbone Service Instance Group Address for the VIP-ISID.

            The value of this object MUST be retained across
            reinitializations of the management system."
        REFERENCE   "IEEE Std 802.1AC, 6.10, 12.8.2.1.3 o), 12.8.2.3.2 f), 26.4.1"
        DEFVAL { forceFalse }
        ::= { ieee8021BridgeBasePortEntry 10 }

    ieee8021BridgeBasePortOperPointToPoint OBJECT-TYPE
        SYNTAX      TruthValue
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "For a port running spanning tree, this object represents
             the operational point-to-point status of the LAN segment
             attached to this port.  It indicates whether a port is
             considered to have a point-to-point connection.
             If adminPointToPointMAC is set to auto(2), then the value
             of operPointToPointMAC is determined in accordance with the
             specific procedures defined for the MAC entity concerned,
             as defined in IEEE Std 802.1AC.  The value is
             determined dynamically; that is, it is re-evaluated whenever
             the value of adminPointToPointMAC changes, and whenever
             the specific procedures defined for the MAC entity evaluate
             a change in its point-to-point status.

             For a VIP, this object simply reflects the value of the
             corresponding instance of ieee8021BridgeBasePortAdminPointToPoint.
             The value will be true(1) if that object is forceTrue(1), and
             the value will be false(2) if the value of that object is either
             forceFalse(2) or auto(3)."
        REFERENCE   "IEEE Std 802.1AC, 6.10, 12.8.2.1.3 p),
                     12.8.2.3.2 f), 26.4.1"
        ::= { ieee8021BridgeBasePortEntry 11 }

    ieee8021BridgeBasePortName OBJECT-TYPE
        SYNTAX      SnmpAdminString
        MAX-ACCESS  read-only
        STATUS      current
        DESCRIPTION
            "A text string of up to 32 characters, of
            locally determined significance."
        REFERENCE   "12.4.2.1"
        ::= { ieee8021BridgeBasePortEntry 12 }
```

```
-- ============================================================
-- The Generic Bridge ifIndex  to Port Table
-- ============================================================
ieee8021BridgeBaseIfToPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeBaseIfToPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains generic information about every
        ifIndex that is associated with this Bridge."
    REFERENCE   "17.2.2"
    ::= { ieee8021BridgeBase 5 }

ieee8021BridgeBaseIfToPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeBaseIfToPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current

    DESCRIPTION
        "A list of objects containing information for each ifIndex
         of the Bridge."
    INDEX  {   ifIndex  }
    ::= { ieee8021BridgeBaseIfToPortTable 1 }

Ieee8021BridgeBaseIfToPortEntry ::=
    SEQUENCE {
        ieee8021BridgeBaseIfIndexComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021BridgeBaseIfIndexPort
            IEEE8021BridgePortNumber
     }

 ieee8021BridgeBaseIfIndexComponentId     OBJECT-TYPE
     SYNTAX      IEEE8021PbbComponentIdentifier
     MAX-ACCESS  read-only
     STATUS      current
     DESCRIPTION
         "The component ID for this ifIndex."
     ::= { ieee8021BridgeBaseIfToPortEntry 1 }

 ieee8021BridgeBaseIfIndexPort            OBJECT-TYPE
     SYNTAX      IEEE8021BridgePortNumber
     MAX-ACCESS  read-only
     STATUS      current
     DESCRIPTION
         "The port for this ifIndex."
     ::= { ieee8021BridgeBaseIfToPortEntry 2 }


-- ============================================================
-- port number table section 12.5.1
-- ============================================================

ieee8021BridgePhyPortTable OBJECT-TYPE
   SYNTAX      SEQUENCE OF Ieee8021BridgePhyPortEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A table that contains ISS port number to Bridge
    componentID and port number mapping."
   REFERENCE   "12.5.1"
   ::= { ieee8021BridgeBase 6}

ieee8021BridgePhyPortEntry OBJECT-TYPE
   SYNTAX      Ieee8021BridgePhyPortEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A list of objects containing mapping for ISS port
    numbers to Bridge componentID and port numbers "
   INDEX  { ieee8021BridgePhyPort }
   ::= { ieee8021BridgePhyPortTable 1 }
```

```
   Ieee8021BridgePhyPortEntry ::=
   SEQUENCE {
         ieee8021BridgePhyPort
                  IEEE8021BridgePortNumber,
         ieee8021BridgePhyPortIfIndex
                  InterfaceIndexOrZero,
         ieee8021BridgePhyMacAddress
                  MacAddress,
         ieee8021BridgePhyPortToComponentId
                  IEEE8021PbbComponentIdentifierOrZero,
         ieee8021BridgePhyPortToInternalPort
                  IEEE8021BridgePortNumberOrZero
   }


ieee8021BridgePhyPort  OBJECT-TYPE
   SYNTAX       IEEE8021BridgePortNumber
   MAX-ACCESS   not-accessible
   STATUS       current
   DESCRIPTION
   "The ISS port."
   REFERENCE   "12.26"
   ::= { ieee8021BridgePhyPortEntry 1 }


ieee8021BridgePhyPortIfIndex  OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The value of the instance of the IfIndex object,
        defined in the IF-MIB, for the interface corresponding
        to this port, or the value 0 if the port has not been
        bound to an underlying frame source and sink.

        The underlying IfEntry indexed by this column MUST
        be persistent across reinitializations of the
        management system."
    ::= { ieee8021BridgePhyPortEntry 2 }

ieee8021BridgePhyMacAddress OBJECT-TYPE
   SYNTAX      MacAddress
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The MAC address"
   ::= { ieee8021BridgePhyPortEntry 3 }

ieee8021BridgePhyPortToComponentId OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifierOrZero
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "The component ID that this ISS port belongs to."

   ::= { ieee8021BridgePhyPortEntry 4 }


ieee8021BridgePhyPortToInternalPort   OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumberOrZero
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "The port number to which this ISS port maps to."

   ::= { ieee8021BridgePhyPortEntry 5 }

-- ============================================================
-- the ieee8021BridgeTp subtree
-- ============================================================
-- This is implemented by those Bridges that support the
-- transparent bridging mode.  A transparent Bridge will
```

```
-- implement this subtree.
-- ============================================================

-- ============================================================
--  Port Table for Transparent Bridges
-- ============================================================

ieee8021BridgeTpPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeTpPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about every port that
        is associated with this transparent Bridge."
    REFERENCE   "12.4.2"
    ::= { ieee8021BridgeTp 1 }

ieee8021BridgeTpPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeTpPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information for each port of
         a transparent Bridge."
    INDEX   { ieee8021BridgeTpPortComponentId,
              ieee8021BridgeTpPort }
    ::= { ieee8021BridgeTpPortTable 1 }

Ieee8021BridgeTpPortEntry ::=
    SEQUENCE {
        ieee8021BridgeTpPortComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021BridgeTpPort
            IEEE8021BridgePortNumber,
        ieee8021BridgeTpPortMaxInfo
            Integer32,
        ieee8021BridgeTpPortInFrames
            Counter64,
        ieee8021BridgeTpPortOutFrames
            Counter64,
        ieee8021BridgeTpPortInDiscards
            Counter64
    }

ieee8021BridgeTpPortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgeTpPortEntry 1 }

ieee8021BridgeTpPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The port number of the port for which this entry
        contains Transparent bridging management information."
    ::= { ieee8021BridgeTpPortEntry 2 }

ieee8021BridgeTpPortMaxInfo OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "bytes"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum size of the INFO (non-MAC) field that
        this port will receive or transmit."
```

```
    ::= { ieee8021BridgeTpPortEntry 3 }

ieee8021BridgeTpPortInFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of frames that have been received by this
        port from its segment.  Note that a frame received on the
        interface corresponding to this port is only counted by
        this object if and only if it is for a protocol being
        processed by the local bridging function, including
        Bridge management frames.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3 a)"
    ::= { ieee8021BridgeTpPortEntry 4 }

ieee8021BridgeTpPortOutFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of frames that have been transmitted by this
        port to its segment.  Note that a frame transmitted on
        the interface corresponding to this port is only counted
        by this object if and only if it is for a protocol being
        processed by the local bridging function, including
        Bridge management frames.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3 d)"
    ::= { ieee8021BridgeTpPortEntry 5 }

ieee8021BridgeTpPortInDiscards OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Count of received valid frames that were discarded
        (i.e., filtered) by the Forwarding Process.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3 c)"
    ::= { ieee8021BridgeTpPortEntry 6 }

-- ============================================================
-- the ieee8021BridgePriority subtree
-- ============================================================

-- ============================================================
-- Port Priority Table
-- ============================================================

ieee8021BridgePortPriorityTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortPriorityEntry
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "A table that contains information about every port that
        is associated with this transparent Bridge."
    ::= { ieee8021BridgePriority 1 }

ieee8021BridgePortPriorityEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of Default User Priorities for each port of a
        transparent Bridge.  This is indexed by
        ieee8021BridgeBasePortComponentId and
        ieee8021BridgeBasePort."
    AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021BridgePortPriorityTable 1 }

Ieee8021BridgePortPriorityEntry ::=
    SEQUENCE {
        ieee8021BridgePortDefaultUserPriority
            IEEE8021PriorityValue,
        ieee8021BridgePortNumTrafficClasses
            Integer32,
        ieee8021BridgePortPriorityCodePointSelection
            IEEE8021PriorityCodePoint,
        ieee8021BridgePortUseDEI
            TruthValue,
        ieee8021BridgePortRequireDropEncoding
            TruthValue,
        ieee8021BridgePortServiceAccessPrioritySelection
            TruthValue
    }

ieee8021BridgePortDefaultUserPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The default ingress priority for this port.  This
        only has effect on media, such as Ethernet, that do not
        support native priority.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021BridgePortPriorityEntry 1 }

ieee8021BridgePortNumTrafficClasses OBJECT-TYPE
    SYNTAX      Integer32 (1..8)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The number of egress traffic classes supported on this
        port.  This object may optionally be read-only.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021BridgePortPriorityEntry 2 }

ieee8021BridgePortPriorityCodePointSelection OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        " This object identifies the rows in the PCP encoding and
          decoding tables that are used to remark frames on this
          port if this remarking is enabled."
    REFERENCE   "12.6.2.6, 12.6.2.7"
    ::= { ieee8021BridgePortPriorityEntry 3 }

ieee8021BridgePortUseDEI OBJECT-TYPE
    SYNTAX      TruthValue
```

```
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "If the Use_DEI is set to true(1) for the Port then the
        drop_eligible parameter is encoded in the DEI of transmitted
        frames, and the drop_eligible parameter shall be true(1) for a
        received frame if the DEI is set in the VLAN tag or the Priority
        Code Point Decoding Table indicates drop_eligible True for
        the received PCP value. If the Use_DEI parameter is false(2),
        the DEI shall be transmitted as zero and ignored on receipt.
        The default value of the Use_DEI parameter is false(2)."
    REFERENCE   "12.6.2.11, 12.6.2.12"
    ::= { ieee8021BridgePortPriorityEntry 4 }

ieee8021BridgePortRequireDropEncoding OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "If a Bridge supports encoding or decoding of drop_eligible
        from the PCP field of a VLAN tag (6.9.3) on any of its Ports,
        then it shall implement a Boolean parameter Require Drop
        Encoding on each of its Ports with default value false(2). If
        Require Drop Encoding is True and the Bridge Port cannot
        encode particular priorities with drop_eligible, then frames
        queued with those priorities and drop_eligible true(1) shall
        be discarded and not transmitted."
    REFERENCE   "12.6.2.13, 12.6.2.14"
    DEFVAL { false }
    ::= { ieee8021BridgePortPriorityEntry 5 }

ieee8021BridgePortServiceAccessPrioritySelection OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "Indication of whether the Service Access Priority Selection
        function is supported on the Customer Bridge Port to request
        priority handling of the frame from a Port-based service
        interface."
    REFERENCE   "12.6.2.15, 12.6.2.16"
    ::= { ieee8021BridgePortPriorityEntry 6 }

-- ============================================================
-- Priority Regeneration Table
-- ============================================================

ieee8021BridgeUserPriorityRegenTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeUserPriorityRegenEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of Regenerated User Priorities for each received
        priority on each port of a Bridge.  The regenerated
        priority value may be used to index the Traffic
        Class Table for each input port.  This only has effect
        on media that support native priority.  The default
        values for Regenerated User Priorities are the same as
        the User Priorities."
    REFERENCE   "6.5.9, 6.9.4"
    ::= { ieee8021BridgePriority 2 }

ieee8021BridgeUserPriorityRegenEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeUserPriorityRegenEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A mapping of incoming priority to a regenerated
        priority."
    INDEX   { ieee8021BridgeBasePortComponentId,
              ieee8021BridgeBasePort,
              ieee8021BridgeUserPriority }
```

```
    ::= { ieee8021BridgeUserPriorityRegenTable 1 }

Ieee8021BridgeUserPriorityRegenEntry ::=
    SEQUENCE {
        ieee8021BridgeUserPriority
            IEEE8021PriorityValue,
        ieee8021BridgeRegenUserPriority
            IEEE8021PriorityValue
    }

ieee8021BridgeUserPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The priority for a frame received on this port."
    ::= { ieee8021BridgeUserPriorityRegenEntry 1 }

ieee8021BridgeRegenUserPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The regenerated priority that the incoming User
        Priority is mapped to for this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021BridgeUserPriorityRegenEntry 2 }

-- ============================================================
-- Traffic Class Table
-- ============================================================

ieee8021BridgeTrafficClassTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeTrafficClassEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table mapping evaluated priority to Traffic
        Class, for forwarding by the Bridge.  Traffic class is a
        number in the range (0..(ieee8021BridgePortNumTrafficClasses-1))."
    REFERENCE   "8.6.6, Table 8-5"
    ::= { ieee8021BridgePriority 3 }

ieee8021BridgeTrafficClassEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeTrafficClassEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Priority to Traffic Class mapping."
    INDEX   { ieee8021BridgeBasePortComponentId,
              ieee8021BridgeBasePort,
              ieee8021BridgeTrafficClassPriority }
    ::= { ieee8021BridgeTrafficClassTable 1 }

Ieee8021BridgeTrafficClassEntry ::=
    SEQUENCE {
        ieee8021BridgeTrafficClassPriority
            IEEE8021PriorityValue,
        ieee8021BridgeTrafficClass
            Integer32
    }

ieee8021BridgeTrafficClassPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Priority value determined for the received frame.
        This value is equivalent to the priority indicated in
        the tagged frame received, or one of the evaluated
```

```
        priorities, determined according to the media-type.
        For untagged frames received from Ethernet media, this
        value is equal to the ieee8021BridgePortDefaultUserPriority value
        for the ingress port.

        For untagged frames received from non-Ethernet media,
        this value is equal to the ieee8021BridgeRegenUserPriority value
        for the ingress port and media-specific priority."
    ::= { ieee8021BridgeTrafficClassEntry 1 }

ieee8021BridgeTrafficClass OBJECT-TYPE
    SYNTAX      Integer32 (0..7)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The Traffic Class the received frame is mapped to.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021BridgeTrafficClassEntry 2 }

-- ============================================================
-- Outbound Access Priority Table
-- ============================================================

ieee8021BridgePortOutboundAccessPriorityTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortOutboundAccessPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table mapping regenerated priority to Outbound
        Access Priority.  This is a fixed mapping for all port
        types."
    REFERENCE   "IEEE Std 802.1AC"
    ::= { ieee8021BridgePriority 4 }

ieee8021BridgePortOutboundAccessPriorityEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortOutboundAccessPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Regenerated priority to Outbound Access Priority
        mapping."
    INDEX   { ieee8021BridgeBasePortComponentId,
              ieee8021BridgeBasePort,
              ieee8021BridgeRegenUserPriority }
    ::= { ieee8021BridgePortOutboundAccessPriorityTable 1 }

Ieee8021BridgePortOutboundAccessPriorityEntry ::=
    SEQUENCE {
        ieee8021BridgePortOutboundAccessPriority
            IEEE8021PriorityValue
    }

ieee8021BridgePortOutboundAccessPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Outbound Access Priority the received frame is
        mapped to."
    ::= { ieee8021BridgePortOutboundAccessPriorityEntry 1 }

-- ============================================================
-- ieee8021BridgePortDecodingTable:
-- ============================================================

ieee8021BridgePortDecodingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortDecodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "A table that contains information about Priority Code
        Point Decoding Table for a Port of a provider Bridge.
        Alternative values for each table are specified as rows
        in Table 6-3 (6.9.3), with each alternative labeled by
        the number of distinct priorities that can be communicated,
        and the number of these for which drop precedence can
        be communicated.  All writable objects in this table MUST
        be persistent over power up restart/reboot."
    ::= { ieee8021BridgePriority 5 }

ieee8021BridgePortDecodingEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortDecodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Priority Code Point Decoding
        information for a port of a provider Bridge."
    INDEX { ieee8021BridgePortDecodingComponentId,
            ieee8021BridgePortDecodingPortNum,
            ieee8021BridgePortDecodingPriorityCodePointRow,
            ieee8021BridgePortDecodingPriorityCodePoint }
    ::= { ieee8021BridgePortDecodingTable 1 }

Ieee8021BridgePortDecodingEntry ::= SEQUENCE {
      ieee8021BridgePortDecodingComponentId
          IEEE8021PbbComponentIdentifier,
      ieee8021BridgePortDecodingPortNum
          IEEE8021BridgePortNumber,
      ieee8021BridgePortDecodingPriorityCodePointRow
          IEEE8021PriorityCodePoint,
      ieee8021BridgePortDecodingPriorityCodePoint
          Integer32,
      ieee8021BridgePortDecodingPriority
          IEEE8021PriorityValue,
      ieee8021BridgePortDecodingDropEligible
          TruthValue
}

ieee8021BridgePortDecodingComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgePortDecodingEntry 1 }

ieee8021BridgePortDecodingPortNum OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A unique identifier of a port controlled by this VLAN
        bridging entity."
    ::= { ieee8021BridgePortDecodingEntry 2 }

ieee8021BridgePortDecodingPriorityCodePointRow OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-2 (6.9.3) indicating the PCP."
    ::= { ieee8021BridgePortDecodingEntry 3 }

ieee8021BridgePortDecodingPriorityCodePoint OBJECT-TYPE
    SYNTAX      Integer32 (0..7)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific PCP value in Table 6-2 (6.9.3)."
```

```
    ::= { ieee8021BridgePortDecodingEntry 4 }

ieee8021BridgePortDecodingPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The specific priority value in Table 6-2 (6.9.3)."
    REFERENCE   "6.9.3, 12.6.2.8, 12.6.2.9"
    ::= { ieee8021BridgePortDecodingEntry 5 }

ieee8021BridgePortDecodingDropEligible OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The drop eligibility value in Table 6-3 (6.9.3)."
    REFERENCE   "6.9.3, 12.6.2.8, 12.6.2.9"
    ::= { ieee8021BridgePortDecodingEntry 6 }

-- ============================================================
-- ieee8021BridgePortEncodingTable:
-- ============================================================

ieee8021BridgePortEncodingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortEncodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about Priority Code
        Point Decoding Table for a Port of a provider Bridge.
        Alternative values for each table are specified as rows
        in Table 6-2 (6.9.3), with each alternative labeled by
        the number of distinct priorities that can be communicated,
        and the number of these for which drop precedence can be
        communicated.  All writable objects in this table MUST be
        persistent over power up restart/reboot."
    ::= { ieee8021BridgePriority 6 }

ieee8021BridgePortEncodingEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortEncodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Priority Code Point Encoding
        information for a port of a provider Bridge."
    INDEX { ieee8021BridgePortEncodingComponentId,
            ieee8021BridgePortEncodingPortNum,
            ieee8021BridgePortEncodingPriorityCodePointRow,
            ieee8021BridgePortEncodingPriorityCodePoint,
            ieee8021BridgePortEncodingDropEligible }
    ::= { ieee8021BridgePortEncodingTable 1 }

Ieee8021BridgePortEncodingEntry ::= SEQUENCE {
      ieee8021BridgePortEncodingComponentId
          IEEE8021PbbComponentIdentifier,
      ieee8021BridgePortEncodingPortNum
          IEEE8021BridgePortNumber,
      ieee8021BridgePortEncodingPriorityCodePointRow
          IEEE8021PriorityCodePoint,
      ieee8021BridgePortEncodingPriorityCodePoint
          Integer32,
      ieee8021BridgePortEncodingDropEligible
          TruthValue,
      ieee8021BridgePortEncodingPriority
          IEEE8021PriorityValue
}

ieee8021BridgePortEncodingComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgePortEncodingEntry 1 }

ieee8021BridgePortEncodingPortNum OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A unique identifier of a port controlled by this VLAN bridging
        entity."
    ::= { ieee8021BridgePortEncodingEntry 2 }

ieee8021BridgePortEncodingPriorityCodePointRow OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-2 (6.9.3) indicating the PCP row.
         (i.e., 8P0D, 7P1D, 6P2D, 5P3D)"
    ::= { ieee8021BridgePortEncodingEntry 3 }

ieee8021BridgePortEncodingPriorityCodePoint OBJECT-TYPE
    SYNTAX      Integer32 (0..7)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-2 (6.9.3) indicating the PCP.
         (i.e., 0,1,2,3,4,5,6,7)."
    ::= { ieee8021BridgePortEncodingEntry 4 }

ieee8021BridgePortEncodingDropEligible OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-2 (6.9.3) indicating the drop
         eligibility.  A value of true(1) means eligible for drop."
    ::= { ieee8021BridgePortEncodingEntry 5 }

ieee8021BridgePortEncodingPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The encoding priority in Table 6-2 (6.9.3)."
    REFERENCE   "6.9.3, 12.6.2.9, 12.6.2.10"
    ::= { ieee8021BridgePortEncodingEntry 6 }

-- ================================================================
-- ieee8021BridgeServiceAccessPriorityTable:
-- ================================================================

ieee8021BridgeServiceAccessPriorityTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeServiceAccessPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about the  Service Access
        Priority Selection function for a provider Bridge.  The use
        of this table enables a mechanism for a Customer Bridge
        attached to a Provider Bridged Network to request priority
        handling of frames.  All writable objects in this table MUST
        be persistent over power up restart/reboot."
    ::= { ieee8021BridgePriority 7 }

ieee8021BridgeServiceAccessPriorityEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeServiceAccessPriorityEntry
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "A list of objects containing information about the Service
         Access Priority Selection function for a provider Bridge."
    INDEX { ieee8021BridgeServiceAccessPriorityComponentId,
            ieee8021BridgeServiceAccessPriorityPortNum,
            ieee8021BridgeServiceAccessPriorityReceived }
    ::= { ieee8021BridgeServiceAccessPriorityTable 1 }

Ieee8021BridgeServiceAccessPriorityEntry ::= SEQUENCE {
      ieee8021BridgeServiceAccessPriorityComponentId
          IEEE8021PbbComponentIdentifier,
      ieee8021BridgeServiceAccessPriorityPortNum
          IEEE8021BridgePortNumber,
      ieee8021BridgeServiceAccessPriorityReceived
          IEEE8021PriorityValue,
      ieee8021BridgeServiceAccessPriorityValue
          IEEE8021PriorityValue
}

ieee8021BridgeServiceAccessPriorityComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021BridgeServiceAccessPriorityEntry 1 }

ieee8021BridgeServiceAccessPriorityPortNum OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A unique identifier of a port controlled by this VLAN bridging
        entity."
    ::= { ieee8021BridgeServiceAccessPriorityEntry 2 }

ieee8021BridgeServiceAccessPriorityReceived OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The default received priority value in Table 6-4.
         (i.e., 0,1,2,3,4,5,6,7)"
    ::= { ieee8021BridgeServiceAccessPriorityEntry 3 }

ieee8021BridgeServiceAccessPriorityValue OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The regenerated priority value in Table 6-4.
         (i.e., 0,1,2,3,4,5,6,7)"
    REFERENCE   "12.6.2.17, 112.6.2.18"
    ::= { ieee8021BridgeServiceAccessPriorityEntry 4 }

-- ================================================================
-- the ieee8021BridgeMrp subtree
-- ================================================================

-- ================================================================
-- The MRP Port Table
-- ================================================================

ieee8021BridgePortMrpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortMrpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "A table of MRP control information about every Bridge
        port.  This is indexed by ieee8021BridgeBasePortComponentId
        and ieee8021BridgeBasePort."
    ::= { ieee8021BridgeMrp 1 }

ieee8021BridgePortMrpEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortMrpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "MRP control information for a Bridge Port."
    AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021BridgePortMrpTable 1 }

Ieee8021BridgePortMrpEntry ::=
    SEQUENCE {
        ieee8021BridgePortMrpJoinTime
            TimeInterval,
        ieee8021BridgePortMrpLeaveTime
            TimeInterval,
        ieee8021BridgePortMrpLeaveAllTime
            TimeInterval
    }

ieee8021BridgePortMrpJoinTime OBJECT-TYPE
    SYNTAX      TimeInterval
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The MRP Join time, in centiseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { 20 }
    ::= { ieee8021BridgePortMrpEntry 1 }

ieee8021BridgePortMrpLeaveTime OBJECT-TYPE
    SYNTAX      TimeInterval
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The MRP Leave time, in centiseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { 60 }
    ::= { ieee8021BridgePortMrpEntry 2 }

ieee8021BridgePortMrpLeaveAllTime OBJECT-TYPE
    SYNTAX      TimeInterval
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The MRP LeaveAll time, in centiseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { 1000 }
    ::= { ieee8021BridgePortMrpEntry 3 }

-- ============================================================
-- The MMRP Port Configuration and Status Table
-- ============================================================

ieee8021BridgePortMmrpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgePortMmrpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "A table of MMRP control and status information about
        every Bridge Port.  Augments the ieee8021BridgeBasePortTable."
    ::= { ieee8021BridgeMmrp 1 }

ieee8021BridgePortMmrpEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgePortMmrpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "MMRP control and status information for a Bridge Port."
    AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021BridgePortMmrpTable 1 }

Ieee8021BridgePortMmrpEntry ::=
    SEQUENCE {
        ieee8021BridgePortMmrpEnabledStatus
            TruthValue,
        ieee8021BridgePortMmrpFailedRegistrations
            Counter64,
        ieee8021BridgePortMmrpLastPduOrigin
            MacAddress,
        ieee8021BridgePortRestrictedGroupRegistration
            TruthValue
    }

ieee8021BridgePortMmrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative state of MMRP operation on this port.  The
        value true(1) indicates that MMRP is enabled on this port
        in all VLANs as long as ieee8021BridgeMmrpEnabledStatus is
        also true(1).  A value of false(2) indicates that MMRP is
        disabled on this port in all VLANs: any MMRP packets received
        will be silently discarded, and no MMRP registrations will be
        propagated from other ports.  Setting this to a value of
        true(1) will be stored by the agent but will only take
        effect on the MMRP protocol operation if
        ieee8021BridgeMmrpEnabledStatus
        also indicates the value true(1).  This object affects
        all MMRP Applicant and Registrar state machines on this
        port.  A transition from false(2) to true(1) will
        cause a reset of all MMRP state machines on this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { true }
    ::= { ieee8021BridgePortMmrpEntry 1 }

ieee8021BridgePortMmrpFailedRegistrations OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "failed MMRP registrations"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The total number of failed MMRP registrations, for any
        reason, in all VLANs, on this port."
    ::= { ieee8021BridgePortMmrpEntry 2 }

ieee8021BridgePortMmrpLastPduOrigin OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Source MAC Address of the last MMRP message
        received on this port."
    ::= { ieee8021BridgePortMmrpEntry 3 }

ieee8021BridgePortRestrictedGroupRegistration OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
```

```
    STATUS      current
    DESCRIPTION
        "The state of Restricted Group Registration on this port.
         If the value of this control is true(1), then creation
         of a new dynamic entry is permitted only if there is a
         Static Filtering Entry for the VLAN concerned, in which
         the Registrar Administrative Control value is Normal
         Registration.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "11.2.3.2.3, 12.11.1.3"
    DEFVAL      { false }
    ::= { ieee8021BridgePortMmrpEntry 4 }

-- ============================================================
-- I-LAN Interface configuration table
-- ============================================================

ieee8021BridgeILanIfTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeILanIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
         "This table is a sparse augmentation of ifTable and controls
          the creation of the I-LAN Interface.  An I-LAN Interface is
          used to create internal connections between Bridge Ports in a
          802.1 device.  An I-LAN Interfaces can be directly associated
          with a set of Bridge Ports.  An I-LAN Interfaces can also be
          used as a stacking interface to relate other interfaces before
          association to Bridge Ports.

          For example, an I-LAN interface can be created to link traffic
          between a PIP and a CBP.  In this case a CBP is created on the
          B-Component and the CBP's related IfEntry is stacked upon the
          IfEntry of the I-LAN.  The PIP is stacked upon the I-LAN using
          the IfStackTable.  Finally, a VIP is created on the I-Component
          and is associated with the PIP, thus completing the path from
          the I-Component's MAC relay to the CBP on the B-Component.

          Entries in this table MUST be persistent over power up
          restart/reboot."
    REFERENCE   "17.3.2.2"
    ::= { ieee8021BridgeInternalLan 1 }

ieee8021BridgeILanIfEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeILanIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Each entry consists of a Row Status to control creation."
    INDEX       { ifIndex }
    ::= { ieee8021BridgeILanIfTable 1 }

Ieee8021BridgeILanIfEntry ::=
    SEQUENCE {
        ieee8021BridgeILanIfRowStatus
            RowStatus
    }

ieee8021BridgeILanIfRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object is used to create and delete entries in this
         table and the Interface table."
    ::= { ieee8021BridgeILanIfEntry 1 }

-- ============================================================
-- Dynamic Port Creation table
-- ============================================================
```

```
ieee8021BridgeDot1dPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeDot1dPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
         "This table provides the capability to dynamically create and
          delete MAC Bridge Ports.  Each entry in this table MUST
          have a corresponding entry in the ieee8021BridgeBasePortTable.

          Entries in this table MUST be persistent over power up
          restart/reboot."
    REFERENCE   "17.5.3"
    ::= { ieee8021BridgeDot1d 1 }

ieee8021BridgeDot1dPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeDot1dPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Each entry consists of a Row Status to control creation."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort }
    ::= { ieee8021BridgeDot1dPortTable 1 }

Ieee8021BridgeDot1dPortEntry ::=
    SEQUENCE {
        ieee8021BridgeDot1dPortRowStatus
            RowStatus
    }

ieee8021BridgeDot1dPortRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object is used to create and delete entries in this
         table and the ieee8021BridgeBasePortTable."
    ::= { ieee8021BridgeDot1dPortEntry 1 }


-- ============================================================
-- IEEE 802.1Q Bridge MIB - Conformance Information
-- ============================================================

ieee8021BridgeCompliances
    OBJECT IDENTIFIER ::= { ieee8021BridgeConformance 1 }
ieee8021BridgeGroups
    OBJECT IDENTIFIER ::= { ieee8021BridgeConformance 2 }

-- ============================================================
-- units of conformance
-- ============================================================

-- ============================================================
-- the ieee8021BridgeBase group
-- ============================================================

ieee8021BridgeBaseBridgeGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBaseBridgeAddress,
        ieee8021BridgeBaseNumPorts,
        ieee8021BridgeBaseComponentType
    }
    STATUS      current
    DESCRIPTION
        "Bridge level information for this device."
    ::= { ieee8021BridgeGroups 1 }

ieee8021BridgeBasePortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBasePortIfIndex,
```

```
        ieee8021BridgeBasePortDelayExceededDiscards,
        ieee8021BridgeBasePortMtuExceededDiscards,
        ieee8021BridgeBasePortType,
        ieee8021BridgeBasePortExternal,
        ieee8021BridgeBasePortAdminPointToPoint,
        ieee8021BridgeBasePortOperPointToPoint,
        ieee8021BridgeBasePortName
    }
    STATUS      current
    DESCRIPTION
        "Information for each port on this device."
    ::= { ieee8021BridgeGroups 2 }

ieee8021BridgeCapGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBaseDeviceCapabilities,
        ieee8021BridgeBasePortCapabilities,
        ieee8021BridgeBasePortTypeCapabilities
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects indicating the optional
        capabilities of the device."
    ::= { ieee8021BridgeGroups 3 }

ieee8021BridgeDeviceMmrpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBaseMmrpEnabledStatus
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing device-level control
        for the Multicast Filtering extended Bridge services."
    ::= { ieee8021BridgeGroups 4 }

-- ============================================================
-- the ieee8021BridgeTp group
-- ============================================================

ieee8021BridgeTpPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeTpPortMaxInfo,
        ieee8021BridgeTpPortInFrames,
        ieee8021BridgeTpPortOutFrames,
        ieee8021BridgeTpPortInDiscards
    }
    STATUS      current
    DESCRIPTION
        "Dynamic Filtering Database information for each port of
        the Bridge."
    ::= { ieee8021BridgeGroups 6 }

-- ============================================================
-- Bridge Priority groups
-- ============================================================

ieee8021BridgeDevicePriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBaseTrafficClassesEnabled
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing device-level control
        for the Priority services."
    ::= { ieee8021BridgeGroups 7 }

ieee8021BridgeDefaultPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortDefaultUserPriority,
        ieee8021BridgePortPriorityCodePointSelection,
        ieee8021BridgePortUseDEI,
        ieee8021BridgePortRequireDropEncoding,
```

```
        ieee8021BridgePortServiceAccessPrioritySelection
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects defining the priority
        applicable to each port for media that do not support
        native priority."
    ::= { ieee8021BridgeGroups 8 }

ieee8021BridgeRegenPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeRegenUserPriority
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects defining the User Priorities
        applicable to each port for media that support native
        priority."
    ::= { ieee8021BridgeGroups 9 }

ieee8021BridgePriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortNumTrafficClasses,
        ieee8021BridgeTrafficClass
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects defining the traffic classes
        within a Bridge for each evaluated priority."
    ::= { ieee8021BridgeGroups 10 }

ieee8021BridgeAccessPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortOutboundAccessPriority
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects defining the media-dependent
        outbound access level for each priority."
    ::= { ieee8021BridgeGroups 11 }

ieee8021BridgePortMrpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortMrpJoinTime,
        ieee8021BridgePortMrpLeaveTime,
        ieee8021BridgePortMrpLeaveAllTime
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing port level control
        and status information for MRP operation."
    ::= { ieee8021BridgeGroups 12 }

ieee8021BridgePortMmrpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortMmrpEnabledStatus,
        ieee8021BridgePortMmrpFailedRegistrations,
        ieee8021BridgePortMmrpLastPduOrigin,
        ieee8021BridgePortRestrictedGroupRegistration
    }
    STATUS      deprecated
    DESCRIPTION
        "A collection of objects providing port level control
        and status information for MMRP operation."
    ::= { ieee8021BridgeGroups 13 }

ieee8021BridgePortDecodingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortDecodingPriority,
        ieee8021BridgePortDecodingDropEligible
    }
    STATUS      current
```

```
    DESCRIPTION
        "A collection of objects providing statistics counters for
        decoding priority and drop eligibility for Bridge Ports."
    ::= { ieee8021BridgeGroups 14 }

ieee8021BridgePortEncodingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgePortEncodingPriority
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing statistics counters for
        encoding priority and drop eligibility for Bridge Ports."
    ::= { ieee8021BridgeGroups 15 }

ieee8021BridgeServiceAccessPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeServiceAccessPriorityValue
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing statistics
        counters for service access priority."
    ::= { ieee8021BridgeGroups 16 }

-- ============================================================
-- Internal LAN group
-- ============================================================

ieee8021BridgeInternalLANGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeILanIfRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing control of internal
        LAN configuration."
    ::= { ieee8021BridgeGroups 17 }

-- ============================================================
-- Bridge Creation Group
-- ============================================================

ieee8021BridgeCreatableBaseBridgeGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeBaseRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Controls the management system directed creation of
         Bridge Components."
    ::= { ieee8021BridgeGroups 18 }

-- ============================================================
-- Dot1d Dynamic Port Creation group
-- ============================================================

ieee8021BridgeDot1dDynamicPortCreationGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeDot1dPortRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing dynamic creation and
        deletion of MAC Bridge Ports."
    ::= { ieee8021BridgeGroups 19 }


-- ============================================================
-- Bridge interface index to port table group
-- ============================================================
```

```
ieee8021BridgeBaseIfToPortGroup OBJECT-GROUP
    OBJECTS {
    ieee8021BridgeBaseIfIndexComponentId,
    ieee8021BridgeBaseIfIndexPort

    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing a map between interface
        index and component ID and Bridge Ports."
    ::= { ieee8021BridgeGroups 20 }



-- ============================================================
-- Bridge interface index to component group
-- ============================================================
ieee8021BridgePhyPortGroup   OBJECT-GROUP
   OBJECTS {
   ieee8021BridgePhyPortIfIndex,
   ieee8021BridgePhyMacAddress,
   ieee8021BridgePhyPortToComponentId,
   ieee8021BridgePhyPortToInternalPort
   }
   STATUS      current
   DESCRIPTION
   "The collection of objects used to represent a ISS port management objects."
   ::= { ieee8021BridgeGroups 21 }


-- ============================================================
-- compliance statements
-- ============================================================

ieee8021BridgeCompliance1 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        VLAN-unaware bridging services as defined in
        IEEE Std 802.1Q.  Such devices support
        path cost values of 32-bits, and Bridge and port priority
        values are more restricted than in IEEE Std 802.1D-1995.

        Full support for the IEEE 802.1Q management objects requires
        implementation of the objects listed in the systemGroup
        from the SNMPv2-MIB [RFC3418], as well as the objects
        listed in the ifGeneralInformationGroup from the
        IF-MIB [RFC2863]."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE IF-MIB -- The interfaces MIB, RFC 2863
        MANDATORY-GROUPS {
            ifGeneralInformationGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeBaseBridgeGroup,
            ieee8021BridgeBasePortGroup
        }

    GROUP ieee8021BridgeCreatableBaseBridgeGroup
    DESCRIPTION
        "Implementation of this group is mandatory for
         Bridges that allow management systems to add and delete
         Bridge components.  Provider Backbone Edge Bridges would
         typically fall in this category."
```

```
    GROUP   ieee8021BridgeTpPortGroup
    DESCRIPTION
        "Implementation of this group is mandatory for
        Bridges that support the transparent bridging
        mode.  A transparent Bridge will implement
        this group."

    GROUP   ieee8021BridgeInternalLANGroup
    DESCRIPTION
        "Implementation of this group is optional.  It can be supported
        to provide control over the relationship between interfaces and
        Bridge Ports where such relationships are more complex than a
        simple 1-to-1 mapping."

    GROUP   ieee8021BridgeDot1dDynamicPortCreationGroup
    DESCRIPTION
        "Implementation of this group is optional.  It can be supported
        to provide the ability to dynamically create and delete
        MAC Bridge Ports."

    GROUP  ieee8021BridgeBaseIfToPortGroup
    DESCRIPTION
         "A collection of objects providing a map between interface
        index and component ID and Bridge Ports."
    GROUP   ieee8021BridgePhyPortGroup
    DESCRIPTION
         "A collection of objects providing a map between port numbers
         to the component id, interface index."

    ::= { ieee8021BridgeCompliances 3 }


ieee8021BridgeCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        VLAN-unaware bridging services as defined in
        IEEE Std 802.1Q.  Such devices support
        path cost values of 32-bits, and Bridge and port priority
        values are more restricted than in IEEE Std 802.1D-1995.

        Full support for the IEEE 802.1Q management objects requires
        implementation of the objects listed in the systemGroup
        from the SNMPv2-MIB [RFC3418], as well as the objects
        listed in the ifGeneralInformationGroup from the
        IF-MIB [RFC2863]."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE IF-MIB -- The interfaces MIB, RFC 2863
        MANDATORY-GROUPS {
            ifGeneralInformationGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeBaseBridgeGroup,
            ieee8021BridgeBasePortGroup
        }

    GROUP ieee8021BridgeCreatableBaseBridgeGroup
    DESCRIPTION
        "Implementation of this group is mandatory for
         Bridges that allow management systems to add and delete
         Bridge components.  Provider Backbone Edge Bridges would
         typically fall in this category."

    GROUP   ieee8021BridgeTpPortGroup
    DESCRIPTION
```

```
        "Implementation of this group is mandatory for
        Bridges that support the transparent bridging
        mode.  A transparent Bridge will implement
        this group."

    GROUP   ieee8021BridgeInternalLANGroup
    DESCRIPTION
        "Implementation of this group is optional.  It can be supported
        to provide control over the relationship between interfaces and
        Bridge Ports where such relationships are more complex than a
        simple 1-to-1 mapping."

    GROUP   ieee8021BridgeDot1dDynamicPortCreationGroup
    DESCRIPTION
        "Implementation of this group is optional.  It can be supported
        to provide the ability to dynamically create and delete
        Bridge Ports."

    ::= { ieee8021BridgeCompliances 1 }

ieee8021BridgePriorityAndMulticastFilteringCompliance MODULE-COMPLIANCE
    STATUS  deprecated
    DESCRIPTION
        "The compliance statement for device support of Priority
        and Multicast Filtering extended bridging services."

    MODULE
        MANDATORY-GROUPS { ieee8021BridgeCapGroup }

        GROUP       ieee8021BridgeDeviceMmrpGroup
        DESCRIPTION
            "This group is mandatory for devices supporting the MMRP
            application, defined by IEEE 802.1Q Extended Filtering
            Services."

        GROUP       ieee8021BridgeDevicePriorityGroup
        DESCRIPTION
            "This group is mandatory only for devices supporting
            the priority forwarding operations defined by IEEE
            802.1Q."

        GROUP       ieee8021BridgeDefaultPriorityGroup
        DESCRIPTION
            "This group is mandatory only for devices supporting
            the priority forwarding operations defined by the
            extended Bridge services with media types, such as
            Ethernet, that do not support native priority."

        GROUP       ieee8021BridgeRegenPriorityGroup
        DESCRIPTION
            "This group is mandatory only for devices supporting
            the priority forwarding operations defined by IEEE Std
            802.1Q and that have interface media types that support
            native priority."

        GROUP       ieee8021BridgePriorityGroup
        DESCRIPTION
            "This group is mandatory only for devices supporting
            the priority forwarding operations defined by
            IEEE Std 802.1Q."

        GROUP       ieee8021BridgeAccessPriorityGroup
        DESCRIPTION
            "This group is optional and is relevant only for devices
            supporting the priority forwarding operations defined by
            IEEE Std 802.1Q and that have interface media types that
            support native Access Priority."

        GROUP       ieee8021BridgePortMrpGroup
        DESCRIPTION
            "This group is mandatory for devices supporting any
            of the MRP applications: e.g., MMRP, defined by the
```

```
            extended filtering services; or MVRP.
            Refer to the Q-BRIDGE-MIB for
            conformance statements for MVRP."

        GROUP       ieee8021BridgePortMmrpGroup
        DESCRIPTION
            "This group is mandatory for devices supporting the
            MMRP application, as defined by IEEE 802.1Q Extended
            Filtering Services."

        GROUP       ieee8021BridgePortDecodingGroup
        DESCRIPTION
            "This group is optional and supports Priority Code Point
            Decoding Table for a Port of a provider Bridge."

        GROUP       ieee8021BridgePortEncodingGroup
        DESCRIPTION
            "This group is optional and supports Priority Code Point
            Encoding Table for a Port of a provider Bridge."

        GROUP       ieee8021BridgeServiceAccessPriorityGroup
        DESCRIPTION
            "This group is optional and supports Priority Code Point
            Encoding Table for a Port of a provider Bridge."

        OBJECT      ieee8021BridgePortNumTrafficClasses
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required."

        OBJECT      ieee8021BridgeTrafficClass
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required."

        OBJECT      ieee8021BridgeRegenUserPriority
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required."

       ::= { ieee8021BridgeCompliances 2 }

END
```

17.7.3 Definitions for the IEEE8021-SPANNING-TREE-MIB module

```
IEEE8021-SPANNING-TREE-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q spanning tree devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, NOTIFICATION-TYPE,
    Counter64, Integer32, TimeTicks
        FROM SNMPv2-SMI
    MODULE-COMPLIANCE, OBJECT-GROUP, NOTIFICATION-GROUP
        FROM SNMPv2-CONF
    TruthValue
        FROM SNMPv2-TC
    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber
        FROM IEEE8021-TC-MIB
    BridgeId, Timeout
        FROM BRIDGE-MIB
    ;

ieee8021SpanningTreeMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Spanning-Tree MIB module for managing devices that
        support IEEE 802.1Q.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            ieee8021SpanningTreeRstpTxHoldCount default value
            changed to 6 to match Table 13-5."

    REVISION     "201103240000Z" -- March 24, 2011
    DESCRIPTION
          "Minor edits to contact information and addition of
          fragile Bridge as part of 2011 revision of
          IEEE Std 802.1Q."
```

```
    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
         "Initial revision, derived from RFC 4188."
    ::= { ieee802dot1mibs 3 }

-- ================================================================
-- subtrees in the Spanning-Tree MIB
-- ================================================================

ieee8021SpanningTreeNotifications
    OBJECT IDENTIFIER ::= { ieee8021SpanningTreeMib 0 }

ieee8021SpanningTreeObjects
    OBJECT IDENTIFIER ::= { ieee8021SpanningTreeMib 1 }

ieee8021SpanningTreeConformance
    OBJECT IDENTIFIER ::= { ieee8021SpanningTreeMib 2 }


-- ================================================================
-- the ieee8021SpanningTreeTable
-- ================================================================
ieee8021SpanningTreeTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SpanningTreeEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information related to STP about
        every Bridge."
    REFERENCE   "12.8.1"
    ::= { ieee8021SpanningTreeObjects 1 }

ieee8021SpanningTreeEntry OBJECT-TYPE
    SYNTAX      Ieee8021SpanningTreeEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information for each Bridge
         about the Spanning Tree Protocol for that Bridge."
    INDEX  { ieee8021SpanningTreeComponentId }
    ::= { ieee8021SpanningTreeTable 1 }

Ieee8021SpanningTreeEntry ::=
    SEQUENCE {
        ieee8021SpanningTreeComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021SpanningTreeProtocolSpecification
            INTEGER,
        ieee8021SpanningTreePriority
            Integer32,
        ieee8021SpanningTreeTimeSinceTopologyChange
            TimeTicks,
        ieee8021SpanningTreeTopChanges
            Counter64,
        ieee8021SpanningTreeDesignatedRoot
            BridgeId,
        ieee8021SpanningTreeRootCost
            Integer32,
        ieee8021SpanningTreeRootPort
            IEEE8021BridgePortNumber,
        ieee8021SpanningTreeMaxAge
            Timeout,
        ieee8021SpanningTreeHelloTime
            Timeout,
        ieee8021SpanningTreeHoldTime
            Integer32,
        ieee8021SpanningTreeForwardDelay
            Timeout,
        ieee8021SpanningTreeBridgeMaxAge
            Timeout,
        ieee8021SpanningTreeBridgeHelloTime
            Timeout,
```

```
        ieee8021SpanningTreeBridgeForwardDelay
            Timeout,
        ieee8021SpanningTreeVersion
            INTEGER,
        ieee8021SpanningTreeRstpTxHoldCount
            Integer32
    }

ieee8021SpanningTreeComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021SpanningTreeEntry 1 }

ieee8021SpanningTreeProtocolSpecification OBJECT-TYPE
    SYNTAX      INTEGER {
                    unknown(1),
                    decLb100(2),
                    ieee8021d(3),
                    ieee8021q(4)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "An indication of what version of the Spanning Tree Protocol is
        being run.  The value 'decLb100(2)' indicates the DEC LANbridge
        100 Spanning Tree protocol.  IEEE 802.1D implementations will
        return 'ieee8021d(3)'.  New enumerated values may be added in
        the future to the definition of this object to reflect future
        versions of the IEEE Spanning Tree protocol."
    ::= { ieee8021SpanningTreeEntry 2 }

ieee8021SpanningTreePriority OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value of the write-able portion of the Bridge ID
        (i.e., the first two octets of the (8 octet long) Bridge
        ID).  The other (last) 6 octets of the Bridge ID are
        given by the value of ieee8021BridgeBaseBridgeAddress.
        On Bridges supporting IEEE 802.1t or IEEE 802.1w,
        permissible values are 0-61440, in steps of 4096.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 a)"
    ::= { ieee8021SpanningTreeEntry 3 }

ieee8021SpanningTreeTimeSinceTopologyChange OBJECT-TYPE
    SYNTAX      TimeTicks
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The time (in hundredths of a second) since the
        last time a topology change was detected by the
        Bridge entity.
        For RSTP, this reports the time since the tcWhile
        timer for any port on this Bridge was nonzero."
    REFERENCE   "12.8.1.1.3 b)"
    ::= { ieee8021SpanningTreeEntry 4 }

ieee8021SpanningTreeTopChanges OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "topology changes"
    MAX-ACCESS  read-only
```

```
    STATUS      current
    DESCRIPTION
        "The total number of topology changes detected by
        this Bridge since the management entity was last
        reset or initialized.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system."
    REFERENCE   "12.8.1.1.3 c)"
    ::= { ieee8021SpanningTreeEntry 5 }

ieee8021SpanningTreeDesignatedRoot OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Bridge identifier of the root of the spanning
        tree, as determined by the Spanning Tree Protocol,
        as executed by this node.  This value is used as
        the Root Identifier parameter in all Configuration
        Bridge PDUs originated by this node."
    REFERENCE   "12.8.1.1.3 e)"
    ::= { ieee8021SpanningTreeEntry 6 }

ieee8021SpanningTreeRootCost OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The cost of the path to the root as seen from
        this Bridge."
    REFERENCE   "12.8.1.1.3 f)"
    ::= { ieee8021SpanningTreeEntry 7 }

ieee8021SpanningTreeRootPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The port number of the port that offers the lowest
        cost path from this Bridge to the root Bridge."
    REFERENCE   "12.8.1.1.3 g)"
    ::= { ieee8021SpanningTreeEntry 8 }

ieee8021SpanningTreeMaxAge OBJECT-TYPE
    SYNTAX      Timeout
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum age of Spanning Tree Protocol information
        learned from the network on any port before it is
        discarded, in units of hundredths of a second.  This is
        the actual value that this Bridge is currently using."
    REFERENCE   "12.8.1.1.3 h)"
    ::= { ieee8021SpanningTreeEntry 9 }

ieee8021SpanningTreeHelloTime OBJECT-TYPE
    SYNTAX      Timeout
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The amount of time between the transmission of
        Configuration Bridge PDUs by this node on any port when
        it is the root of the spanning tree, or trying to become
        so, in units of hundredths of a second.  This is the
        actual value that this Bridge is currently using."
    REFERENCE   "12.8.1.1.3 k)"
    ::= { ieee8021SpanningTreeEntry 10 }

ieee8021SpanningTreeHoldTime OBJECT-TYPE
```

```
    SYNTAX      Integer32
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This time value determines the interval length
        during which no more than two Configuration Bridge
        PDUs shall be transmitted by this node, in units
        of hundredths of a second."
    REFERENCE   "12.8.1.1.3 m)"
    ::= { ieee8021SpanningTreeEntry 11 }

ieee8021SpanningTreeForwardDelay OBJECT-TYPE
    SYNTAX      Timeout
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This time value, measured in units of hundredths of a
        second, controls how fast a port changes its spanning
        state when moving towards the Forwarding state.  The
        value determines how long the port stays in each of the
        Listening and Learning states, which precede the
        Forwarding state.  This value is also used when a
        topology change has been detected and is underway, to
        age all dynamic entries in the Filtering Database.
        [Note that this value is the one that this Bridge is
        currently using, in contrast to
        ieee8021SpanningTreeBridgeForwardDelay, which is the
        value that this Bridge and all others would start using
        if/when this Bridge were to become the root.]"
    REFERENCE   "12.8.1.1.3 i)"
    ::= { ieee8021SpanningTreeEntry 12 }

ieee8021SpanningTreeBridgeMaxAge OBJECT-TYPE
    SYNTAX      Timeout (600..4000)
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value that all Bridges use for MaxAge when this
        Bridge is acting as the root.  Note that IEEE Std 802.1D-1998
        specifies that the range for this parameter is related
        to the value of ieee8021SpanningTreeBridgeHelloTime.  The
        granularity of this timer is specified by IEEE Std 802.1D-1998
        to be 1 second.  An agent may return an SNMP badValue error
        (or its equivalent if another protocol is used) if a set
        is attempted to a value that is not a whole number of
        seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 j)"
    ::= { ieee8021SpanningTreeEntry 13 }

ieee8021SpanningTreeBridgeHelloTime OBJECT-TYPE
    SYNTAX      Timeout (100..1000)
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value that all Bridges use for HelloTime when this
        Bridge is acting as the root.  The granularity of this
        timer is specified by IEEE Std 802.1D-1998 to be 1 second.
        An agent may return an SNMP badValue error (or its equivalent
        if another protocol is used) if a set is attempted to a
        value that is not a whole number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 k)"
    ::= { ieee8021SpanningTreeEntry 14 }
```

```
ieee8021SpanningTreeBridgeForwardDelay OBJECT-TYPE
    SYNTAX      Timeout (400..3000)
    UNITS       "centi-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value that all Bridges use for ForwardDelay when
        this Bridge is acting as the root.  Note that IEEE Std
        802.1D-1998 specifies that the range for this parameter
        is related to the value of ieee8021SpanningTreeBridgeMaxAge.
        The granularity of this timer is specified by IEEE Std 802.1D-1998
        to be 1 second.  An agent may return an SNMP badValue error
        (or its equivalent if another protocol is used) if a set is
        attempted to a value that is not a whole number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 l)"
    ::= { ieee8021SpanningTreeEntry 15 }

ieee8021SpanningTreeVersion OBJECT-TYPE
    SYNTAX      INTEGER {
                    stp(0),
                    rstp(2),
                    mstp(3)
                }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The version of Spanning Tree Protocol the Bridge is
        currently running.  The values are directly from
        the IEEE standard.  New values may be defined as future
        versions of the protocol become available.

        The value 'stp(0)' indicates the Bridge is running the
        Spanning Tree Protocol specified in IEEE Std 802.1D-1998.

        The value 'rstp(2)' indicates the Bridge is running RSTP
        specified in IEEE 802.1Q.

        The value 'mstp(3)' indicates the Bridge is running
        MSTP specified in Clause 13 of IEEE Std 802.1Q.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 n)"
    ::= { ieee8021SpanningTreeEntry 16 }

ieee8021SpanningTreeRstpTxHoldCount OBJECT-TYPE
    SYNTAX      Integer32 (1..10)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value used by the Port Transmit state machine to limit
         the maximum transmission rate.  This is used by Bridges
         that are running RSTP.

         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "12.8.1.1.3 m), 13.26.12"
    DEFVAL      { 6 }
    ::= { ieee8021SpanningTreeEntry 17 }

-- ============================================================
-- The Spanning Tree Port Table
-- ============================================================

ieee8021SpanningTreePortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SpanningTreePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
        "A table that contains port-specific information
        for the Spanning Tree Protocol."
    REFERENCE   "12.8.2"
    ::= { ieee8021SpanningTreeObjects 2 }

ieee8021SpanningTreePortEntry OBJECT-TYPE
    SYNTAX      Ieee8021SpanningTreePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information maintained by
         every port about the Spanning Tree Protocol state for
         that port."
    INDEX   { ieee8021SpanningTreePortComponentId,
              ieee8021SpanningTreePort }
    ::= { ieee8021SpanningTreePortTable 1 }

Ieee8021SpanningTreePortEntry ::=
    SEQUENCE {
        ieee8021SpanningTreePortComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021SpanningTreePort
            IEEE8021BridgePortNumber,
        ieee8021SpanningTreePortPriority
            Integer32,
        ieee8021SpanningTreePortState
            INTEGER,
        ieee8021SpanningTreePortEnabled
            TruthValue,
        ieee8021SpanningTreePortPathCost
            Integer32,
        ieee8021SpanningTreePortDesignatedRoot
            BridgeId,
        ieee8021SpanningTreePortDesignatedCost
            Integer32,
        ieee8021SpanningTreePortDesignatedBridge
            BridgeId,
        ieee8021SpanningTreePortDesignatedPort
            OCTET STRING,
        ieee8021SpanningTreePortForwardTransitions
            Counter64,
        ieee8021SpanningTreeRstpPortProtocolMigration
            TruthValue,
        ieee8021SpanningTreeRstpPortAdminEdgePort
            TruthValue,
        ieee8021SpanningTreeRstpPortOperEdgePort
            TruthValue,
        ieee8021SpanningTreeRstpPortAdminPathCost
            Integer32
    }

ieee8021SpanningTreePortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021SpanningTreePortEntry 1 }

ieee8021SpanningTreePort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The port number of the port for which this entry
        contains Spanning Tree Protocol management information."
    REFERENCE   "12.8.2.1.2 a)"
    ::= { ieee8021SpanningTreePortEntry 2 }
```

```
ieee8021SpanningTreePortPriority OBJECT-TYPE
    SYNTAX      Integer32 (0..255)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value of the priority field that is contained in
        the first (in network byte order) octet of the (2 octet
        long) Port ID.  The other octet of the Port ID is given
        by the value of ieee8021SpanningTreePort.
        On Bridges supporting IEEE 802.1t or IEEE 802.1w,
        permissible values are 0-240, in steps of 16.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 c)"
    ::= { ieee8021SpanningTreePortEntry 3 }

ieee8021SpanningTreePortState OBJECT-TYPE
    SYNTAX      INTEGER {
                    disabled(1),
                    blocking(2),
                    listening(3),
                    learning(4),
                    forwarding(5),
                    broken(6)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The port's current state, as defined by application of
        the Spanning Tree Protocol.  This state controls what
        action a port takes on reception of a frame.  If the
        Bridge has detected a port that is malfunctioning, it
        will place that port into the broken(6) state.  For
        ports that are disabled (see
        ieee8021SpanningTreePortEnabled), this object will have a
        value of disabled(1).  The values disabled, blocking,
        listening, and broken correspond to the Clause 12 port
        state of 'Discarding'. The value learning corresponds to
        the Clause 12 port state of 'Learning'. The value forwarding
        corresponds to the Clause 12 port state of 'Forwarding'."

    REFERENCE   "12.8.2.1.3 b)"
    ::= { ieee8021SpanningTreePortEntry 4 }

ieee8021SpanningTreePortEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The enabled/disabled status of the port.  A value of true(1)
        means the spanning-tree protocol is enabled for this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 m)"
    ::= { ieee8021SpanningTreePortEntry 5 }

ieee8021SpanningTreePortPathCost OBJECT-TYPE
    SYNTAX      Integer32 (1..200000000)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The contribution of this port to the path cost of
        paths towards the spanning tree root that include
        this port.  Table 13-4 recommends defaults and ranges
        for Port Path Cost values, in inverse proportion
        to the speed of the attached LAN. If this object is used
        to set the Path Cost it is possible to restore the
        default setting using the
        ieee8021SpanningTreeRstpPortAdminPathCost object.
```

```
        Table 13-4 recommends defaults and ranges for Port
        Path Cost values, in inverse proportion to the speed of the
        attached LAN. If this object is used to set the Path
     Cost it is possible to restore the default
        setting using the ieee8021MstpPortAdminPathCost object.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 d)"
        ::= { ieee8021SpanningTreePortEntry 6 }

ieee8021SpanningTreePortDesignatedRoot OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The unique Bridge Identifier of the Bridge
        recorded as the Root in the Configuration BPDUs
        transmitted by the Designated Bridge for the
        segment to which the port is attached."
    REFERENCE   "12.8.2.1.3 e)"
    ::= { ieee8021SpanningTreePortEntry 7 }

ieee8021SpanningTreePortDesignatedCost OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The path cost of the Designated Port of the segment
        connected to this port.  This value is compared to the
        Root Path Cost field in received Bridge PDUs."
    REFERENCE   "12.8.2.1.3 f)"
    ::= { ieee8021SpanningTreePortEntry 8 }

ieee8021SpanningTreePortDesignatedBridge OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Bridge Identifier of the Bridge that this
        port considers to be the Designated Bridge for
        this port's segment."
    REFERENCE   "12.8.2.1.3 g)"
    ::= { ieee8021SpanningTreePortEntry 9 }

ieee8021SpanningTreePortDesignatedPort OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (2))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Port Identifier of the port on the Designated
        Bridge for this port's segment."
    REFERENCE   "12.8.2.1.3 h)"
    ::= { ieee8021SpanningTreePortEntry 10 }

ieee8021SpanningTreePortForwardTransitions OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "forwarding transitions"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of times this port has transitioned
        from the Learning state to the Forwarding state.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    ::= { ieee8021SpanningTreePortEntry 11 }
```

```
ieee8021SpanningTreeRstpPortProtocolMigration OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "When operating in RSTP (version 2) mode, writing true(1)
         to this object forces this port to transmit RSTP BPDUs.
         Any other operation on this object has no effect and
         it always returns false(2) when read."
    REFERENCE   "12.8.2.5"
    ::= { ieee8021SpanningTreePortEntry 12 }

ieee8021SpanningTreeRstpPortAdminEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the Edge Port parameter.
         A value of true(1) indicates that this port should be
         assumed as an edge-port, and a value of false(2) indicates
         that this port should be assumed as a non-edge-port.

         Setting this object will also cause the corresponding
         instance of ieee8021SpanningTreeRstpPortOperEdgePort to
         change to the same value.  Note that even when this
         object's value is true(1), the value of the corresponding
         instance of ieee8021SpanningTreeRstpPortOperEdgePort can
         be false(2) if a BPDU has been received.

         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 k)"
    ::= { ieee8021SpanningTreePortEntry 13 }

ieee8021SpanningTreeRstpPortOperEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the Edge Port parameter.  The
         object is initialized to the value of the corresponding
         instance of ieee8021SpanningTreeRstpPortAdminEdgePort.
         When the corresponding instance of
         ieee8021SpanningTreeRstpPortAdminEdgePort is set, this
         object will be changed as well.  This object will also be
         changed to false(2) on reception of a BPDU."
    REFERENCE   "12.8.2.1.3 l)"
    ::= { ieee8021SpanningTreePortEntry 14 }

ieee8021SpanningTreeRstpPortAdminPathCost OBJECT-TYPE
    SYNTAX      Integer32 (0..200000000)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administratively assigned value for the contribution
         of this port to the path cost of paths toward the spanning
         tree root.

         Writing a value of '0' assigns the automatically calculated
         default Path Cost value to the port.  If the default Path
         Cost is being used, this object returns '0' when read.

         This complements the object ieee8021SpanningTreePortPathCost,
         which returns the operational value of the path cost.

         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 d)"
    ::= { ieee8021SpanningTreePortEntry 15 }
```

```
-- ============================================================
-- The Spanning Tree Port Extension Table
-- ============================================================

ieee8021SpanningTreePortExtensionTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SpanningTreePortExtensionEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains port-specific information
        for the Spanning Tree Protocol."
    REFERENCE   "12.8.2"
    ::= { ieee8021SpanningTreeObjects 3 }

ieee8021SpanningTreePortExtensionEntry OBJECT-TYPE
    SYNTAX      Ieee8021SpanningTreePortExtensionEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of additional objects containing information
         maintained by every port about the Spanning Tree
         Protocol state for that port."
   AUGMENTS { ieee8021SpanningTreePortEntry }
    ::= { ieee8021SpanningTreePortExtensionTable 1 }

Ieee8021SpanningTreePortExtensionEntry ::=
    SEQUENCE {

        ieee8021SpanningTreeRstpPortAutoEdgePort
            TruthValue,
        ieee8021SpanningTreeRstpPortAutoIsolatePort
            TruthValue,
        ieee8021SpanningTreeRstpPortIsolatePort
            TruthValue
    }

ieee8021SpanningTreeRstpPortAutoEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the Auto Edge Port parameter.
         A value of true(1) indicates if the Bridge detection state
         machine (BDM, 13.33) is to detect other Bridges
         attached to the LAN, and set
         ieee8021SpanningTreeRstpPortOperEdgePort automatically.
         The default value is true(1)

    This is optional and provided only by implementations
    that support the automatic identification of edge ports.

         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 m)"
    ::= { ieee8021SpanningTreePortExtensionEntry 1 }

ieee8021SpanningTreeRstpPortAutoIsolatePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the Isolate Port parameter.

    A value of true(1) indicates a Designated Port will
    transition to discarding if both
    ieee8021SpanningTreeRstpPortAdminEdgePort and
    ieee8021SpanningTreeRstpPortAutoEdgePort are FALSE and
    the other Bridge presumed to be attached to the same
    point-to-point LAN does not transmit periodic BPDUs.

    This is optional and provided only by implementations
    that support the automatic identification of edge ports."
```

```
    REFERENCE   "12.8.2.1.3 n)"
    ::= { ieee8021SpanningTreePortExtensionEntry 2 }

ieee8021SpanningTreeRstpPortIsolatePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the Isolate Port parameter.

    A value of true(1), Set by the Bridge detection state
         machine (BDM, 13.33), indicates when the Spanning Tree
         Protocol Entity of a neighboring Bridge has apparently
    failed ."
    REFERENCE   "12.8.2.1.3 o)"
    ::= { ieee8021SpanningTreePortExtensionEntry 3 }



-- ================================================================
-- Notifications for use by Bridges
-- ================================================================
-- Notifications for the Spanning Tree Protocol
-- ================================================================

ieee8021SpanningTreeNewRoot NOTIFICATION-TYPE
    -- OBJECTS     { }
    STATUS      current
    DESCRIPTION
        "The ieee8021SpanningTreeNewRoot notification indicates that
        the sending agent has become the new root of the Spanning Tree;
        the notification is sent by a Bridge soon after its election
        as the new root, e.g., upon expiration of the Topology Change
        Timer, immediately subsequent to its election."
    ::= { ieee8021SpanningTreeNotifications 1 }

ieee8021SpanningTreeTopologyChange NOTIFICATION-TYPE
    -- OBJECTS     { }
    STATUS      current
    DESCRIPTION
        "A ieee8021SpanningTreeTopologyChange notification is sent
        by a Bridge when any of its configured ports transitions from
        the Learning state to the Forwarding state, or from the
        Forwarding state to the Blocking state.  The notification
        is not sent if a ieee8021SpanningTreeNewRoot notification
        is sent for the same transition."
    ::= { ieee8021SpanningTreeNotifications 2 }

-- ================================================================
-- IEEE 802.1D MIB - Conformance Information
-- ================================================================

ieee8021SpanningTreeCompliances
    OBJECT IDENTIFIER ::= { ieee8021SpanningTreeConformance 1 }
ieee8021SpanningTreeGroups
    OBJECT IDENTIFIER ::= { ieee8021SpanningTreeConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021SpanningTree group
-- ================================================================

ieee8021SpanningTreeGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SpanningTreeProtocolSpecification,
        ieee8021SpanningTreePriority,
        ieee8021SpanningTreeTimeSinceTopologyChange,
        ieee8021SpanningTreeTopChanges,
        ieee8021SpanningTreeDesignatedRoot,
```

```
        ieee8021SpanningTreeRootCost,
        ieee8021SpanningTreeRootPort,
        ieee8021SpanningTreeMaxAge,
        ieee8021SpanningTreeHelloTime,
        ieee8021SpanningTreeHoldTime,
        ieee8021SpanningTreeForwardDelay,
        ieee8021SpanningTreeBridgeMaxAge,
        ieee8021SpanningTreeBridgeHelloTime,
        ieee8021SpanningTreeBridgeForwardDelay,
        ieee8021SpanningTreeVersion
    }
    STATUS      current
    DESCRIPTION
        "Bridge level Spanning Tree data for this device."
    ::= { ieee8021SpanningTreeGroups 1 }

ieee8021SpanningTreeRstpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SpanningTreeRstpTxHoldCount
    }
    STATUS      current
    DESCRIPTION
        "Bridge level Rstp data for this device."
    ::= { ieee8021SpanningTreeGroups 2 }

ieee8021SpanningTreePortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SpanningTreePortPriority,
        ieee8021SpanningTreePortState,
        ieee8021SpanningTreePortEnabled,
        ieee8021SpanningTreePortPathCost,
        ieee8021SpanningTreePortDesignatedRoot,
        ieee8021SpanningTreePortDesignatedCost,
        ieee8021SpanningTreePortDesignatedBridge,
        ieee8021SpanningTreePortDesignatedPort,
        ieee8021SpanningTreePortForwardTransitions
    }
    STATUS      current
    DESCRIPTION
        "Spanning Tree data for each port on this device."
    ::= { ieee8021SpanningTreeGroups 3 }

ieee8021SpanningTreeRstpPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SpanningTreeRstpPortProtocolMigration,
        ieee8021SpanningTreeRstpPortAdminEdgePort,
        ieee8021SpanningTreeRstpPortOperEdgePort,
        ieee8021SpanningTreeRstpPortAdminPathCost
    }
    STATUS      current
    DESCRIPTION
        "Rstp data for each port on this device."
    ::= { ieee8021SpanningTreeGroups 4 }

ieee8021SpanningTreeRstpFragileGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SpanningTreeRstpPortAutoEdgePort,
        ieee8021SpanningTreeRstpPortAutoIsolatePort,
        ieee8021SpanningTreeRstpPortIsolatePort
    }
    STATUS      current
    DESCRIPTION
        "Rstp fragile Bridge data for each port
         on this device."
    ::= { ieee8021SpanningTreeGroups 6 }

-- ============================================================
-- The Notification Group
-- ============================================================

ieee8021SpanningTreeNotificationGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
```

```
        ieee8021SpanningTreeNewRoot,
        ieee8021SpanningTreeTopologyChange
    }
    STATUS      current
    DESCRIPTION
        "Group of notifications."
    ::= { ieee8021SpanningTreeGroups 5 }

-- ============================================================
-- compliance statements
-- ============================================================

ieee8021SpanningTreeCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting the
        Spanning Tree Protocol."

    MODULE
        MANDATORY-GROUPS {
            ieee8021SpanningTreeGroup,
            ieee8021SpanningTreePortGroup
        }

    OBJECT ieee8021SpanningTreePriority
    SYNTAX Integer32 (0|4096|8192|12288|16384|20480|24576
                     |28672|32768|36864|40960|45056|49152
                     |53248|57344|61440)
    DESCRIPTION
        "The possible values defined by IEEE 802.1t."

    OBJECT ieee8021SpanningTreePortPriority
    SYNTAX Integer32 (0|16|32|48|64|80|96|112|128
                     |144|160|176|192|208|224|240)
    DESCRIPTION
        "The possible values defined by IEEE 802.1t."

    GROUP ieee8021SpanningTreeNotificationGroup
    DESCRIPTION
        "Implementation of this group is optional."

    ::= { ieee8021SpanningTreeCompliances 1 }

ieee8021SpanningTreeRstpCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting RSTP."

    MODULE
        MANDATORY-GROUPS {
            ieee8021SpanningTreeGroup,
            ieee8021SpanningTreeRstpGroup,
            ieee8021SpanningTreePortGroup,
            ieee8021SpanningTreeRstpPortGroup
        }

    OBJECT ieee8021SpanningTreePriority
    SYNTAX Integer32 (0|4096|8192|12288|16384|20480|24576
                     |28672|32768|36864|40960|45056|49152
                     |53248|57344|61440)
    DESCRIPTION
        "The possible values defined by IEEE 802.1t."

    OBJECT ieee8021SpanningTreePortPriority
    SYNTAX Integer32 (0|16|32|48|64|80|96|112|128
                     |144|160|176|192|208|224|240)
    DESCRIPTION
        "The possible values defined by IEEE 802.1t."

    GROUP ieee8021SpanningTreeNotificationGroup
    DESCRIPTION
        "Implementation of this group is optional."
```

```
    GROUP ieee8021SpanningTreeRstpFragileGroup
    DESCRIPTION
        "Implementation of this group is optional."

    ::= { ieee8021SpanningTreeCompliances 2 }

END
```

17.7.4 Definitions for the IEEE8021-Q-BRIDGE-MIB module

```
IEEE8021-Q-BRIDGE-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Gauge32,
    Counter64, Unsigned32, TimeTicks, Integer32
        FROM SNMPv2-SMI
    RowStatus, StorageType, TruthValue, MacAddress
        FROM SNMPv2-TC
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee8021BridgeBasePortComponentId, ieee8021BridgeBasePort,
    ieee8021BridgeBasePortEntry
        FROM IEEE8021-BRIDGE-MIB
    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber, IEEE8021BridgePortNumberOrZero,
    IEEE8021VlanIndex, IEEE8021VlanIndexOrWildcard,
    IEEE8021PortAcceptableFrameTypes
        FROM IEEE8021-TC-MIB
    PortList, VlanId
        FROM Q-BRIDGE-MIB
    TimeFilter
        FROM RMON2-MIB;

ieee8021QBridgeMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The VLAN Bridge MIB module for managing Virtual Bridged
        Local Area Networks, as defined by IEEE Std 802.1Q.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            VLAN Learning Constraints objects deprecated
            and removed from compliances.
```

```
            ieee8021QbridgeEgressVidXTable properly reindexed;
            old version deprecated and new version named
            ieee8021QbridgeEgressVidXV2Table."

    REVISION     "201112120000Z" -- December 12, 2011
    DESCRIPTION
         "Addition of the VID Translation MIB Subtree for IEEE Std 802.1aq"

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
         "Initial version, derived from RFC 4363."
    ::= { ieee802dot1mibs 4 }

ieee8021QBridgeMibObjects OBJECT IDENTIFIER ::= { ieee8021QBridgeMib 1 }

-- ============================================================
-- subtrees in the Q-BRIDGE MIB
-- ============================================================

ieee8021QBridgeBase      OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 1 }
ieee8021QBridgeTp        OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 2 }
ieee8021QBridgeStatic    OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 3 }
ieee8021QBridgeVlan      OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 4 }
ieee8021QBridgeProtocol  OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 5 }
ieee8021QBridgeVIDX      OBJECT IDENTIFIER ::= { ieee8021QBridgeMibObjects 6 }

-- ============================================================
-- ieee8021QBridgeBase subtree
-- ============================================================

-- ============================================================
-- ieee8021QBridgeTable - Table of VLAN Bridges
-- ============================================================

ieee8021QBridgeTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains generic information about every
        VLAN Bridge."
    REFERENCE   "12.4"
    ::= { ieee8021QBridgeBase 1 }

ieee8021QBridgeEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information for each VLAN Bridge."
    INDEX   { ieee8021QBridgeComponentId }
    ::= { ieee8021QBridgeTable 1 }

Ieee8021QBridgeEntry ::=
    SEQUENCE {
        ieee8021QBridgeComponentId        IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeVlanVersionNumber  INTEGER,
        ieee8021QBridgeMaxVlanId          VlanId,
        ieee8021QBridgeMaxSupportedVlans  Unsigned32,
        ieee8021QBridgeNumVlans           Gauge32,
        ieee8021QBridgeMvrpEnabledStatus  TruthValue
    }

ieee8021QBridgeComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeEntry 1 }

ieee8021QBridgeVlanVersionNumber OBJECT-TYPE
    SYNTAX      INTEGER {
                    version1(1),
                    version2(2)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The version number of IEEE 802.1Q that this device
        supports.  Reported as 1 by VLAN Bridges that support
        only SST operation, and reported as 2 by VLAN Bridges
        that support MST operation."
    REFERENCE   "12.10.1.1"
    ::= { ieee8021QBridgeEntry 2 }

ieee8021QBridgeMaxVlanId OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum IEEE 802.1Q VLAN-ID that this device
        supports."
    REFERENCE   "9.6"
    ::= { ieee8021QBridgeEntry 3 }

ieee8021QBridgeMaxSupportedVlans OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "vlans"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum number of IEEE 802.1Q VLANs that this
        device supports."
    REFERENCE   "12.10.1.1"
    ::= { ieee8021QBridgeEntry 4 }

ieee8021QBridgeNumVlans OBJECT-TYPE
    SYNTAX      Gauge32
    UNITS       "vlans"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The current number of IEEE 802.1Q VLANs that are
        configured in this device."
    REFERENCE   "12.7.1.1"
    ::= { ieee8021QBridgeEntry 5 }

ieee8021QBridgeMvrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative status requested by management for
        MVRP.  The value true(1) indicates that MVRP should
        be enabled on this device, on all ports for which it has
        not been specifically disabled.  When false(2), MVRP
        is disabled on all ports, and all MVRP packets will be
        forwarded transparently.  This object affects all MVRP
        Applicant and Registrar state machines.  A transition
        from false(2) to true(1) will cause a reset of all
        MVRP state machines on all ports.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { true }
```

```
    ::= { ieee8021QBridgeEntry 6 }

-- ============================================================
-- ieee8021QBridgeCVlanPortTable - Table of C-VLAN ports
-- ============================================================

ieee8021QBridgeCVlanPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeCVlanPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table provides the capability to create and delete
        customer VLAN ports.  Entries in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "12.16.1.1.3 h4), 12.16.2.1,
                 12.13.1.1, 12.13.1.2, 12.15"
    ::= { ieee8021QBridgeBase 2 }

ieee8021QBridgeCVlanPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeCVlanPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information for each VLAN Bridge."
    INDEX   { ieee8021QBridgeCVlanPortComponentId,
              ieee8021QBridgeCVlanPortNumber }
    ::= { ieee8021QBridgeCVlanPortTable 1 }

Ieee8021QBridgeCVlanPortEntry ::=
    SEQUENCE {
        ieee8021QBridgeCVlanPortComponentId  IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeCVlanPortNumber       IEEE8021BridgePortNumber,
        ieee8021QBridgeCVlanPortRowStatus    RowStatus
    }

ieee8021QBridgeCVlanPortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component containing the customer VLAN port represented
        by this row."
    ::= { ieee8021QBridgeCVlanPortEntry 1 }

ieee8021QBridgeCVlanPortNumber OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The customer VLAN port number represented by this row."
    ::= { ieee8021QBridgeCVlanPortEntry 2 }

ieee8021QBridgeCVlanPortRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of the entry, and is used to create
        and delete entries in this table.  Each entry in this table that
        is valid will have a corresponding entry in the
        ieee8021BridgeBasePortTable whose value for
        ieee8021BridgeBasePortType is customerVlanPort(2).  The
        corresponding value of ieee8021BridgeBasePortIfIndex must
        be set at the time the value of this object transitions
        to valid(1).

        Entries in this table must be persistent across
        reinitializations of the management system."
    ::= { ieee8021QBridgeCVlanPortEntry 3 }

-- ============================================================
-- the ieee8021QBridgeTp subtree
```

```
-- ============================================================

-- ============================================================
-- the current Filtering Database Table
-- ============================================================

ieee8021QBridgeFdbTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains configuration and control
        information for each Filtering Database currently
        operating on this device.  Entries in this table appear
        automatically when VLANs are assigned FDB IDs in the
        ieee8021QBridgeVlanCurrentTable."
    REFERENCE   "12.7.1"
    ::= { ieee8021QBridgeTp 1 }

ieee8021QBridgeFdbEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information about a specific Filtering Database."
    INDEX   { ieee8021QBridgeFdbComponentId,
              ieee8021QBridgeFdbId }
    ::= { ieee8021QBridgeFdbTable 1 }

Ieee8021QBridgeFdbEntry ::=
    SEQUENCE {
        ieee8021QBridgeFdbComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeFdbId
            Unsigned32,
        ieee8021QBridgeFdbDynamicCount
            Gauge32,
        ieee8021QBridgeFdbLearnedEntryDiscards
            Counter64,
        ieee8021QBridgeFdbAgingTime
            Integer32
    }

ieee8021QBridgeFdbComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeFdbEntry 1 }

ieee8021QBridgeFdbId OBJECT-TYPE
    SYNTAX       Unsigned32 (0..4294967295)
    MAX-ACCESS   not-accessible
    STATUS       current
    DESCRIPTION
        "The identity of this Filtering Database."
    ::= { ieee8021QBridgeFdbEntry 2 }

ieee8021QBridgeFdbDynamicCount OBJECT-TYPE
    SYNTAX       Gauge32
    UNITS        "database entries"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The current number of dynamic entries in this
        Filtering Database."
    REFERENCE   "12.7.1.1.3"
    ::= { ieee8021QBridgeFdbEntry 3 }
```

```
ieee8021QBridgeFdbLearnedEntryDiscards OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "database entries"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The total number of Filtering Database entries that
        have been or would have been learned, but have been
        discarded due to a lack of storage space in the
        Filtering Database.  If this counter is increasing, it
        indicates that the Filtering Database is regularly
        becoming full (a condition that has unpleasant
        performance effects on the subnetwork).  If this counter
        has a significant value but is not presently increasing,
        it indicates that the problem has been occurring but is
        not persistent.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system."
    ::= { ieee8021QBridgeFdbEntry 4 }

ieee8021QBridgeFdbAgingTime OBJECT-TYPE
    SYNTAX      Integer32 (10..1000000)
    UNITS       "seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The timeout period in seconds for aging out
        dynamically-learned forwarding information.
        IEEE Std 802.1D-1998 recommends a default of 300 seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.7.1.2"
    ::= { ieee8021QBridgeFdbEntry 5 }

-- ============================================================
-- Multiple Filtering Databases for IEEE 802.1Q Transparent Devices
-- This table is an alternative to the ieee8021BridgeTpFdbTable,
-- previously defined for IEEE 802.1D devices that only support a
-- single Filtering Database.
-- ============================================================

ieee8021QBridgeTpFdbTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeTpFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about unicast entries
        for which the device has forwarding and/or filtering
        information.  This information is used by the
        transparent bridging function in determining how to
        propagate a received frame."
    REFERENCE   "12.7.1"
    ::= { ieee8021QBridgeTp 2 }

ieee8021QBridgeTpFdbEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeTpFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information about a specific unicast MAC address for
        which the device has some forwarding and/or filtering
        information."
    INDEX   { ieee8021QBridgeFdbComponentId,
              ieee8021QBridgeFdbId,
              ieee8021QBridgeTpFdbAddress }
    ::= { ieee8021QBridgeTpFdbTable 1 }

Ieee8021QBridgeTpFdbEntry ::=
    SEQUENCE {
```

```
        ieee8021QBridgeTpFdbAddress
            MacAddress,
        ieee8021QBridgeTpFdbPort
            IEEE8021BridgePortNumberOrZero,
        ieee8021QBridgeTpFdbStatus
            INTEGER
    }

ieee8021QBridgeTpFdbAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A unicast MAC address for which the device has
        forwarding and/or filtering information."
    ::= { ieee8021QBridgeTpFdbEntry 1 }

ieee8021QBridgeTpFdbPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Either the value '0', or the port number of the port on
        which a frame having a source address equal to the value
        of the corresponding instance of ieee8021QBridgeTpFdbAddress has
        been seen.  A value of '0' indicates that the port
        number has not been learned but that the device does
        have some forwarding/filtering information about this
        address (e.g., in the ieee8021QBridgeStaticUnicastTable).
        Implementors are encouraged to assign the port value to
        this object whenever it is learned, even for addresses
        for which the corresponding value of ieee8021QBridgeTpFdbStatus is
        not learned(3)."
    ::= { ieee8021QBridgeTpFdbEntry 2 }

ieee8021QBridgeTpFdbStatus OBJECT-TYPE
    SYNTAX      INTEGER {
                    other(1),
                    invalid(2),
                    learned(3),
                    self(4),
                    mgmt(5)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The status of this entry.  The meanings of the values
        are:
            other(1) - none of the following.  This may include
                the case where some other MIB object (not the
                corresponding instance of ieee8021QBridgeTpFdbPort, nor an
                entry in the ieee8021QBridgeStaticUnicastTable) is being
                used to determine if and how frames addressed to
                the value of the corresponding instance of
                ieee8021QBridgeTpFdbAddress are being forwarded.
            invalid(2) - this entry is no longer valid (e.g., it
                was learned but has since aged out), but has not
                yet been flushed from the table.
            learned(3) - the value of the corresponding instance
                of ieee8021QBridgeTpFdbPort was learned and is being used.
            self(4) - the value of the corresponding instance of
                ieee8021QBridgeTpFdbAddress represents one of the device's
                addresses.  The corresponding instance of
                ieee8021QBridgeTpFdbPort indicates which of the device's
                ports has this address.
            mgmt(5) - the value of the corresponding instance of
                ieee8021QBridgeTpFdbAddress is also the value of an
                existing instance of ieee8021QBridgeStaticUnicastAddress."
    ::= { ieee8021QBridgeTpFdbEntry 3 }

-- ============================================================
-- Dynamic Group Registration Table
```

```
-- ============================================================

ieee8021QBridgeTpGroupTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeTpGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing filtering information for VLANs
        configured into the Bridge by (local or network)
        management, or learned dynamically, specifying the set of
        ports to which frames received on a VLAN for this FDB
        and containing a specific Group destination address are
        allowed to be forwarded."
    REFERENCE   "12.7.4"
    ::= { ieee8021QBridgeTp 3 }

ieee8021QBridgeTpGroupEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeTpGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Filtering information configured into the Bridge by
        management, or learned dynamically, specifying the set of
        ports to which frames received on a VLAN and containing
        a specific Group destination address are allowed to be
        forwarded.  The subset of these ports learned dynamically
        is also provided."
    INDEX   { ieee8021QBridgeVlanCurrentComponentId,
              ieee8021QBridgeVlanIndex,
              ieee8021QBridgeTpGroupAddress }
    ::= { ieee8021QBridgeTpGroupTable 1 }

Ieee8021QBridgeTpGroupEntry ::=
    SEQUENCE {
        ieee8021QBridgeTpGroupAddress
            MacAddress,
        ieee8021QBridgeTpGroupEgressPorts
            PortList,
        ieee8021QBridgeTpGroupLearnt
            PortList
    }

ieee8021QBridgeTpGroupAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The destination Group MAC address in a frame to which
        this entry's filtering information applies."
    ::= { ieee8021QBridgeTpGroupEntry 1 }

ieee8021QBridgeTpGroupEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The complete set of ports, in this VLAN, to which
        frames destined for this Group MAC address are currently
        being explicitly forwarded.  This does not include ports
        for which this address is only implicitly forwarded, in
        the ieee8021QBridgeForwardAllPorts list."
    ::= { ieee8021QBridgeTpGroupEntry 2 }

ieee8021QBridgeTpGroupLearnt OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The subset of ports in ieee8021QBridgeTpGroupEgressPorts that
        were learned by MMRP or some other dynamic mechanism, in
        this Filtering database."
    ::= { ieee8021QBridgeTpGroupEntry 3 }
```

```
-- ============================================================
-- Service Requirements subtree
-- ============================================================

ieee8021QBridgeForwardAllTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeForwardAllEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing forwarding information for each
        VLAN, specifying the set of ports to which forwarding of
        all multicasts applies, configured statically by
        management or dynamically by MMRP.  An entry appears in
        this table for all VLANs that are currently
        instantiated."
    REFERENCE   "12.7.2, 12.7.7"
    ::= { ieee8021QBridgeTp 4 }

ieee8021QBridgeForwardAllEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeForwardAllEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Forwarding information for a VLAN, specifying the set
        of ports to which all multicasts should be forwarded,
        configured statically by management or dynamically by
        MMRP."
    INDEX   { ieee8021QBridgeVlanCurrentComponentId,
              ieee8021QBridgeForwardAllVlanIndex }
    ::= { ieee8021QBridgeForwardAllTable 1 }

Ieee8021QBridgeForwardAllEntry ::=
    SEQUENCE {
        ieee8021QBridgeForwardAllVlanIndex
            IEEE8021VlanIndexOrWildcard,
        ieee8021QBridgeForwardAllPorts
            PortList,
        ieee8021QBridgeForwardAllStaticPorts
            PortList,
        ieee8021QBridgeForwardAllForbiddenPorts
            PortList
    }

ieee8021QBridgeForwardAllVlanIndex OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndexOrWildcard
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The VLAN-ID or other identifier referring to this VLAN."
    ::= { ieee8021QBridgeForwardAllEntry 1 }

ieee8021QBridgeForwardAllPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The complete set of ports in this VLAN to which all
        multicast group-addressed frames are to be forwarded.
        This includes ports for which this need has been
        determined dynamically by MMRP, or configured statically
        by management."
    ::= { ieee8021QBridgeForwardAllEntry 2 }

ieee8021QBridgeForwardAllStaticPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The set of ports configured by management in this VLAN
        to which all multicast group-addressed frames are to be
        forwarded.  Ports entered in this list will also appear
```

```
        in the complete set shown by ieee8021QBridgeForwardAllPorts.  This
        value will be restored after the device is reset.  This
        only applies to ports that are members of the VLAN,
        defined by ieee8021QBridgeVlanCurrentEgressPorts.  A port may not
        be added in this set if it is already a member of the
        set of ports in ieee8021QBridgeForwardAllForbiddenPorts.  The
        default value is a string of ones of appropriate length,
        to indicate the standard behavior of using basic
        filtering services, i.e., forward all multicasts to all
        ports.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeForwardAllEntry 3 }

ieee8021QBridgeForwardAllForbiddenPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The set of ports configured by management in this VLAN
        for which the Service Requirement attribute Forward All
        Multicast Groups may not be dynamically registered by
        MMRP.  This value will be restored after the device is
        reset.  A port may not be added in this set if it is
        already a member of the set of ports in
        ieee8021QBridgeForwardAllStaticPorts.  The default value is a
        string of zeros of appropriate length.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeForwardAllEntry 4 }

ieee8021QBridgeForwardUnregisteredTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeForwardUnregisteredEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing forwarding information for each
        VLAN, specifying the set of ports to which forwarding of
        multicast group-addressed frames for which no
        more specific forwarding information applies.  This is
        configured statically by management and determined
        dynamically by MMRP.  An entry appears in this table for
        all VLANs that are currently instantiated."
    REFERENCE   "12.7.2, 12.7.7"
    ::= { ieee8021QBridgeTp 5 }

ieee8021QBridgeForwardUnregisteredEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeForwardUnregisteredEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Forwarding information for a VLAN, specifying the set
        of ports to which all multicasts for which there is no
        more specific forwarding information shall be forwarded.
        This is configured statically by management or
        dynamically by MMRP."
    INDEX   { ieee8021QBridgeVlanCurrentComponentId,
              ieee8021QBridgeForwardUnregisteredVlanIndex }
    ::= { ieee8021QBridgeForwardUnregisteredTable 1 }

Ieee8021QBridgeForwardUnregisteredEntry ::=
    SEQUENCE {
        ieee8021QBridgeForwardUnregisteredVlanIndex
            IEEE8021VlanIndexOrWildcard,
        ieee8021QBridgeForwardUnregisteredPorts
            PortList,
        ieee8021QBridgeForwardUnregisteredStaticPorts
            PortList,
        ieee8021QBridgeForwardUnregisteredForbiddenPorts
            PortList
```

```
    }

ieee8021QBridgeForwardUnregisteredVlanIndex OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndexOrWildcard
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The VLAN-ID or other identifier referring to this VLAN."
    ::= { ieee8021QBridgeForwardUnregisteredEntry 1 }

ieee8021QBridgeForwardUnregisteredPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The complete set of ports in this VLAN to which
        multicast group-addressed frames for which there is no
        more specific forwarding information will be forwarded.
        This includes ports for which this need has been
        determined dynamically by MMRP, or configured statically
        by management."
    ::= { ieee8021QBridgeForwardUnregisteredEntry 2 }

ieee8021QBridgeForwardUnregisteredStaticPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The set of ports configured by management, in this
        VLAN, to which multicast group-addressed frames for
        which there is no more specific forwarding information
        are to be forwarded.  Ports entered in this list will
        also appear in the complete set shown by
        ieee8021QBridgeForwardUnregisteredPorts.  This value will be
        restored after the device is reset.  A port may not be
        added in this set if it is already a member of the set
        of ports in ieee8021QBridgeForwardUnregisteredForbiddenPorts.  The
        default value is a string of zeros of appropriate
        length, although this has no effect with the default
        value of ieee8021QBridgeForwardAllStaticPorts.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeForwardUnregisteredEntry 3 }

ieee8021QBridgeForwardUnregisteredForbiddenPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The set of ports configured by management in this VLAN
        for which the Service Requirement attribute Forward
        Unregistered Multicast Groups may not be dynamically
        registered by MMRP.  This value will be restored after
        the device is reset.  A port may not be added in this
        set if it is already a member of the set of ports in
        ieee8021QBridgeForwardUnregisteredStaticPorts.  The default value
        is a string of zeros of appropriate length.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeForwardUnregisteredEntry 4 }

-- ============================================================
-- The Static (Destination-Address Filtering) Database
-- ============================================================

ieee8021QBridgeStaticUnicastTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeStaticUnicastEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "A table containing filtering information for Unicast
        MAC addresses for each Filtering Database, configured
        into the device by (local or network) management
        specifying the set of ports to which frames received
        from specific ports and containing specific unicast
        destination addresses are allowed to be forwarded.
        Entries are valid for unicast addresses only.

        Two modes of operation are supported by this table. When
        the receive port index is non-zero, this table is
        supporting an IEEE 802.1D filtering database as specified in
        14.7.6.1 of IEEE Std 802.1D.  If the receive port is zero,
        the table is operating as specified in IEEE Std 802.1Q
        8.8.1 and 12.7.7.  An agent must at least
        support the IEEE Std 802.1Q mode of operation."
    REFERENCE   "8.8.1, 12.7.7;
                 IEEE Std 802.1D 7.9.1, 14.7.6.1"
    ::= { ieee8021QBridgeStatic 1 }

ieee8021QBridgeStaticUnicastEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeStaticUnicastEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Filtering information configured into the device by
        (local or network) management specifying the set of
        ports to which frames received from a specific port and
        containing a specific unicast destination address are
        allowed to be forwarded."
    INDEX   {
        ieee8021QBridgeStaticUnicastComponentId,
        ieee8021QBridgeStaticUnicastVlanIndex,
        ieee8021QBridgeStaticUnicastAddress,
        ieee8021QBridgeStaticUnicastReceivePort
    }
    ::= { ieee8021QBridgeStaticUnicastTable 1 }

Ieee8021QBridgeStaticUnicastEntry ::=
    SEQUENCE {
        ieee8021QBridgeStaticUnicastComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeStaticUnicastVlanIndex
            IEEE8021VlanIndexOrWildcard,
        ieee8021QBridgeStaticUnicastAddress
            MacAddress,
        ieee8021QBridgeStaticUnicastReceivePort
            IEEE8021BridgePortNumberOrZero,
        ieee8021QBridgeStaticUnicastStaticEgressPorts
            PortList,
        ieee8021QBridgeStaticUnicastForbiddenEgressPorts
            PortList,
        ieee8021QBridgeStaticUnicastStorageType
            StorageType,
        ieee8021QBridgeStaticUnicastRowStatus
            RowStatus
    }

ieee8021QBridgeStaticUnicastComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeStaticUnicastEntry 1 }

ieee8021QBridgeStaticUnicastVlanIndex OBJECT-TYPE
    SYNTAX       IEEE8021VlanIndexOrWildcard
    MAX-ACCESS   not-accessible
    STATUS       current
```

```
    DESCRIPTION
        "The Vlan to which this entry applies."
    ::= { ieee8021QBridgeStaticUnicastEntry 2 }

ieee8021QBridgeStaticUnicastAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The destination MAC address in a frame to which this
        entry's filtering information applies.  This object must
        take the value of a unicast address."
    ::= { ieee8021QBridgeStaticUnicastEntry 3 }

ieee8021QBridgeStaticUnicastReceivePort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Either the value '0' or the port number of the port
        from which a frame must be received in order for this
        entry's filtering information to apply.  A value of zero
        indicates that this entry applies on all ports of the
        device for which there is no other applicable entry. An
        implementation is required to support the '0' value and
        may optionally support non-zero values for this column."
    ::= { ieee8021QBridgeStaticUnicastEntry 4 }

ieee8021QBridgeStaticUnicastStaticEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports to which frames received from a
        specific port and destined for a specific unicast address
        must be forwarded, regardless of
        any dynamic information, e.g., from MMRP.  A port may not
        be added in this set if it is already a member of the
        set of ports in ieee8021QBridgeStaticUnicastForbiddenEgressPorts.
        The default value of this object is a string of ones of
        appropriate length."
    DEFVAL      { ''H }
    ::= { ieee8021QBridgeStaticUnicastEntry 5 }


ieee8021QBridgeStaticUnicastForbiddenEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports to which frames received from a
        specific port and destined for a specific unicast
        MAC address must not be forwarded, regardless
        of any dynamic information, e.g., from MMRP.  A port may
        not be added in this set if it is already a member of the
        set of ports in ieee8021QBridgeStaticUnicastStaticEgressPorts.
        The default value of this object is a string of zeros of
        appropriate length."
    DEFVAL      { ''H }
    ::= { ieee8021QBridgeStaticUnicastEntry 6 }

ieee8021QBridgeStaticUnicastStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The storage type for this conceptual row.  If this object
        has a value of permanent(4), then no other objects are
        required to be able to be modified."
    DEFVAL { nonVolatile }
    ::= { ieee8021QBridgeStaticUnicastEntry 7 }
```

```
ieee8021QBridgeStaticUnicastRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry, and is used
        to create/delete entries in the table.

        An entry of this table may be set to active without setting
        any other columns of the table.  Also, other columns of this
        table may be set while the value of this object is active(1)."
    ::= { ieee8021QBridgeStaticUnicastEntry 8 }

ieee8021QBridgeStaticMulticastTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeStaticMulticastEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing filtering information for Multicast
        and Broadcast MAC addresses for each VLAN, configured
        into the device by (local or network) management
        specifying the set of ports to which frames received
        from specific ports and containing specific Multicast
        and Broadcast destination addresses are allowed to be
        forwarded.  A value of zero in this table (as the port
        number from which frames with a specific destination
        address are received) is used to specify all ports for
        which there is no specific entry in this table for that
        particular destination address.  Entries are valid for
        Multicast and Broadcast addresses only."
    REFERENCE   "12.7.7, 8.8.1"
    ::= { ieee8021QBridgeStatic 2 }

ieee8021QBridgeStaticMulticastEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeStaticMulticastEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Filtering information configured into the device by
        (local or network) management specifying the set of
        ports to which frames received from this specific port
        for this VLAN and containing this Multicast or Broadcast
        destination address are allowed to be forwarded."
    INDEX   {
        ieee8021QBridgeVlanCurrentComponentId,
        ieee8021QBridgeVlanIndex,
        ieee8021QBridgeStaticMulticastAddress,
        ieee8021QBridgeStaticMulticastReceivePort
    }
    ::= { ieee8021QBridgeStaticMulticastTable 1 }

Ieee8021QBridgeStaticMulticastEntry ::=
    SEQUENCE {
        ieee8021QBridgeStaticMulticastAddress
            MacAddress,
        ieee8021QBridgeStaticMulticastReceivePort
            IEEE8021BridgePortNumberOrZero,
        ieee8021QBridgeStaticMulticastStaticEgressPorts
            PortList,
        ieee8021QBridgeStaticMulticastForbiddenEgressPorts
            PortList,
        ieee8021QBridgeStaticMulticastStorageType
            StorageType,
        ieee8021QBridgeStaticMulticastRowStatus
            RowStatus
    }

ieee8021QBridgeStaticMulticastAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "The destination MAC address in a frame to which this
        entry's filtering information applies.  This object must
        take the value of a Multicast or Broadcast address."
    ::= { ieee8021QBridgeStaticMulticastEntry 1 }

ieee8021QBridgeStaticMulticastReceivePort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Either the value '0' or the port number of the port
        from which a frame must be received in order for this
        entry's filtering information to apply.  A value of zero
        indicates that this entry applies on all ports of the
        device for which there is no other applicable entry. An
        implementation is required to support the '0' value and
        may optionally support non-zero values for this column."
    ::= { ieee8021QBridgeStaticMulticastEntry 2 }

ieee8021QBridgeStaticMulticastStaticEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports to which frames received from a
        specific port and destined for a specific Multicast or
        Broadcast MAC address must be forwarded, regardless of
        any dynamic information, e.g., from MMRP.  A port may not
        be added in this set if it is already a member of the
        set of ports in ieee8021QBridgeStaticMulticastForbiddenEgressPorts.
        The default value of this object is a string of ones of
        appropriate length."
    DEFVAL      { ''H }
    ::= { ieee8021QBridgeStaticMulticastEntry 3 }

ieee8021QBridgeStaticMulticastForbiddenEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports to which frames received from a
        specific port and destined for a specific Multicast or
        Broadcast MAC address must not be forwarded, regardless
        of any dynamic information, e.g., from MMRP.  A port may
        not be added in this set if it is already a member of the
        set of ports in ieee8021QBridgeStaticMulticastStaticEgressPorts.
        The default value of this object is a string of zeros of
        appropriate length."
    DEFVAL      { ''H }
    ::= { ieee8021QBridgeStaticMulticastEntry 4 }

ieee8021QBridgeStaticMulticastStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The storage type for this conceptual row.  If this object
        has a value of permanent(4), then no other objects are
        required to be able to be modified."
    DEFVAL      { nonVolatile }
    ::= { ieee8021QBridgeStaticMulticastEntry 5 }

ieee8021QBridgeStaticMulticastRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry, and is used
        to create/delete entries in the table.

        An entry of this table may be set to active without setting
        any other columns of the table.  Also, other columns of this
```

```
        table may be set while the value of this object is active(1)."
    ::= { ieee8021QBridgeStaticMulticastEntry 6 }

-- ============================================================
-- The Current VLAN Database
-- ============================================================

ieee8021QBridgeVlanNumDeletes OBJECT-TYPE
    SYNTAX     Counter64
    UNITS      "vlan deletions"
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "The number of times a VLAN entry has been deleted from
        the ieee8021QBridgeVlanCurrentTable (for any reason).
        If an entry is deleted, then inserted, and then deleted,
        this counter will be incremented by 2.  Discontinuities
        in this value can only occur at a reboot."
    ::= { ieee8021QBridgeVlan 1 }

ieee8021QBridgeVlanCurrentTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeVlanCurrentEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing current configuration information
        for each VLAN currently configured into the device by
        (local or network) management, or dynamically created
        as a result of MVRP requests received."
    REFERENCE   "12.10.2"
    ::= { ieee8021QBridgeVlan 2 }

ieee8021QBridgeVlanCurrentEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeVlanCurrentEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information for a VLAN configured into the device by
        (local or network) management, or dynamically created
        as a result of MVRP requests received."
    INDEX   { ieee8021QBridgeVlanTimeMark,
              ieee8021QBridgeVlanCurrentComponentId,
              ieee8021QBridgeVlanIndex }
    ::= { ieee8021QBridgeVlanCurrentTable 1 }

Ieee8021QBridgeVlanCurrentEntry ::=
    SEQUENCE {
        ieee8021QBridgeVlanTimeMark
            TimeFilter,
        ieee8021QBridgeVlanCurrentComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeVlanIndex
            IEEE8021VlanIndex,
        ieee8021QBridgeVlanFdbId
            Unsigned32,
        ieee8021QBridgeVlanCurrentEgressPorts
            PortList,
        ieee8021QBridgeVlanCurrentUntaggedPorts
            PortList,
        ieee8021QBridgeVlanStatus
            INTEGER,
        ieee8021QBridgeVlanCreationTime
            TimeTicks
    }

ieee8021QBridgeVlanTimeMark OBJECT-TYPE
    SYNTAX      TimeFilter
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A TimeFilter for this entry.  See the TimeFilter
        textual convention to see how this works."
```

```
    ::= { ieee8021QBridgeVlanCurrentEntry 1 }

ieee8021QBridgeVlanCurrentComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeVlanCurrentEntry 2 }

ieee8021QBridgeVlanIndex OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The VLAN-ID or other identifier referring to this VLAN."
    ::= { ieee8021QBridgeVlanCurrentEntry 3 }

ieee8021QBridgeVlanFdbId OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Filtering Database used by this VLAN.  This is one
        of the ieee8021QBridgeFdbId values in the ieee8021QBridgeFdbTable.
        This value is allocated automatically by the device whenever
        the VLAN is created: either dynamically by MVRP, or by
        management, in ieee8021QBridgeVlanStaticTable.  Allocation of this
        value follows the learning constraints defined for this
        VLAN in ieee8021QBridgeLearningConstraintsTable."
    ::= { ieee8021QBridgeVlanCurrentEntry 4 }

ieee8021QBridgeVlanCurrentEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The set of ports that are transmitting traffic for
        this VLAN as either tagged or untagged frames."
    REFERENCE   "12.10.2.1"
    ::= { ieee8021QBridgeVlanCurrentEntry 5 }

ieee8021QBridgeVlanCurrentUntaggedPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The set of ports that are transmitting traffic for
        this VLAN as untagged frames."
    REFERENCE   "12.10.2.1"
    ::= { ieee8021QBridgeVlanCurrentEntry 6 }

ieee8021QBridgeVlanStatus OBJECT-TYPE
    SYNTAX      INTEGER {
                    other(1),
                    permanent(2),
                    dynamicMvrp(3)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry.
            other(1) - this entry is currently in use, but the
                conditions under which it will remain so differ
                from the following values.
            permanent(2) - this entry, corresponding to an entry
                in ieee8021QBridgeVlanStaticTable, is currently in use and
                will remain so after the next reset of the
                device.  The port lists for this entry include
```

```
                ports from the equivalent ieee8021QBridgeVlanStaticTable
                entry and ports learned dynamically.
            dynamicMvrp(3) - this entry is currently in use
                and will remain so until removed by MVRP.  There
                is no static entry for this VLAN, and it will be
                removed when the last port leaves the VLAN."
    ::= { ieee8021QBridgeVlanCurrentEntry 7 }

ieee8021QBridgeVlanCreationTime OBJECT-TYPE
    SYNTAX      TimeTicks
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of sysUpTime when this VLAN was created."
    ::= { ieee8021QBridgeVlanCurrentEntry 8 }

-- ============================================================
-- The Static VLAN Database
-- ============================================================

ieee8021QBridgeVlanStaticTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeVlanStaticEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing static configuration information for
        each VLAN configured into the device by (local or
        network) management.  All entries are persistent and will
        be restored after the device is reset."
    REFERENCE   "12.7.5"
    ::= { ieee8021QBridgeVlan 3 }

ieee8021QBridgeVlanStaticEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeVlanStaticEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Static information for a VLAN configured into the
        device by (local or network) management."
    INDEX   { ieee8021QBridgeVlanStaticComponentId,
              ieee8021QBridgeVlanStaticVlanIndex }
    ::= { ieee8021QBridgeVlanStaticTable 1 }

Ieee8021QBridgeVlanStaticEntry ::=
    SEQUENCE {
        ieee8021QBridgeVlanStaticComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeVlanStaticVlanIndex
            IEEE8021VlanIndex,
        ieee8021QBridgeVlanStaticName
            SnmpAdminString,
        ieee8021QBridgeVlanStaticEgressPorts
            PortList,
        ieee8021QBridgeVlanForbiddenEgressPorts
            PortList,
        ieee8021QBridgeVlanStaticUntaggedPorts
            PortList,
        ieee8021QBridgeVlanStaticRowStatus
            RowStatus
    }

ieee8021QBridgeVlanStaticComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeVlanStaticEntry 1 }
```

```
ieee8021QBridgeVlanStaticVlanIndex OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The VLAN-ID or other identifier referring to this VLAN."
    ::= { ieee8021QBridgeVlanStaticEntry 2 }

ieee8021QBridgeVlanStaticName OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE (0..32))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "An administratively assigned string, which may be used
        to identify the VLAN."
    REFERENCE   "12.10.2.11"
    ::= { ieee8021QBridgeVlanStaticEntry 3 }

ieee8021QBridgeVlanStaticEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports that are permanently assigned to the
        egress list for this VLAN by management.  Changes to a
        bit in this object affect the per-port, per-VLAN
        Registrar control for Registration Fixed for the
        relevant MVRP state machine on each port.  A port may
        not be added in this set if it is already a member of
        the set of ports in ieee8021QBridgeVlanForbiddenEgressPorts.  The
        default value of this object is a string of zeros of
        appropriate length, indicating not fixed."
    REFERENCE   "12.7.7.3, 11.2.3.2.3"
    ::= { ieee8021QBridgeVlanStaticEntry 4 }

ieee8021QBridgeVlanForbiddenEgressPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports that are prohibited by management
        from being included in the egress list for this VLAN.
        Changes to this object that cause a port to be included
        or excluded affect the per-port, per-VLAN Registrar
        control for Registration Forbidden for the relevant MVRP
        state machine on each port.  A port may not be added in
        this set if it is already a member of the set of ports
        in ieee8021QBridgeVlanStaticEgressPorts.  The default value of
        this object is a string of zeros of appropriate length,
        excluding all ports from the forbidden set."
    REFERENCE   "12.7.7.3, 11.2.3.2.3"
    ::= { ieee8021QBridgeVlanStaticEntry 5 }

ieee8021QBridgeVlanStaticUntaggedPorts OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The set of ports that should transmit egress frames
        for this VLAN as untagged.  The default value of this
        object for the default VLAN (ieee8021QBridgeVlanIndex = 1) is a string
        of appropriate length including all ports.  There is no
        specified default for other VLANs.  If a device agent cannot
        support the set of ports being set, then it will reject the
        set operation with an error.  For example, a
        manager might attempt to set more than one VLAN to be untagged
        on egress where the device does not support this IEEE 802.1Q
        option."
    REFERENCE   "12.10.2.1"
    ::= { ieee8021QBridgeVlanStaticEntry 6 }

ieee8021QBridgeVlanStaticRowStatus OBJECT-TYPE
```

```
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry, and is used
        to create/delete entries.  Any object in an entry of this table
        may be modified while the value of the corresponding instance
        of this object is active(1)."
    ::= { ieee8021QBridgeVlanStaticEntry 7 }

ieee8021QBridgeNextFreeLocalVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeNextFreeLocalVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about the next free VLAN
        value for a statically configured VLAN Bridge."
    ::= { ieee8021QBridgeVlan 4 }

ieee8021QBridgeNextFreeLocalVlanEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeNextFreeLocalVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The next free VLAN value for a statically configured VLAN Bridge"
    INDEX   { ieee8021QBridgeNextFreeLocalVlanComponentId }
    ::= { ieee8021QBridgeNextFreeLocalVlanTable 1 }

Ieee8021QBridgeNextFreeLocalVlanEntry ::=
    SEQUENCE {
        ieee8021QBridgeNextFreeLocalVlanComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeNextFreeLocalVlanIndex
            Unsigned32
    }

ieee8021QBridgeNextFreeLocalVlanComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeNextFreeLocalVlanEntry 1 }

ieee8021QBridgeNextFreeLocalVlanIndex OBJECT-TYPE
    SYNTAX      Unsigned32 (0|4096..4294967295)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The next available value for ieee8021QBridgeVlanIndex of a local
        VLAN entry in ieee8021QBridgeVlanStaticTable.  This will report
        values >=4096 if a new Local VLAN may be created or else
        the value 0 if this is not possible.

        A row creation operation in this table for an entry with a local
        VlanIndex value may fail if the current value of this object
        is not used as the index.  Even if the value read is used,
        there is no guarantee that it will still be the valid index
        when the create operation is attempted; another manager may
        have already got in during the intervening time interval.
        In this case, ieee8021QBridgeNextFreeLocalVlanIndex should be re-read
        and the creation re-tried with the new value.

        This value will automatically change when the current value is
        used to create a new row."
    ::= { ieee8021QBridgeNextFreeLocalVlanEntry 2 }

-- ============================================================
-- The VLAN Port Configuration Table
```

```
-- ============================================================

ieee8021QBridgePortVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgePortVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing per-port control and status
        information for VLAN configuration in the device."
    REFERENCE   "12.10.1"
    ::= { ieee8021QBridgeVlan 5 }

ieee8021QBridgePortVlanEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgePortVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information controlling VLAN configuration for a port
        on the device.  This is indexed by ieee8021BridgeBasePort."
    AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021QBridgePortVlanTable 1 }

Ieee8021QBridgePortVlanEntry ::=
    SEQUENCE {
        ieee8021QBridgePvid
            IEEE8021VlanIndex,
        ieee8021QBridgePortAcceptableFrameTypes
            IEEE8021PortAcceptableFrameTypes,
        ieee8021QBridgePortIngressFiltering
            TruthValue,
        ieee8021QBridgePortMvrpEnabledStatus
            TruthValue,
        ieee8021QBridgePortMvrpFailedRegistrations
            Counter64,
        ieee8021QBridgePortMvrpLastPduOrigin
            MacAddress,
        ieee8021QBridgePortRestrictedVlanRegistration
            TruthValue
    }

ieee8021QBridgePvid OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The PVID, the VLAN-ID assigned to untagged frames or
        Priority-tagged frames received on this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.10.1.1"
    DEFVAL      { 1 }
    ::= { ieee8021QBridgePortVlanEntry 1 }

ieee8021QBridgePortAcceptableFrameTypes OBJECT-TYPE
    SYNTAX      IEEE8021PortAcceptableFrameTypes
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "When this is admitTagged(3), the device will
        discard untagged frames or Priority-tagged frames
        received on this port.  When admitAll(1), untagged
        frames or Priority-tagged frames received on this port
        will be accepted and assigned to a VID based on the
        PVID and VID Set for this port.

        This control does not affect VLAN-independent Bridge
        Protocol Data Unit (BPDU) frames, such as MVRP and
        Spanning Tree Protocol (STP).  It does affect VLAN-
        dependent BPDU frames, such as MMRP.

        The value of this object MUST be retained across
```

```
        reinitializations of the management system."
    REFERENCE   "12.10.1.3"
    DEFVAL      { admitAll }
    ::= { ieee8021QBridgePortVlanEntry 2 }

ieee8021QBridgePortIngressFiltering OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "When this is true(1), the device will discard incoming
        frames for VLANs that do not include this Port in its
        Member set.  When false(2), the port will accept all
        incoming frames.

        This control does not affect VLAN-independent BPDU
        frames, such as MVRP and STP.  It does affect VLAN-
        dependent BPDU frames, such as MMRP.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.10.1.4"
    DEFVAL      { false }
    ::= { ieee8021QBridgePortVlanEntry 3 }

ieee8021QBridgePortMvrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The state of MVRP operation on this port.  The value
        true(1) indicates that MVRP is enabled on this port,
        as long as ieee8021QBridgeMvrpEnabledStatus is also enabled
        for this device.  When false(2) but
        ieee8021QBridgeMvrpEnabledStatus is still
        enabled for the device, MVRP is disabled on this port:
        any MVRP packets received will be silently discarded, and
        no MVRP registrations will be propagated from other
        ports.  This object affects all MVRP Applicant and
        Registrar state machines on this port.  A transition
        from false(2) to true(1) will cause a reset of all
        MVRP state machines on this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    DEFVAL      { true }
    ::= { ieee8021QBridgePortVlanEntry 4 }

ieee8021QBridgePortMvrpFailedRegistrations OBJECT-TYPE
    SYNTAX      Counter64
    UNITS      "failed MVRP registrations"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The total number of failed MVRP registrations, for any
        reason, on this port.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    ::= { ieee8021QBridgePortVlanEntry 5 }

ieee8021QBridgePortMvrpLastPduOrigin OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Source MAC Address of the last MVRP message
        received on this port."
    ::= { ieee8021QBridgePortVlanEntry 6 }
```

```
ieee8021QBridgePortRestrictedVlanRegistration OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The state of Restricted VLAN Registration on this port.
         If the value of this control is true(1), then creation
         of a new dynamic VLAN entry is permitted only if there
         is a Static VLAN Registration Entry for the VLAN concerned,
         in which the Registrar Administrative Control value for
         this port is Normal Registration.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "11.2.3.2.3, 12.10.1.6."
    DEFVAL      { false }
    ::= { ieee8021QBridgePortVlanEntry 7 }

-- ================================================================
-- Per port VLAN Statistics Table
-- ================================================================

ieee8021QBridgePortVlanStatisticsTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgePortVlanStatisticsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing per-port, per-VLAN statistics for
        traffic received."
    ::= { ieee8021QBridgeVlan 6 }

ieee8021QBridgePortVlanStatisticsEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgePortVlanStatisticsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Traffic statistics for a VLAN on an interface."
    INDEX   { ieee8021BridgeBasePortComponentId,
              ieee8021BridgeBasePort,
              ieee8021QBridgeVlanIndex }
    ::= { ieee8021QBridgePortVlanStatisticsTable 1 }

Ieee8021QBridgePortVlanStatisticsEntry ::=
    SEQUENCE {
        ieee8021QBridgeTpVlanPortInFrames
            Counter64,
        ieee8021QBridgeTpVlanPortOutFrames
            Counter64,
        ieee8021QBridgeTpVlanPortInDiscards
            Counter64
    }

ieee8021QBridgeTpVlanPortInFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS      "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of valid frames received by this port from
        its segment that were classified as belonging to this
        VLAN.  Note that a frame received on this port is
        counted by this object if and only if it is for a
        protocol being processed by the local forwarding process
        for this VLAN.  This object includes received Bridge
        management frames classified as belonging to this VLAN
        (e.g., MMRP, but not MVRP or STP.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
```

```
        interface (if any)."
    REFERENCE   "12.6.1.1.3(a)"
    ::= { ieee8021QBridgePortVlanStatisticsEntry 1 }

ieee8021QBridgeTpVlanPortOutFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS      "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of valid frames transmitted by this port to
        its segment from the local forwarding process for this
        VLAN.  This includes Bridge management frames originated
        by this device that are classified as belonging to this
        VLAN (e.g., MMRP, but not MVRP or STP).

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3(d)"
    ::= { ieee8021QBridgePortVlanStatisticsEntry 2 }

ieee8021QBridgeTpVlanPortInDiscards OBJECT-TYPE
    SYNTAX      Counter64
    UNITS      "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of valid frames received by this port from
        its segment that were classified as belonging to this
        VLAN and that were discarded due to VLAN-related reasons.
        Specifically, the IEEE 802.1Q counters for Discard
        Inbound and Discard on Ingress Filtering.

        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
    REFERENCE   "12.6.1.1.3"
    ::= { ieee8021QBridgePortVlanStatisticsEntry 3 }

-- ============================================================
-- The VLAN Learning Constraints Table (now deprecated)
-- ============================================================

ieee8021QBridgeLearningConstraintsTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeLearningConstraintsEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "A table containing learning constraints for sets of
        Shared and Independent VLANs.  Entries in this table are
        persistent and are preserved across reboots."
    REFERENCE   "12.10.3.1 of IEEE Std 802.1Q-2012"
    ::= { ieee8021QBridgeVlan 8 }

ieee8021QBridgeLearningConstraintsEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeLearningConstraintsEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "A learning constraint defined for a VLAN."
    INDEX   { ieee8021QBridgeLearningConstraintsComponentId,
              ieee8021QBridgeLearningConstraintsVlan,
              ieee8021QBridgeLearningConstraintsSet }
    ::= { ieee8021QBridgeLearningConstraintsTable 1 }

Ieee8021QBridgeLearningConstraintsEntry ::=
    SEQUENCE {
```

```
        ieee8021QBridgeLearningConstraintsComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeLearningConstraintsVlan
            IEEE8021VlanIndex,
        ieee8021QBridgeLearningConstraintsSet
            Integer32,
        ieee8021QBridgeLearningConstraintsType
            INTEGER,
        ieee8021QBridgeLearningConstraintsStatus
            RowStatus
    }

ieee8021QBridgeLearningConstraintsComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeLearningConstraintsEntry 1 }

ieee8021QBridgeLearningConstraintsVlan OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The index of the row in ieee8021QBridgeVlanCurrentTable for the
        VLAN constrained by this entry."
    ::= { ieee8021QBridgeLearningConstraintsEntry 2 }

ieee8021QBridgeLearningConstraintsSet OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The identity of the constraint set to which
        ieee8021QBridgeLearningConstraintsVlan belongs.  These values may
        be chosen by the management station."
    ::= { ieee8021QBridgeLearningConstraintsEntry 3 }

ieee8021QBridgeLearningConstraintsType OBJECT-TYPE
    SYNTAX      INTEGER {
                    independent(1),
                    shared(2)
                }
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The type of constraint this entry defines.
            independent(1) - the VLAN, ieee8021QBridgeLearningConstraintsVlan,
                uses a filtering database independent from all
                other VLANs in the same set, defined by
                ieee8021QBridgeLearningConstraintsSet.
            shared(2) - the VLAN, ieee8021QBridgeLearningConstraintsVlan,
                shares the same filtering database as all other VLANs
                in the same set, defined by
                ieee8021QBridgeLearningConstraintsSet."
    ::= { ieee8021QBridgeLearningConstraintsEntry 4 }

ieee8021QBridgeLearningConstraintsStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The status of this entry.  Any object in an entry of this table
        may be modified while the value of the corresponding instance
        of this object is active(1)."
    ::= { ieee8021QBridgeLearningConstraintsEntry 5 }

ieee8021QBridgeLearningConstraintDefaultsTable OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF Ieee8021QBridgeLearningConstraintDefaultsEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "A table containing learning constraints for sets of
        Shared and Independent VLANs."
    REFERENCE   "12.10.3.1 of IEEE Std 802.1Q-2012"
    ::= { ieee8021QBridgeVlan 9 }

ieee8021QBridgeLearningConstraintDefaultsEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeLearningConstraintDefaultsEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "A learning constraint defined for a VLAN."
    INDEX   { ieee8021QBridgeLearningConstraintDefaultsComponentId }
    ::= { ieee8021QBridgeLearningConstraintDefaultsTable 1 }

Ieee8021QBridgeLearningConstraintDefaultsEntry ::=
    SEQUENCE {
        ieee8021QBridgeLearningConstraintDefaultsComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeLearningConstraintDefaultsSet
            Integer32,
        ieee8021QBridgeLearningConstraintDefaultsType
            INTEGER
    }

ieee8021QBridgeLearningConstraintDefaultsComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeLearningConstraintDefaultsEntry 1 }

ieee8021QBridgeLearningConstraintDefaultsSet OBJECT-TYPE
    SYNTAX      Integer32 (0..65535)
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
        "The identity of the constraint set to which a VLAN
        belongs, if there is not an explicit entry for that VLAN
        in ieee8021QBridgeLearningConstraintsTable.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeLearningConstraintDefaultsEntry 2 }

ieee8021QBridgeLearningConstraintDefaultsType OBJECT-TYPE
    SYNTAX      INTEGER {
                    independent(1),
                    shared(2)
                }
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
        "The type of constraint set to which a VLAN belongs, if
        there is not an explicit entry for that VLAN in
        ieee8021QBridgeLearningConstraintsTable.  The types are as defined
        for ieee8021QBridgeLearningConstraintsType.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021QBridgeLearningConstraintDefaultsEntry 3 }

-- ============================================================
-- ieee8021QBridgeProtocol subtree
-- ============================================================
```

```
ieee8021QBridgeProtocolGroupTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeProtocolGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains mappings from Protocol
         Templates to Protocol Group Identifiers used for
         Port-and-Protocol-based VLAN Classification.

         Entries in this table must be persistent over power
         up restart/reboot."
    REFERENCE   "12.10.1"
    ::= { ieee8021QBridgeProtocol 1 }

ieee8021QBridgeProtocolGroupEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeProtocolGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A mapping from a Protocol Template to a Protocol
         Group Identifier."
    REFERENCE   "12.10.1.1.3 d)"
    INDEX       { ieee8021QBridgeProtocolGroupComponentId,
                  ieee8021QBridgeProtocolTemplateFrameType,
                  ieee8021QBridgeProtocolTemplateProtocolValue }
    ::= { ieee8021QBridgeProtocolGroupTable 1 }

Ieee8021QBridgeProtocolGroupEntry ::=
    SEQUENCE {
        ieee8021QBridgeProtocolGroupComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021QBridgeProtocolTemplateFrameType
            INTEGER,
        ieee8021QBridgeProtocolTemplateProtocolValue
            OCTET STRING,
        ieee8021QBridgeProtocolGroupId
            Integer32,
        ieee8021QBridgeProtocolGroupRowStatus
            RowStatus
    }

ieee8021QBridgeProtocolGroupComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021QBridgeProtocolGroupEntry 1 }

ieee8021QBridgeProtocolTemplateFrameType OBJECT-TYPE
    SYNTAX      INTEGER {
                  ethernet  (1),
                  rfc1042   (2),
                  snap8021H (3),
                  snapOther (4),
                  llcOther  (5)
                }
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The data-link encapsulation format or the
         'detagged_frame_type' in a Protocol Template."
    REFERENCE   "12.10.1.8"
    ::= { ieee8021QBridgeProtocolGroupEntry 2 }

ieee8021QBridgeProtocolTemplateProtocolValue OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (2 | 5))
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "The identification of the protocol above the data-link
         layer in a Protocol Template.  Depending on the
         frame type, the octet string will have one of the
         following values:

         For 'ethernet', 'rfc1042' and 'snap8021H',
             this is the 16-bit (2-octet) IEEE 802.3 Type Field.
         For 'snapOther',
             this is the 40-bit (5-octet) PID.
         For 'llcOther',
             this is the 2-octet IEEE 802.2 Link Service Access
             Point (LSAP) pair: first octet for Destination Service
             Access Point (DSAP) and second octet for Source Service
             Access Point (SSAP)."
    REFERENCE   "12.10.1.8"
    ::= { ieee8021QBridgeProtocolGroupEntry 3 }

ieee8021QBridgeProtocolGroupId OBJECT-TYPE
    SYNTAX      Integer32 (0..2147483647)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Represents a group of protocols that are associated
         together when assigning a VID to a frame."
    REFERENCE   "12.10.1.8"
    ::= { ieee8021QBridgeProtocolGroupEntry 4 }

ieee8021QBridgeProtocolGroupRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry."
    ::= { ieee8021QBridgeProtocolGroupEntry 5 }

ieee8021QBridgeProtocolPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeProtocolPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains VID sets used for
         Port-and-Protocol-based VLAN Classification."
    REFERENCE   "12.10.1"
    ::= { ieee8021QBridgeProtocol 2 }

ieee8021QBridgeProtocolPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeProtocolPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A VID set for a port."
    REFERENCE   "12.10.1.1.3 c)"
    INDEX       { ieee8021BridgeBasePortComponentId,
                  ieee8021BridgeBasePort,
                  ieee8021QBridgeProtocolPortGroupId }
    ::= { ieee8021QBridgeProtocolPortTable 1 }

Ieee8021QBridgeProtocolPortEntry ::=
    SEQUENCE {
        ieee8021QBridgeProtocolPortGroupId
            Integer32,
        ieee8021QBridgeProtocolPortGroupVid
            VlanId,
        ieee8021QBridgeProtocolPortRowStatus
            RowStatus
    }

ieee8021QBridgeProtocolPortGroupId OBJECT-TYPE
    SYNTAX      Integer32 (1..2147483647)
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "Designates a group of protocols in the Protocol
         Group Database."
    REFERENCE   "12.10.1.2"
    ::= { ieee8021QBridgeProtocolPortEntry 1 }

ieee8021QBridgeProtocolPortGroupVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The VID associated with a group of protocols for
         each port."
    REFERENCE   "12.10.1.2"
    ::= { ieee8021QBridgeProtocolPortEntry 2 }

ieee8021QBridgeProtocolPortRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object indicates the status of this entry."
    ::= { ieee8021QBridgeProtocolPortEntry 3 }

-- ============================================================
-- ieee8021QBridgeVIDX subtree
--
-- ============================================================

ieee8021QBridgeVIDXTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeVIDXEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is used to configure the VID Translation
        Table defined in 12.10.1.8 and 6.9.  The Bridge VID
        Translation Table is used to implement a mapping between a
        local VID, and a relay VID, used by the filtering and
        forwarding process.  Each row in this table is indexed by
        component, port, and local VID value and a value to be used
        for the specified VID as specified in (6.9).  Entries in
        this table must be persistent over power up restart/reboot."
 REFERENCE   "12.10.1.8, 6.9"
    ::= { ieee8021QBridgeVIDX 1 }

ieee8021QBridgeVIDXEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeVIDXEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry for the S-VID translation table, which includes
        both the Local and Relay S-VIDs."

    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021QBridgeVIDXLocalVid }
    ::= { ieee8021QBridgeVIDXTable 1 }

Ieee8021QBridgeVIDXEntry ::=
      SEQUENCE {
          ieee8021QBridgeVIDXLocalVid VlanId,
          ieee8021QBridgeVIDXRelayVid VlanId,
          ieee8021QBridgeVIDXRowStatus RowStatus
}

ieee8021QBridgeVIDXLocalVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Local VID after translation received at the ISS or EISS."
```

```
    REFERENCE   "12.10.1.8.1, 12.10.1.8.2 "
    ::= { ieee8021QBridgeVIDXEntry 1 }

ieee8021QBridgeVIDXRelayVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The Relay VID received before translation received at ISS or EISS."
    REFERENCE   "12.10.1.8.1, 12.10.1.8.2"
    ::= { ieee8021QBridgeVIDXEntry 2 }

ieee8021QBridgeVIDXRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of an entry in this table,
        and is used to create/delete entries. It is an
        implementation specific decision as to whether
        any column in this table may be set while the
        corresponding instance of this object is valid(1)."
    REFERENCE   "12.10.1.8.1, 12.10.1.8.2"
    ::= { ieee8021QBridgeVIDXEntry 3 }

-- ============================================================
-- ieee8021QBridgeEgressVidXTable:
-- ============================================================

ieee8021QBridgeEgressVidXTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeEgressVidXEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "This table is used to configure the VID Translation
        Table defined in 12.10.1.9 and 6.9.  The Bridge VID
        Egress Translation Table is used to implement a mapping between a
        relay VID, and a local VID, used by the filtering and
        forwarding process.  Each row in this table is indexed by
        component, port, and relay VID value and a value to be used
        for the specified local VID as specified in (6.9).  Entries in
        this table must be persistent over power up restart/reboot."
    REFERENCE   "12.10.1.9, 6.9"
    ::= { ieee8021QBridgeVIDX 2 }

ieee8021QBridgeEgressVidXEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeEgressVidXEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "An entry for the Egress VID translation table, which includes
        both the relay and local IDs between which the PNP or CNP
        translates."

    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021QBridgeEgressVidXRelayVid }
    ::= { ieee8021QBridgeEgressVidXTable 1 }

Ieee8021QBridgeEgressVidXEntry ::=
      SEQUENCE {
          ieee8021QBridgeEgressVidXRelayVid VlanId,
          ieee8021QBridgeEgressVidXLocalVid VlanId,
          ieee8021QBridgeEgressVidXRowStatus RowStatus
}

ieee8021QBridgeEgressVidXRelayVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The Relay VID after translation transmitted to the
```

```
          ISS or EISS."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
     ::= { ieee8021QBridgeEgressVidXEntry 1 }

ieee8021QBridgeEgressVidXLocalVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The Local VID before translation transmitted to the
         ISS or EISS."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
    ::= { ieee8021QBridgeEgressVidXEntry 2 }


ieee8021QBridgeEgressVidXRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
       "This indicates the status of an entry in this table,
        and is used to create/delete entries. It is an
        implementation specific decision as to whether
        any column in this table may be set while the
        corresponding instance of this object is valid(1)."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
   ::= { ieee8021QBridgeEgressVidXEntry 3 }

-- ============================================================
-- ieee8021QBridgeEgressVidXV2Table:
-- ============================================================

ieee8021QBridgeEgressVidXV2Table OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeEgressVidXV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is used to configure the VID Translation
        Table defined in 12.10.1.9 and 6.9.  The Bridge VID
        Egress Translation Table is used to implement a mapping between a
        relay VID, and a local VID, used by the filtering and
        forwarding process.  Each row in this table is indexed by
        component, port, and relay VID value and a value to be used
        for the specified local VID as specified in (6.9).  Entries in
        this table must be persistent over power up restart/reboot."
    REFERENCE   "12.10.1.9, 6.9"
    ::= { ieee8021QBridgeVIDX 3 }

ieee8021QBridgeEgressVidXV2Entry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeEgressVidXV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry for the Egress VID translation table, which includes
        both the relay and local IDs between which the PNP or CNP
        translates."

    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021QBridgeEgressVidXV2RelayVid }
    ::= { ieee8021QBridgeEgressVidXV2Table 1 }

Ieee8021QBridgeEgressVidXV2Entry ::=
      SEQUENCE {
          ieee8021QBridgeEgressVidXV2RelayVid VlanId,
          ieee8021QBridgeEgressVidXV2LocalVid VlanId,
          ieee8021QBridgeEgressVidXV2RowStatus RowStatus
}

ieee8021QBridgeEgressVidXV2RelayVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "The Relay VID after translation transmitted to the
         ISS or EISS."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
     ::= { ieee8021QBridgeEgressVidXV2Entry 1 }

ieee8021QBridgeEgressVidXV2LocalVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The Local VID before translation transmitted to the
         ISS or EISS."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
    ::= { ieee8021QBridgeEgressVidXV2Entry 2 }


ieee8021QBridgeEgressVidXV2RowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "This indicates the status of an entry in this table,
        and is used to create/delete entries. It is an
        implementation specific decision as to whether
        any column in this table may be set while the
        corresponding instance of this object is valid(1)."
    REFERENCE   "12.10.1.9.1, 12.10.1.9.2"
   ::= { ieee8021QBridgeEgressVidXV2Entry 3 }


-- ============================================================
-- IEEE 802.1Q MIB - Conformance Information
-- ============================================================

ieee8021QBridgeConformance
    OBJECT IDENTIFIER ::= { ieee8021QBridgeMib 2 }

ieee8021QBridgeGroups
    OBJECT IDENTIFIER ::= { ieee8021QBridgeConformance 1 }

ieee8021QBridgeCompliances
    OBJECT IDENTIFIER ::= { ieee8021QBridgeConformance 2 }

-- ============================================================
-- units of conformance
-- ============================================================

ieee8021QBridgeBaseGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeVlanVersionNumber,
        ieee8021QBridgeMaxVlanId,
        ieee8021QBridgeMaxSupportedVlans,
        ieee8021QBridgeNumVlans,
        ieee8021QBridgeMvrpEnabledStatus
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing device-level control
        and status information for the VLAN Bridge
        services."
    ::= { ieee8021QBridgeGroups 1 }

ieee8021QBridgeFdbUnicastGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeFdbDynamicCount,
        ieee8021QBridgeFdbLearnedEntryDiscards,
        ieee8021QBridgeFdbAgingTime,
        ieee8021QBridgeTpFdbPort,
        ieee8021QBridgeTpFdbStatus
    }
```

```
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about all
        unicast addresses, learned dynamically or statically
        configured by management, in each Filtering Database."
    ::= { ieee8021QBridgeGroups 2 }

ieee8021QBridgeFdbMulticastGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeTpGroupEgressPorts,
        ieee8021QBridgeTpGroupLearnt
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about all
        multicast addresses, learned dynamically or statically
        configured by management, in each Filtering Database."
    ::= { ieee8021QBridgeGroups 3 }

ieee8021QBridgeServiceRequirementsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeForwardAllPorts,
        ieee8021QBridgeForwardAllStaticPorts,
        ieee8021QBridgeForwardAllForbiddenPorts,
        ieee8021QBridgeForwardUnregisteredPorts,
        ieee8021QBridgeForwardUnregisteredStaticPorts,
        ieee8021QBridgeForwardUnregisteredForbiddenPorts
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about
        service requirements, learned dynamically or statically
        configured by management, in each Filtering Database."
    ::= { ieee8021QBridgeGroups 4 }

ieee8021QBridgeFdbStaticGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeStaticUnicastStaticEgressPorts,
        ieee8021QBridgeStaticUnicastForbiddenEgressPorts,
        ieee8021QBridgeStaticUnicastStorageType,
        ieee8021QBridgeStaticUnicastRowStatus,
        ieee8021QBridgeStaticMulticastStaticEgressPorts,
        ieee8021QBridgeStaticMulticastForbiddenEgressPorts,
        ieee8021QBridgeStaticMulticastStorageType,
        ieee8021QBridgeStaticMulticastRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about
        unicast and multicast addresses statically configured by
        management, in each Filtering Database or VLAN."
    ::= { ieee8021QBridgeGroups 5 }

ieee8021QBridgeVlanGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeVlanNumDeletes,
        ieee8021QBridgeVlanFdbId,
        ieee8021QBridgeVlanCurrentEgressPorts,
        ieee8021QBridgeVlanCurrentUntaggedPorts,
        ieee8021QBridgeVlanStatus,
        ieee8021QBridgeVlanCreationTime
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about
        all VLANs currently configured on this device."
    ::= { ieee8021QBridgeGroups 6 }

ieee8021QBridgeVlanStaticGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeVlanStaticName,
        ieee8021QBridgeVlanStaticEgressPorts,
```

```
        ieee8021QBridgeVlanForbiddenEgressPorts,
        ieee8021QBridgeVlanStaticUntaggedPorts,
        ieee8021QBridgeVlanStaticRowStatus,
        ieee8021QBridgeNextFreeLocalVlanIndex
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing information about
        VLANs statically configured by management."
    ::= { ieee8021QBridgeGroups 7 }

ieee8021QBridgeVlanStatisticsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeTpVlanPortInFrames,
        ieee8021QBridgeTpVlanPortOutFrames,
        ieee8021QBridgeTpVlanPortInDiscards
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing per-port frame
        statistics for all VLANs currently configured on this
        device."
    ::= { ieee8021QBridgeGroups 8 }

ieee8021QBridgeLearningConstraintsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeLearningConstraintsType,
        ieee8021QBridgeLearningConstraintsStatus
    }
    STATUS      deprecated
    DESCRIPTION
        "A collection of objects defining the Filtering Database
        constraints all VLANs have with each other."
    ::= { ieee8021QBridgeGroups 9 }

ieee8021QBridgeLearningConstraintDefaultGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeLearningConstraintDefaultsSet,
        ieee8021QBridgeLearningConstraintDefaultsType
    }
    STATUS      deprecated
    DESCRIPTION
        "A collection of objects defining the default Filtering
        Database constraints for VLANs that have no specific
        constraints defined."
    ::= { ieee8021QBridgeGroups 10 }

ieee8021QBridgeClassificationDeviceGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeProtocolGroupId,
        ieee8021QBridgeProtocolGroupRowStatus
    }
    STATUS      current
    DESCRIPTION
        "VLAN classification information for the Bridge."
    ::= { ieee8021QBridgeGroups 11 }

ieee8021QBridgeClassificationPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeProtocolPortGroupVid,
        ieee8021QBridgeProtocolPortRowStatus
    }
    STATUS      current
    DESCRIPTION
        "VLAN classification information for individual ports."
    ::= { ieee8021QBridgeGroups 12 }

ieee8021QBridgePortGroup2 OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgePvid,
        ieee8021QBridgePortAcceptableFrameTypes,
        ieee8021QBridgePortIngressFiltering,
```

```
        ieee8021QBridgePortMvrpEnabledStatus,
        ieee8021QBridgePortMvrpFailedRegistrations,
        ieee8021QBridgePortMvrpLastPduOrigin,
        ieee8021QBridgePortRestrictedVlanRegistration
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing port-level VLAN
        control and status information for all ports."
    ::= { ieee8021QBridgeGroups 13 }

ieee8021QBridgeCVlanPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeCVlanPortRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Objects used to create/delete customer VLAN ports."
    ::= { ieee8021QBridgeGroups 14 }

ieee8021QBridgeVIDXGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeVIDXRelayVid,
        ieee8021QBridgeVIDXRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Ingress or Ingress/Egress VID translation for
        individual ports."
    ::= { ieee8021QBridgeGroups 15 }

ieee8021QBridgeEgressVIDXGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeEgressVidXLocalVid,
        ieee8021QBridgeEgressVidXRowStatus
    }
    STATUS      deprecated
    DESCRIPTION
        "Egress VID translation for individual ports."
    ::= { ieee8021QBridgeGroups 16 }

ieee8021QBridgeEgressVIDXV2Group OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeEgressVidXV2LocalVid,
        ieee8021QBridgeEgressVidXV2RowStatus
    }
    STATUS      current
    DESCRIPTION
        "Egress VID translation for individual ports."
    ::= { ieee8021QBridgeGroups 17 }


-- ================================================================
-- compliance statements
-- ================================================================

ieee8021QBridgeCompliance MODULE-COMPLIANCE
    STATUS  deprecated
    DESCRIPTION
        "The compliance statement for device support of Virtual
        LAN Bridge services."

    MODULE
        MANDATORY-GROUPS {
            ieee8021QBridgeBaseGroup,
            ieee8021QBridgeVlanGroup,
            ieee8021QBridgeVlanStaticGroup,
            ieee8021QBridgePortGroup2
        }

        GROUP       ieee8021QBridgeFdbUnicastGroup
        DESCRIPTION
```

```
    "This group is mandatory for Bridges that implement
    IEEE 802.1Q transparent bridging."

GROUP       ieee8021QBridgeFdbMulticastGroup
DESCRIPTION
    "This group is mandatory for Bridges that implement
    IEEE 802.1Q transparent bridging."
GROUP       ieee8021QBridgeServiceRequirementsGroup
DESCRIPTION
    "This group is mandatory for Bridges that implement
    extended filtering services.  All objects must be
    read-write if extended-filtering services are
    enabled."

GROUP       ieee8021QBridgeFdbStaticGroup
DESCRIPTION
    "This group is optional."

GROUP       ieee8021QBridgeVlanStatisticsGroup
DESCRIPTION
    "This group is optional as there may be significant
    implementation cost associated with its support."

GROUP       ieee8021QBridgeClassificationDeviceGroup
DESCRIPTION
    "This group is mandatory ONLY for devices implementing
     VLAN Classification as specified in IEEE 802.1v."

GROUP       ieee8021QBridgeClassificationPortGroup
DESCRIPTION
    "This group is mandatory ONLY for devices implementing
     VLAN Classification as specified in IEEE 802.1v."

GROUP       ieee8021QBridgeCVlanPortGroup
DESCRIPTION
    "This group is mandatory ONLY for devices supporting
     creation/deletion of customer VLAN ports."

GROUP       ieee8021QBridgeVIDXGroup
DESCRIPTION
    "This group is mandatory ONLY for devices supporting
     VID translation of customer and/or provider VLAN ports."

GROUP       ieee8021QBridgeEgressVIDXGroup
DESCRIPTION
    "This group is mandatory ONLY for devices supporting
     separate Ingress and Egress VID translation of
     of customer and provider VLAN ports."

OBJECT      ieee8021QBridgePortAcceptableFrameTypes
MIN-ACCESS  read-only
DESCRIPTION
    "Write access is not required as this is an optional
    capability in IEEE 802.1Q."

OBJECT      ieee8021QBridgePortIngressFiltering
MIN-ACCESS  read-only
DESCRIPTION
    "Write access is not required as this is an optional
    capability in IEEE 802.1Q."

OBJECT      ieee8021QBridgeLearningConstraintDefaultsSet
MIN-ACCESS  read-only
DESCRIPTION
    "Write access is not required as this is an optional
    capability in IEEE 802.1Q-2012."

OBJECT      ieee8021QBridgeLearningConstraintDefaultsType
MIN-ACCESS  read-only
DESCRIPTION
    "Write access is not required as this is an optional
    capability in IEEE 802.1Q-2012."
```

```
        OBJECT      ieee8021QBridgeProtocolGroupId
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1v."

        OBJECT      ieee8021QBridgeProtocolGroupRowStatus
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1v."

        ::= { ieee8021QBridgeCompliances 1 }

ieee8021QBridgeComplianceV2 MODULE-COMPLIANCE
    STATUS  current
    DESCRIPTION
        "The compliance statement for device support of Virtual
        LAN Bridge services."

    MODULE
        MANDATORY-GROUPS {
            ieee8021QBridgeBaseGroup,
            ieee8021QBridgeVlanGroup,
            ieee8021QBridgeVlanStaticGroup,
            ieee8021QBridgePortGroup2
        }

        GROUP       ieee8021QBridgeFdbUnicastGroup
        DESCRIPTION
            "This group is mandatory for Bridges that implement
            IEEE 802.1Q transparent bridging."

        GROUP       ieee8021QBridgeFdbMulticastGroup
        DESCRIPTION
            "This group is mandatory for Bridges that implement
            IEEE 802.1Q transparent bridging."
        GROUP       ieee8021QBridgeServiceRequirementsGroup
        DESCRIPTION
            "This group is mandatory for Bridges that implement
            extended filtering services.  All objects must be
            read-write if extended-filtering services are
            enabled."

        GROUP       ieee8021QBridgeFdbStaticGroup
        DESCRIPTION
            "This group is optional."

        GROUP       ieee8021QBridgeVlanStatisticsGroup
        DESCRIPTION
            "This group is optional as there may be significant
            implementation cost associated with its support."

        GROUP       ieee8021QBridgeClassificationDeviceGroup
        DESCRIPTION
            "This group is mandatory ONLY for devices implementing
             VLAN Classification as specified in IEEE 802.1v."

        GROUP       ieee8021QBridgeClassificationPortGroup
        DESCRIPTION
            "This group is mandatory ONLY for devices implementing
             VLAN Classification as specified in IEEE 802.1v."

        GROUP       ieee8021QBridgeCVlanPortGroup
        DESCRIPTION
            "This group is mandatory ONLY for devices supporting
             creation/deletion of customer VLAN ports."

        GROUP       ieee8021QBridgeVIDXGroup
        DESCRIPTION
            "This group is mandatory ONLY for devices supporting
```

```
             VID translation of customer and/or provider VLAN ports."

        GROUP       ieee8021QBridgeEgressVIDXV2Group
        DESCRIPTION
            "This group is mandatory ONLY for devices supporting
             separate Ingress and Egress VID translation of
             of customer and provider VLAN ports."

        OBJECT      ieee8021QBridgePortAcceptableFrameTypes
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1Q."

        OBJECT      ieee8021QBridgePortIngressFiltering
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1Q."

        OBJECT      ieee8021QBridgeProtocolGroupId
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1v."

        OBJECT      ieee8021QBridgeProtocolGroupRowStatus
        MIN-ACCESS  read-only
        DESCRIPTION
            "Write access is not required as this is an optional
            capability in IEEE 802.1v."

        ::= { ieee8021QBridgeCompliances 2 }

END
```

17.7.5 Definitions for the IEEE8021-PB-MIB module

```
IEEE8021-PB-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE Std 802.1Q Provider Bridge Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE
        FROM SNMPv2-SMI
    TruthValue, RowStatus
        FROM SNMPv2-TC
    ieee802dot1mibs, IEEE8021PbbComponentIdentifierOrZero,
    IEEE8021PortAcceptableFrameTypes, IEEE8021PriorityValue,
    IEEE8021BridgePortNumberOrZero, IEEE8021BridgePortType
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBasePortComponentId, ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    VlanId, VlanIdOrNone
        FROM Q-BRIDGE-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021PbMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "Provider Bridge MIB module.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            Bug fixes to conformance section."


    REVISION     "201202100000Z" -- February 10, 2012"
    DESCRIPTION
         "Deprecated ieee8021PbVidTranslationTable
          moved the new object to the Q Bridge as part
          of VID translation for IEEE Std 802.1aq."
```

```
    REVISION     "201104060000Z" -- April 6, 2011
    DESCRIPTION
         "Additions to support Remote Customer Service Interfaces."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Change to ieee8021PbEdgePortAcceptableFrameTypes
          permissible values, addition of
          IEEE8021BridgePortNumberOrZero to IMPORTS,
          as part of 2011 revision of IEEE Std 802.1Q."

    REVISION     "201008260000Z" -- August 26, 2010
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          revision of Std 802.1Q."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
        "Initial version."
    ::= { ieee802dot1mibs 5 }

ieee8021PbNotifications  OBJECT IDENTIFIER ::= { ieee8021PbMib 0 }
ieee8021PbObjects        OBJECT IDENTIFIER ::= { ieee8021PbMib 1 }
ieee8021PbConformance    OBJECT IDENTIFIER ::= { ieee8021PbMib 2 }

-- ============================================================
-- ieee8021PbVidTranslationTable:
-- Deprecated and moved VID translation to Q Bridge MIB.
-- ============================================================

ieee8021PbVidTranslationTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbVidTranslationEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "This table is used to configure the VID Translation Table
        defined in 12.10.1.8.  The VID
        Translation Table is used to implement a bidirectional
        mapping between a local S-VID, used in data and protocol
        frames transmitted and received through a CNP or PNP,
        and a relay S-VID, used by the filtering and forwarding
        process.  Each row in this table is indexed by component,
        port, and local S-VID value and indicates the relay S-VID
        value to be used for the specified S-VID.  If no entry for
        a component, port, and local-svid is present in this table
        is present then the relay S-VID used for a frame received
        on that port with the local S-VID value will be the S-VID
        that has the same numeric value as the local S-VID of the
        received frame.

        Entries in this table must be persistent over power up
        restart/reboot."
    REFERENCE   "12.10.1.8"
    ::= { ieee8021PbObjects 1 }

ieee8021PbVidTranslationEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbVidTranslationEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "An entry for the S-VID translation table, which includes
        both the Local and Relay S-VIDs between which the PNP or CNP
        translates.

        Note that the component ID of entries in this table must refer
        to the S-VLAN Component of a Provider Bridge."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021PbVidTranslationLocalVid }
    ::= { ieee8021PbVidTranslationTable 1 }

Ieee8021PbVidTranslationEntry ::= SEQUENCE {
```

```
      ieee8021PbVidTranslationLocalVid
          VlanId,
      ieee8021PbVidTranslationRelayVid
          VlanId,
      ieee8021PbVidTranslationRowStatus
          RowStatus
}

ieee8021PbVidTranslationLocalVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The S-VID on received (transmitted) at the ISS of a CNP or PNP."
    ::= { ieee8021PbVidTranslationEntry 1 }

ieee8021PbVidTranslationRelayVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The translated S-VID delivered (received) over the EISS from a
        CNP or PNP.  The default value of this object on creation will
        be the value of the corresponding instance of
        ieee8021PbVidTranslationLocalVid."
    ::= { ieee8021PbVidTranslationEntry 2 }

ieee8021PbVidTranslationRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "This indicates the status of an entry in this table, and is
        used to create/delete entries.

        It is an implementation specific decision as to whether any
        column in this table may be set while the corresponding
        instance of this object is valid(1)."
    ::= { ieee8021PbVidTranslationEntry 3 }

-- ============================================================
-- ieee8021PbCVidRegistrationTable:
-- ============================================================

ieee8021PbCVidRegistrationTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbCVidRegistrationEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table used in a CEP to create the mapping between a C-VID
        and a service represented by an S-VID.

        Note that the component ID of entries in this table must refer
        to the S-VLAN component of a Provider Edge Bridge and the Port
        Number must refer to the port number of the Customer Edge Port
        associated with that Provider Edge Bridge.

        Entries in this table must be persistent over power up
        restart/reboot."
    REFERENCE   "12.13.2.1, 12.13.2.2"
    ::= { ieee8021PbObjects 2 }

ieee8021PbCVidRegistrationEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbCVidRegistrationEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An element of the C-VID registration table accessed by PB
        C-VLAN component, Customer Edge Port Bridge Port number, and
        C-VID.  Each element contains the mapping between a C-VID and
        the S-VID that carries the service and booleans for handling
        untagged frames at the PEP and CEP."
```

```
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021PbCVidRegistrationCVid }
    ::= { ieee8021PbCVidRegistrationTable 1 }

Ieee8021PbCVidRegistrationEntry ::= SEQUENCE {
      ieee8021PbCVidRegistrationCVid
          VlanId,
      ieee8021PbCVidRegistrationSVid
          VlanId,
      ieee8021PbCVidRegistrationUntaggedPep
          TruthValue,
      ieee8021PbCVidRegistrationUntaggedCep
          TruthValue,
      ieee8021PbCVidRegistrationRowStatus
          RowStatus
}

ieee8021PbCVidRegistrationCVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "C-VID of this C-VID registration entry."
    ::= { ieee8021PbCVidRegistrationEntry 1 }

ieee8021PbCVidRegistrationSVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "S-VID for this C-VID registration entry."
    ::= { ieee8021PbCVidRegistrationEntry 2 }

ieee8021PbCVidRegistrationUntaggedPep OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A flag indicating if this C-VID should be carried untagged
        at the PEP.  A value of true(1) means untagged."
    DEFVAL { true }
    ::= { ieee8021PbCVidRegistrationEntry 3 }

ieee8021PbCVidRegistrationUntaggedCep OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A flag indicating if this C-VID should be carried untagged
        at the CEP.  A value of true(1) means untagged."
    DEFVAL { true }
    ::= { ieee8021PbCVidRegistrationEntry 4 }

ieee8021PbCVidRegistrationRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of an entry in this table, and is
        used to create/delete entries.

        The value of ieee8021PbCVidRegistrationSVid must be set before
        an entry in this table can be made valid.

        It is an implementation specific decision as to whether any
        column in this table may be set while the corresponding
        instance of this object is valid(1)."
    ::= { ieee8021PbCVidRegistrationEntry 5 }

-- ============================================================
-- ieee8021PbEdgePortTable:
```

```
-- ============================================================

ieee8021PbEdgePortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbEdgePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A Provider Edge Port (PEP) table that indicates the subset of
        parameters needed for each PEP."
    REFERENCE   "12.13.2.3, 12.13.2.4"
    ::= { ieee8021PbObjects 3 }

ieee8021PbEdgePortEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbEdgePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry in the PEP table indexed by ComponentID and S-VID and
        containing parameters used to configure ingress filtering on
        the PEP, thus affecting traffic transiting from the provider
        network to the customer edge port.  The columns allow the
        default C-VID value and default priority to be specified
        and PEP's ingress filtering operation to be controlled.

        Note that the component ID of entries in this table must refer
        to an S-VLAN component of a provider edge Bridge and the Bridge
        Port number must refer to the port number of a Customer Edge
        Port associated with that Provider Edge Bridge."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021PbEdgePortSVid }
    ::= { ieee8021PbEdgePortTable 1 }

Ieee8021PbEdgePortEntry ::= SEQUENCE {
      ieee8021PbEdgePortSVid
          VlanId,
      ieee8021PbEdgePortPVID
          VlanId,
      ieee8021PbEdgePortDefaultUserPriority
          IEEE8021PriorityValue,
      ieee8021PbEdgePortAcceptableFrameTypes
          IEEE8021PortAcceptableFrameTypes,
      ieee8021PbEdgePortEnableIngressFiltering
          TruthValue
}

ieee8021PbEdgePortSVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The 12 bit S-VID associated with the PEP."
    ::= { ieee8021PbEdgePortEntry 1 }

ieee8021PbEdgePortPVID OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "A 12-bit C-VID to be used for untagged frames received at
        the Provider Edge Port."
    ::= { ieee8021PbEdgePortEntry 2 }

ieee8021PbEdgePortDefaultUserPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "An integer range 0-7 to be used for untagged frames received
        at the Provider Edge Port."
    ::= { ieee8021PbEdgePortEntry 3 }
```

```
ieee8021PbEdgePortAcceptableFrameTypes OBJECT-TYPE
    SYNTAX      IEEE8021PortAcceptableFrameTypes
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "the Acceptable Frame Types for frames received at the PEP.
        The permissible values for the parameter are:
            1) Admit all frames;
            2) Admit only untagged and Priority-tagged frames;
            3) Admit only VLAN-tagged frames."
    DEFVAL { admitAll }
    ::= { ieee8021PbEdgePortEntry 4 }

ieee8021PbEdgePortEnableIngressFiltering OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "Filtering parameter for frames received at the PEP.
        The permissible values for the parameter are:
            true(1)  Enabled;
            false(2) Disabled."
    DEFVAL { true }
    ::= { ieee8021PbEdgePortEntry 5 }

-- ============================================================
-- ieee8021PbServicePriorityRegenerationTable:
-- ============================================================

ieee8021PbServicePriorityRegenerationTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbServicePriorityRegenerationEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The priority regeneration table for this PEP."
    REFERENCE   "12.13.2.5, 12.13.2.6"
    ::= { ieee8021PbObjects 4 }

ieee8021PbServicePriorityRegenerationEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbServicePriorityRegenerationEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An element of the PEP priority regeneration table indexed
        by Component ID, Bridge Port number, S-VID, and received
        priority.  Each element contains the regenerated priority.

        Note that the component ID of entries in this table must refer
        to the S-VLAN component of a Provider Edge Bridge and the Port
        Number must refer to the port number of the Customer Edge Port
        associated with that S-VLAN component."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021PbServicePriorityRegenerationSVid,
            ieee8021PbServicePriorityRegenerationReceivedPriority }
    ::= { ieee8021PbServicePriorityRegenerationTable 1 }

Ieee8021PbServicePriorityRegenerationEntry ::= SEQUENCE {
      ieee8021PbServicePriorityRegenerationSVid
          VlanId,
      ieee8021PbServicePriorityRegenerationReceivedPriority
          IEEE8021PriorityValue,
      ieee8021PbServicePriorityRegenerationRegeneratedPriority
          IEEE8021PriorityValue
}

ieee8021PbServicePriorityRegenerationSVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "S-VID for this regeneration table entry."
```

```
    ::= { ieee8021PbServicePriorityRegenerationEntry 1 }

ieee8021PbServicePriorityRegenerationReceivedPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Received priority for this regeneration table entry."
    ::= { ieee8021PbServicePriorityRegenerationEntry 2 }

ieee8021PbServicePriorityRegenerationRegeneratedPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The regenerated priority contained in this regeneration table
        entry."
    ::= { ieee8021PbServicePriorityRegenerationEntry 3 }

-- ============================================================
-- ieee8021PbCnpTable
-- ============================================================

ieee8021PbCnpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbCnpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is used for dynamic creation and deletion of
        Customer Network Ports on S-VLAN components or I-components.
        Creation of an entry in this table will implicitly also
        create a corresponding entry in the ieee8021BridgeBasePortTable.

        Entries in this table must be persistent across reinitializations
        of the management system."
    REFERENCE   "12.13.2"
    ::= { ieee8021PbObjects 5 }

ieee8021PbCnpEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbCnpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Represents a dynamically created Customer Network Port."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort }
    ::= { ieee8021PbCnpTable 1 }

Ieee8021PbCnpEntry ::= SEQUENCE {
    ieee8021PbCnpCComponentId
        IEEE8021PbbComponentIdentifierOrZero,
    ieee8021PbCnpSVid
        VlanIdOrNone,
    ieee8021PbCnpRowStatus
        RowStatus
}

ieee8021PbCnpCComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifierOrZero
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The component ID of the C-Vlan component if this is an
        internal customer network port.  The value must be 0 for
        an external customer network port.

        This value must be consistent with the value of the
        corresponding instance of ieee8021PbCnpSVid.
        Both must be non-zero, or both must be zero."
    ::= { ieee8021PbCnpEntry 1 }

ieee8021PbCnpSVid OBJECT-TYPE
```

```
    SYNTAX      VlanIdOrNone
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The S-VID for service for an internal customer network port.
        For an external port, this value must be 0.

        This value must be consistent with the value of the
        corresponding instance of ieee8021PbCnpCComponentId.
        Both must be non-zero, or both must be zero."
    ::= { ieee8021PbCnpEntry 2 }

ieee8021PbCnpRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object is used for creation/deletion of entries in
        this table.

        All columns in this table must have valid values before
        this object can be set to active(1).

        While the value of this object is active(1), the values
        of other columns in the same entry may not be modified."
    ::= { ieee8021PbCnpEntry 3 }

-- ============================================================
-- ieee8021PbPnpTable
-- ============================================================

ieee8021PbPnpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbPnpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is used for dynamic creation and deletion of
        Provider Network Ports on S-VLAN components or B-components.
        Creation of an entry in this table will implicitly also
        create a corresponding entry in the ieee8021BridgeBasePortTable.

        Entries in this table must be persistent across reinitializations
        of the management system."
    REFERENCE   "12.13.1"
    ::= { ieee8021PbObjects 6 }

ieee8021PbPnpEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbPnpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Represents a dynamically created Provider Network Port."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort }
    ::= { ieee8021PbPnpTable 1 }

Ieee8021PbPnpEntry ::= SEQUENCE {
    ieee8021PbPnpRowStatus
        RowStatus
}

ieee8021PbPnpRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object is used for creation/deletion of entries in
        this table."
    ::= { ieee8021PbPnpEntry 1 }

-- ============================================================
-- ieee8021PbCepTable
```

```
-- ============================================================

ieee8021PbCepTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbCepEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This table is used to create Customer Edge Ports, CEPs, on a
        provider edge Bridge.  It is indexed by the ComponentId of the
        PEB's S-VLAN component and by the port number for the CEP.  Note that
        the CEP's port number belongs to the set of port numbers
        associated with the PEB's S-VLAN component.

        Entries in this table must be persistent across reinitializations
        of the management system.  However, note that some column values,
        as noted below, may change across system reinitializations."
    ::= { ieee8021PbObjects 7 }

ieee8021PbCepEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbCepEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The entry of the ieee8021PbCepTable.  Note that the component
         index must refer to the S-VLAN component of a PEB, and that the port
         number for the CEP is allocated from the port number space of
         that S-VLAN component."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort }
    ::= { ieee8021PbCepTable 1 }

Ieee8021PbCepEntry ::=
    SEQUENCE {
        ieee8021PbCepCComponentId  IEEE8021PbbComponentIdentifierOrZero,
        ieee8021PbCepCepPortNumber IEEE8021BridgePortNumberOrZero,
        ieee8021PbCepRowStatus     RowStatus
    }

ieee8021PbCepCComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifierOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This column is an implementation specific column that may be
         used to map the C component associated with this CEP to other
         tables within the system, such as the Entity MIB.  This
         column may not be created or modified by management station
         action.  A value of 0 is always legal, and non-zero values
         will be interpreted in an implementation specific manner.
         The value of this column may or may not persist across system
         restarts."
    ::= { ieee8021PbCepEntry 1 }

ieee8021PbCepCepPortNumber  OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This column is an implementation specific column that may be
         used to map the CEP to other tables within the system, for
         example the Entity MIB.  This column may not be created or
         modified by management station action.  A value of 0 is
         always legal, and non-zero values will be interpreted in an
         implementation specific manner.  The value of this column
         may or may not persist across system restarts."
    ::= { ieee8021PbCepEntry 2 }

ieee8021PbCepRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
```

```
        "This indicates the status of the entry, and is used to create
        and delete entries in this table."
    ::= { ieee8021PbCepEntry 3 }

-- ============================================================
-- ieee8021PbRcapTable
-- ============================================================

ieee8021PbRcapTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbRcapEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This table is used to create Remote Customer Access Ports, on a
        provider edge Bridge.  It is indexed by the ComponentId of the
        PEB's S-VLAN component and by the port number for the RCAP.  Note that
        the index port number belongs to the set of port numbers
        associated with the PEB's primary S-VLAN component.

        Entries in this table must be persistent across reinitializations
        of the management agent.  However, note that some column values,
        as noted below, may change across system reinitializations."
    ::= { ieee8021PbObjects 8 }

ieee8021PbRcapEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbRcapEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The entry of the ieee8021PbRcapTable.  Note that the component
         index must refer to the primary S-VLAN component of a PEB, and that
         the port number index for the RCAP is allocated from the port
         number space of that S-VLAN component."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort }
    ::= { ieee8021PbRcapTable 1 }

Ieee8021PbRcapEntry ::=
    SEQUENCE {
        ieee8021PbRcapSComponentId   IEEE8021PbbComponentIdentifierOrZero,
        ieee8021PbRcapRcapPortNumber IEEE8021BridgePortNumberOrZero,
        ieee8021PbRcapRowStatus      RowStatus
    }

ieee8021PbRcapSComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifierOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This column is an implementation specific column that may be
         used to map the Port-mapping S-VLAN component associated with
         this RCAP to other tables within the system, such as the
         Entity MIB.  This column may not be created or modified
         by management station action.  A value of 0 is always legal,
         and non-zero values will be interpreted in an implementation
         specific manner. The value of this column may or may not
         persist across system restarts."
    ::= { ieee8021PbRcapEntry 1 }

ieee8021PbRcapRcapPortNumber  OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This column is an implementation specific column that may be
         used to map the RCAP to other tables within the system, for
         example the Entity MIB.  This column may not be created or
         modified by management station action.  A value of 0 is
         always legal, and non-zero values will be interpreted in an
         implementation specific manner.  The value of this column
         may or may not persist across system restarts."
    ::= { ieee8021PbRcapEntry 2 }
```

```
ieee8021PbRcapRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of the entry, and is used to create
        and delete entries in this table."
    ::= { ieee8021PbRcapEntry 3 }

-- ============================================================
-- ieee8021PbInternalInterfaceTable:
-- ============================================================

ieee8021PbInternalInterfaceTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbIiEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table used in a Port-mapping S-VLAN component associated with
        a Remote Customer Access Port to manage the mapping between
        external S-VIDs and internal interfaces/S-VIDs.

        Note that the component ID of entries in this table must refer
        to the primary S-VLAN component of a Provider Edge Bridge and
        the Port Number must refer to the port number of a Remote
        Customer Access Port associated with that S-VLAN component.

        Entries in this table must be persistent over power up
        restart/reboot."
    REFERENCE   "12.13.3.1, 12.13.3.2"
    ::= { ieee8021PbObjects 9 }

ieee8021PbIiEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbIiEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An element of the internal interface table accessed by PB
        S-VLAN component ID, Remote Customer Access Port Bridge Port
        number, and external S-VID.  Each element contains the mapping
        between an external S-VID and the internal port it selects and,
        except in the case of a C-tagged service interface the
        internal S-VID that carries the service ."
    INDEX { ieee8021BridgeBasePortComponentId,
            ieee8021BridgeBasePort,
            ieee8021PbIiExternalSVid }
    ::= { ieee8021PbInternalInterfaceTable 1 }

Ieee8021PbIiEntry ::= SEQUENCE {
      ieee8021PbIiExternalSVid       VlanId,
      ieee8021PbIiInternalPortNumber IEEE8021BridgePortNumberOrZero,
      ieee8021PbIiInternalPortType   IEEE8021BridgePortType,
      ieee8021PbIiInternalSVid       VlanIdOrNone,
      ieee8021PbIiRowStatus          RowStatus
}

ieee8021PbIiExternalSVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "External S-VID for this internal interface table entry."
    ::= { ieee8021PbIiEntry 1 }

ieee8021PbIiInternalPortNumber OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The port number for the internal port on the primary
        S-VLAN component.  This port number is used in FDB entries
```

```
        that reference an RCSI.

        The port number of the Remote Customer Access Port can
        be used to identify a PNP on the primary S-VLAN component
        connected to a PNP on the Port-mapping S-VLAN component."
    ::= { ieee8021PbIiEntry 2 }

ieee8021PbIiInternalPortType OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The port type of the internal port on the primary
        S-VLAN component. This indicates the type of RCSI as follows:

             providerNetworkPort(3) - Indicates a PNP (not an RCSI)
             customerNetworkPort(4) - Indicates a Port-based RCSI
             customerEdgePort(5) - Indicates a C-tagged RCSI

        Other port type values are not valid for this field."
    ::= { ieee8021PbIiEntry 3 }

ieee8021PbIiInternalSVid OBJECT-TYPE
    SYNTAX      VlanIdOrNone
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Internal S-VID for this external S-VID entry."
    ::= { ieee8021PbIiEntry 4 }

ieee8021PbIiRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of an entry in this table, and is
        used to create/delete entries.

        The value of ieee8021PbIiExternalSVid must be set before
        an entry in this table can be made valid.deprecated

        It is an implementation specific decision as to whether any
        column in this table may be set while the corresponding
        instance of this object is valid(1)."
    ::= { ieee8021PbIiEntry 5 }

-- ============================================================
-- Conformance Information
-- ============================================================

ieee8021PbGroups
    OBJECT IDENTIFIER ::= { ieee8021PbConformance 1 }
ieee8021PbCompliances
    OBJECT IDENTIFIER ::= { ieee8021PbConformance 2 }

-- ============================================================
-- Units of conformance
-- ============================================================

ieee8021PbVidTranslationGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbVidTranslationRelayVid,
        ieee8021PbVidTranslationRowStatus
    }
    STATUS      deprecated
    DESCRIPTION
        "The collection of objects used to represent a PB
        C-VID/S-VID translation."
    ::= { ieee8021PbGroups 1 }

ieee8021PbCVidRegistrationGroup OBJECT-GROUP
    OBJECTS {
```

```
        ieee8021PbCVidRegistrationSVid,
        ieee8021PbCVidRegistrationUntaggedPep,
        ieee8021PbCVidRegistrationUntaggedCep,
        ieee8021PbCVidRegistrationRowStatus
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent a CEP translation."
    ::= { ieee8021PbGroups 2 }

ieee8021PbEdgePortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbEdgePortPVID,
        ieee8021PbEdgePortDefaultUserPriority,
        ieee8021PbEdgePortAcceptableFrameTypes,
        ieee8021PbEdgePortEnableIngressFiltering
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects user to represent a PEP."
    ::= { ieee8021PbGroups 3 }

ieee8021PbServicePriorityRegenerationGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbServicePriorityRegenerationRegeneratedPriority
    }
    STATUS      current
    DESCRIPTION
        "A regenerated priority value for a PEP."
    ::= { ieee8021PbGroups 4 }

ieee8021PbDynamicCnpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbCnpCComponentId,
        ieee8021PbCnpSVid,
        ieee8021PbCnpRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of customer network ports."
    ::= { ieee8021PbGroups 5 }

ieee8021PbDynamicPnpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbPnpRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of provider network ports."
    ::= { ieee8021PbGroups 6 }

ieee8021PbDynamicCepGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbCepCComponentId,
        ieee8021PbCepCepPortNumber,
        ieee8021PbCepRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of customer edge ports."
    ::= { ieee8021PbGroups 7 }

ieee8021PbDynamicRcapGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbRcapSComponentId,
        ieee8021PbRcapRcapPortNumber,
        ieee8021PbCepRowStatus
    }
    STATUS      deprecated
```

```
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of remote customer access ports."
    ::= { ieee8021PbGroups 8 }

ieee8021PbInternalInterfaceGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbIiInternalPortNumber,
        ieee8021PbIiInternalPortType,
        ieee8021PbIiInternalSVid,
        ieee8021PbIiRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of internal interfaces on a Port-mapping S-VLAN component."
    ::= { ieee8021PbGroups 9 }

ieee8021PbDynamicRcapV2Group OBJECT-GROUP
    OBJECTS {
        ieee8021PbRcapSComponentId,
        ieee8021PbRcapRcapPortNumber,
        ieee8021PbRcapRowStatus
    }
    STATUS      current
    DESCRIPTION
        "A set of objects used for dynamic creation and deletion
        of remote customer access ports."
    ::= { ieee8021PbGroups 10 }


-- ================================================================
-- Compliance statements
-- ================================================================

ieee8021PbCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for device support of Provider
         Bridge services."

    MODULE
        MANDATORY-GROUPS {
            ieee8021PbVidTranslationGroup,
            ieee8021PbCVidRegistrationGroup,
            ieee8021PbEdgePortGroup,
            ieee8021PbServicePriorityRegenerationGroup
        }

        GROUP       ieee8021PbDynamicCnpGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of customer network ports."

        GROUP       ieee8021PbDynamicPnpGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of provider network ports."

        GROUP       ieee8021PbDynamicCepGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of customer edge ports."

        GROUP       ieee8021PbDynamicRcapGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of remote customer access ports."

        GROUP       ieee8021PbInternalInterfaceGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
```

```
            and deletion of internal interfaces on Port-mapping
            S-VLAN components."

    ::= { ieee8021PbCompliances 1 }

ieee8021PbComplianceV2 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for device support of Provider
         Bridge services."

    MODULE
        MANDATORY-GROUPS {
            ieee8021PbCVidRegistrationGroup,
            ieee8021PbEdgePortGroup,
            ieee8021PbServicePriorityRegenerationGroup
        }

        GROUP       ieee8021PbDynamicCnpGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of customer network ports."

        GROUP       ieee8021PbDynamicPnpGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of provider network ports."

        GROUP       ieee8021PbDynamicCepGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of customer edge ports."

        GROUP       ieee8021PbDynamicRcapV2Group
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of remote customer access ports."

        GROUP       ieee8021PbInternalInterfaceGroup
        DESCRIPTION
            "This group is optional and supports dynamic creation
            and deletion of internal interfaces on Port-mapping
            S-VLAN components."

    ::= { ieee8021PbCompliances 2 }

END
```

17.7.6 Definitions for the IEEE8021-MSTP-MIB module

```
IEEE8021-MSTP-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q Multiple Spanning Tree Bridge Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Integer32, Counter64,
    Unsigned32, TimeTicks
        FROM SNMPv2-SMI
    TruthValue, RowStatus
        FROM SNMPv2-TC
    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber, IEEE8021VlanIndex,
    IEEE8021MstIdentifier
        FROM IEEE8021-TC-MIB
    BridgeId
        FROM BRIDGE-MIB
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021MstpMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB modules for managing devices that support
         IEEE Std 802.1Q multiple spanning tree groups.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            Instances of ...value of mstp(2)... changed to
            ...value of mstp(3).
            Defval for ieee8021MstpCistPortAdminEdgePort
            changed to false.
            ieee8021MstpVlanV2Table DESCRIPTION updated
            (4094 not 4096).
            Bug fixes to conformance section."
```

```
    REVISION     "201208100000Z" -- August 10, 2012
    DESCRIPTION
         "Updated cross references to other clauses, particularly
         Clause 13, as part of IEEE 802.1Q Cor-2."

    REVISION     "201112120000Z" -- December 12, 2011
    DESCRIPTION
         "Deprecated ieee8021MstpFidToMstiTable for an identical
          ieee8021MstpFidToMstiV2Table to add 4095 to the range
          of ieee8021MstpFidToMstiV2Fid  and to add 0 and 4095 to
          the range of ieee8021MstpFidToMstiV2MstId for IEEE Std 802.1aq.
          Deprecated ieee8021MstpVlanTable for an identical
          ieee8021MstpVlanV2Table to add 0 & 4095 to the range
          of ieee8021MstpVlanV2MstId for IEEE Std 802.1aq"

    REVISION     "201103230000Z" -- March 23, 2011
    DESCRIPTION
         "Minor edits to contact information, correction to range of
          ieee8021MstpCistMaxHops and addition of fragile Bridge
          as part of 2011 revision of IEEE Std 802.1Q."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
        "Initial version."
    ::= { ieee802dot1mibs 6 }

ieee8021MstpNotifications  OBJECT IDENTIFIER ::= { ieee8021MstpMib 0 }
ieee8021MstpObjects        OBJECT IDENTIFIER ::= { ieee8021MstpMib 1 }
ieee8021MstpConformance    OBJECT IDENTIFIER ::= { ieee8021MstpMib 2 }

-- ================================================================
-- MSTP CIST Table
-- ================================================================

ieee8021MstpCistTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpCistEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Common and Internal Spanning Tree (CIST) Table. Each row in
         the table represents information regarding a Bridge's Bridge
         Protocol Entity for the CIST.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3).

         This table contains objects corresponding to the following items
         from 12.8.1.1 and 12.8.1.3.  Some of those items are provided
         in the IEEE8021-SPANNING-TREE-MIB as noted below.

         From 12.8.1.1:
             Items a), c), o), p), and q) are defined in this table
             The remaining items are covered in the
             IEEE8021-SPANNING-TREE-MIB:
                 b) ieee8021SpanningTreeTimeSinceTopologyChange
                 c) ieee8021SpanningTreeTopChanges
                 e) ieee8021SpanningTreeDesignatedRoot
                 f) ieee8021SpanningTreeRootCost
                 g) ieee8021SpanningTreeRootPort
                 h) ieee8021SpanningTreeMaxAge
                 i) ieee8021SpanningTreeForwardDelay
                 j) ieee8021SpanningTreeBridgeMaxAge
                 k) ieee8021SpanningTreeBridgeHelloTime
                 l) ieee8021SpanningTreeBridgeForwardDelay
                 m) ieee8021SpanningTreeHoldTime
                 n) ieee8021SpanningTreeVersion
         From 12.8.1.3:
             Item g) is defined in this table
             The remaining items are covered in the
```

```
             IEEE8021-SPANNING-TREE-MIB:
                 a) ieee8021SpanningTreeBridgeMaxAge
                 b) ieee8021SpanningTreeBridgeHelloTime
                 c) ieee8021SpanningTreeBridgeForwardDelay
                 d) ieee8021SpanningTreePriority
                 e) ieee8021SpanningTreeVersion
                 f) ieee8021RstpStpExtTxHoldCount"
    REFERENCE   "12.8.1.1, 12.8.1.3"
    ::= { ieee8021MstpObjects 1 }

ieee8021MstpCistEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpCistEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A CIST Table entry."
    INDEX { ieee8021MstpCistComponentId }
    ::= { ieee8021MstpCistTable 1 }

Ieee8021MstpCistEntry ::= SEQUENCE {
    ieee8021MstpCistComponentId             IEEE8021PbbComponentIdentifier,
    ieee8021MstpCistBridgeIdentifier        BridgeId,
    ieee8021MstpCistTopologyChange          TruthValue,
    ieee8021MstpCistRegionalRootIdentifier  BridgeId,
    ieee8021MstpCistPathCost                Unsigned32,
    ieee8021MstpCistMaxHops                 Integer32
}

ieee8021MstpCistComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpCistEntry 1 }

ieee8021MstpCistBridgeIdentifier OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Bridge Identifier for the CIST."
    REFERENCE   "12.8.1.1"
    ::= { ieee8021MstpCistEntry 2 }

ieee8021MstpCistTopologyChange OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an STP Bridge, the value of the Topology Change parameter
        (14.8.1.1.3, item d of IEEE Std 802.1D, 2004 Edition), or in
        an RSTP or MSTP Bridge, asserted if the tcWhile timer for any
        Port for the CIST is non-zero."
    REFERENCE   "13.25.9, 14.8.1.1.3:d of IEEE Std 802.1D-2004"
    ::= { ieee8021MstpCistEntry 3 }

ieee8021MstpCistRegionalRootIdentifier OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the CIST Regional Root Identifier parameter,
         i.e., the Bridge Identifier of the current CIST Regional Root."
    REFERENCE   "13.16.4, 13.26.3"
    ::= { ieee8021MstpCistEntry 4 }

ieee8021MstpCistPathCost OBJECT-TYPE
    SYNTAX      Unsigned32 (0..2147483647)
```

```
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the CIST Path Cost parameter, i.e., the CIST
         path cost from the transmitting Bridge to the CIST Regional Root.
         The sum (about 20 possible out of the given range) of multiple
         port path costs. Also, if the 'transmitting Bridge' is
         the 'CIST Regional Root', then this value could be zero."
    REFERENCE   "13.9:d, 13.10"
    ::= { ieee8021MstpCistEntry 5 }

ieee8021MstpCistMaxHops OBJECT-TYPE
    SYNTAX      Integer32 (6..40)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the MaxHops parameter.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "13.26.4"
    ::= { ieee8021MstpCistEntry 6 }

-- ============================================================
-- ieee8021MstpTable:
-- ============================================================

ieee8021MstpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the MSTP Table. Each row in the Table
         represents information regarding a Bridge's Bridge Protocol
         Entity for the specified Spanning Tree instance.

         Entries in this table MUST be retained across
         reinitializations of the management system.

         Note that entries can be created in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.8.1.2, 12.8.1.4, 12.12.3.2, 12.12.1"
    ::= { ieee8021MstpObjects 2 }

ieee8021MstpEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A MSTP Table entry."
    INDEX { ieee8021MstpComponentId, ieee8021MstpId }
    ::= { ieee8021MstpTable 1 }

Ieee8021MstpEntry ::= SEQUENCE {
      ieee8021MstpComponentId              IEEE8021PbbComponentIdentifier,
      ieee8021MstpId                       IEEE8021MstIdentifier,
      ieee8021MstpBridgeId                 BridgeId,
      ieee8021MstpTimeSinceTopologyChange  TimeTicks,
      ieee8021MstpTopologyChanges          Counter64,
      ieee8021MstpTopologyChange           TruthValue,
      ieee8021MstpDesignatedRoot           BridgeId,
      ieee8021MstpRootPathCost             Integer32,
      ieee8021MstpRootPort                 IEEE8021BridgePortNumber,
      ieee8021MstpBridgePriority           Integer32,
      ieee8021MstpVids0                    OCTET STRING,
      ieee8021MstpVids1                    OCTET STRING,
      ieee8021MstpVids2                    OCTET STRING,
      ieee8021MstpVids3                    OCTET STRING,
      ieee8021MstpRowStatus                RowStatus
}
```

```
ieee8021MstpComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpEntry 1 }

ieee8021MstpId OBJECT-TYPE
    SYNTAX      IEEE8021MstIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, this parameter is the MSTID, i.e., the
         identifier of a Spanning Tree (or MST) Instance."
    ::= { ieee8021MstpEntry 2 }

ieee8021MstpBridgeId OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Bridge Identifier for the MSTI."
    REFERENCE   "13.26.2"
    ::= { ieee8021MstpEntry 3 }

ieee8021MstpTimeSinceTopologyChange OBJECT-TYPE
    SYNTAX      TimeTicks
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, count in seconds of the time elapsed since
         tcWhile was last non-zero for any Port for the MSTI."
    REFERENCE   "13.25.9"
    ::= { ieee8021MstpEntry 4 }

ieee8021MstpTopologyChanges OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "topology changes"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, count of the times tcWhile has been
         non-zero for any Port for the MSTI since the Bridge was powered
         on or initialized."
    REFERENCE   "13.25.9"
    ::= { ieee8021MstpEntry 5 }

ieee8021MstpTopologyChange OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Topology Change parameter value: true(1)
         if tcWhile is non-zero for any Port for the MSTI."
    REFERENCE   "13.25.9"
    ::= { ieee8021MstpEntry 6 }

ieee8021MstpDesignatedRoot OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Designated Root parameter value, i.e., the
         Bridge Identifier of the Root Bridge for the MSTI."
    REFERENCE   "13.27.20"
    ::= { ieee8021MstpEntry 7 }
```

```
ieee8021MstpRootPathCost OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Root Path Cost parameter value, i.e., the
         path cost from the transmitting Bridge to the Root Bridge for
         the MSTI."
    REFERENCE   "13.27.20"
    ::= { ieee8021MstpEntry 8 }

ieee8021MstpRootPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Root Port parameter value, i.e., the Root
         Port for the MSTI."
    REFERENCE   "13.26.9"
    ::= { ieee8021MstpEntry 9 }

ieee8021MstpBridgePriority OBJECT-TYPE
    SYNTAX      Integer32 (0..61440)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Bridge Priority parameter value for the
         MSTI, i.e., the most significant 4 bits of the Bridge Identifier
         for the MSTI."
    REFERENCE   "13.26.3"
    ::= { ieee8021MstpEntry 10 }

ieee8021MstpVids0 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(128))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object contains the first 1024 bits of the 4096 bit vector
         indicating which VIDs are assigned to this MSTID.  The high order
         bit of the first octet corresponds to the first bit of the vector,
         while the low order bit of the last octet corresponds to the last
         bit of this portion of the vector.  A bit that is on (equal to 1)
         indicates that the corresponding VID is assigned to this MSTID."
    ::= { ieee8021MstpEntry 11 }

ieee8021MstpVids1 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(128))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object contains the second 1024 bits of the 4096 bit vector
         indicating which VIDs are assigned to this MSTID.  The high order
         bit of the first octet corresponds to the first bit of this
         portion of the vector, while the low order bit of the last octet
         corresponds to the last bit of this portion of the vector.  A bit
         that is on (equal to 1) indicates that the corresponding VID is
         assigned to this MSTID."
    ::= { ieee8021MstpEntry 12 }

ieee8021MstpVids2 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(128))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object contains the third 1024 bits of the 4096 bit vector
         indicating which VIDs are assigned to this MSTID.  The high order
         bit of the first octet corresponds to the first bit of this
         portion of the vector, while the low order bit of the last octet
         corresponds to the last bit of this portion of the vector.  A bit
         that is on (equal to 1) indicates that the corresponding VID is
         assigned to this MSTID."
```

```
    ::= { ieee8021MstpEntry 13 }

ieee8021MstpVids3 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(128))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object contains the fourth 1024 bits of the 4096 bit vector
         indicating which VIDs are assigned to this MSTID.  The high order
         bit of the first octet corresponds to the first bit of this
         portion of the vector, while the low order bit of the last octet
         corresponds to the last bit of this portion of the vector.  A bit
         that is on (equal to 1) indicates that the corresponding VID is
         assigned to this MSTID."
    ::= { ieee8021MstpEntry 14 }

ieee8021MstpRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of the row.

         Read SNMPv2-TC (RFC2579) for an
         explanation of the possible values this object can take.

         The writable columns in a row cannot be changed if the row
         is active. All columns must have a valid value before a row
         can be activated."
    ::= { ieee8021MstpEntry 15 }

-- ============================================================
-- ieee8021MstpCistPortTable:
-- ============================================================

ieee8021MstpCistPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpCistPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The CIST Port Table. Each row in the Table represents information
         regarding a specific Port within the Bridge's Bridge Protocol
         Entity, for the CIST.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3).

         This table contains objects corresponding to the following items
         from 12.8.2.1, 12.8.2.3, and 12.8.2.5.  Some of those items are
         provided in the IEEE8021-SPANNING-TREE-MIB as noted below.

         From 12.8.2.1:
             Items a), d), e), and i) through w) are defined in this table
             The remaining items are covered in the
             IEEE8021-SPANNING-TREE-MIB:
                 b) ieee8021SpanningTreePortState
                 c) ieee8021SpanningTreePortPriority
                 d) ieee8021SpanningTreePortPathCost
                 f) ieee8021SpanningTreePortDesignatedCost
                 g) ieee8021SpanningTreePortDesignatedBridge
                 h) ieee8021SpanningTreePortDesignatedPort
         From 12.8.2.3:
             Items a), b), and d) through h) are defined in this table
                 (item a is the index)
             The remaining items are covered in the
             IEEE8021-SPANNING-TREE-MIB:
                 b) ieee8021SpanningTreePortPathCost,
```

```
                c) ieee8021SpanningTreePortPriority
            From 12.8.2.5:
                All items are defined in this table
            Also from 12.8.2.1:
                Items u), v), w), and x) are defined in this table
            Also from 12.8.2.3:
                Items i), j), k), and l) are defined in this table"
    REFERENCE   "12.8.2.1, 12.8.2.3, 12.8.2.5"
    ::= { ieee8021MstpObjects 3 }

ieee8021MstpCistPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpCistPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A CIST Port Table entry."
    INDEX { ieee8021MstpCistPortComponentId, ieee8021MstpCistPortNum }
    ::= { ieee8021MstpCistPortTable 1 }

Ieee8021MstpCistPortEntry ::= SEQUENCE {
    ieee8021MstpCistPortComponentId          IEEE8021PbbComponentIdentifier,
    ieee8021MstpCistPortNum                  IEEE8021BridgePortNumber,
    ieee8021MstpCistPortUptime               TimeTicks,
    ieee8021MstpCistPortAdminPathCost        Integer32,
    ieee8021MstpCistPortDesignatedRoot       BridgeId,
    ieee8021MstpCistPortTopologyChangeAck    TruthValue,
    ieee8021MstpCistPortHelloTime            Integer32,
    ieee8021MstpCistPortAdminEdgePort        TruthValue,
    ieee8021MstpCistPortOperEdgePort         TruthValue,
    ieee8021MstpCistPortMacEnabled           TruthValue,
    ieee8021MstpCistPortMacOperational       TruthValue,
    ieee8021MstpCistPortRestrictedRole       TruthValue,
    ieee8021MstpCistPortRestrictedTcn        TruthValue,
    ieee8021MstpCistPortRole                 INTEGER,
    ieee8021MstpCistPortDisputed             TruthValue,
    ieee8021MstpCistPortCistRegionalRootId   BridgeId,
    ieee8021MstpCistPortCistPathCost         Unsigned32,
    ieee8021MstpCistPortProtocolMigration    TruthValue,
    ieee8021MstpCistPortEnableBPDURx         TruthValue,
    ieee8021MstpCistPortEnableBPDUTx         TruthValue,
    ieee8021MstpCistPortPseudoRootId         BridgeId,
    ieee8021MstpCistPortIsL2Gp               TruthValue
}

ieee8021MstpCistPortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpCistPortEntry 1 }

ieee8021MstpCistPortNum OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Port's Port Number parameter value for the CIST, i.e., the
         number of the Bridge Port for the CIST."
    ::= { ieee8021MstpCistPortEntry 2 }

ieee8021MstpCistPortUptime OBJECT-TYPE
    SYNTAX      TimeTicks
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Port's Uptime parameter value for the CIST, i.e., the count
         in seconds of the time elapsed since the Port was last reset or
```

```
          initialized (BEGIN, Annex E)."
    ::= { ieee8021MstpCistPortEntry 3 }

ieee8021MstpCistPortAdminPathCost OBJECT-TYPE
    SYNTAX      Integer32 (0..200000000)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administratively assigned value for the contribution
         of this port to the path cost of paths toward the spanning
         tree root.

         Writing a value of '0' assigns the automatically calculated
         default Path Cost value to the port.  If the default Path
         Cost is being used, this object returns '0' when read.

         This complements the object ieee8021MstpCistPortCistPathCost,
         which returns the operational value of the port path cost.

         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "13.27.25, 17.13.11 of IEEE Std 802.1D"
    ::= { ieee8021MstpCistPortEntry 4 }

ieee8021MstpCistPortDesignatedRoot OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The CIST Regional Root Identifier component of the Port's port
         priority vector, as defined in 13.10, for the CIST."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpCistPortEntry 5 }

ieee8021MstpCistPortTopologyChangeAck OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Port's Topology Change Acknowledge parameter value.
         True(1) if a Configuration Message with a topology change
         acknowledge flag set is to be transmitted. "
    REFERENCE   "13.27.72, 17.19.41 of IEEE Std 802.1D"
    ::= { ieee8021MstpCistPortEntry 6 }

ieee8021MstpCistPortHelloTime OBJECT-TYPE
    SYNTAX      Integer32 (100..1000)
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Port's Hello Time timer parameter value, for the CIST.
         In centi-seconds"
    REFERENCE   "13.27.48"
    ::= { ieee8021MstpCistPortEntry 7 }

ieee8021MstpCistPortAdminEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In a Bridge that supports the identification of edge ports, the
         Port's Admin Edge Port parameter value, for the CIST."
    REFERENCE   "13.27.1"
    DEFVAL      { false }
    ::= { ieee8021MstpCistPortEntry 8 }

ieee8021MstpCistPortOperEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
```

```
        "In a Bridge that supports the identification of edge ports, the
         Port's operational Edge Port parameter value, for the CIST.
         True(1) if it is an operEdge Port."
    REFERENCE   "13.27.44"
    ::= { ieee8021MstpCistPortEntry 9 }

ieee8021MstpCistPortMacEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In a Bridge that supports the MAC Enabled parameter, the current
         state of the MAC Enabled parameter.
         True(1) indicates that administratively the MAC is set as if it
         was connected to a point-to-point LAN."
    REFERENCE   "12.8.2.1.3 p)"
    ::= { ieee8021MstpCistPortEntry 10 }

ieee8021MstpCistPortMacOperational OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In a Bridge that supports the MAC Operational parameter, the
         current state of the MAC Operational parameter.
         True(1) indicates the MAC is operational."
    REFERENCE   "12.8.2.1.3 q)"
    ::= { ieee8021MstpCistPortEntry 11 }

ieee8021MstpCistPortRestrictedRole OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The current state of the restrictedRole parameter for the Port.
         True(1) causes the Port not to be selected as Root Port for the
         CIST or any MSTI. "
    REFERENCE   "13.27.64"
    ::= { ieee8021MstpCistPortEntry 12 }

ieee8021MstpCistPortRestrictedTcn OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The current state of the restrictedTcn parameter for the Port.
         True(1) causes the Port not to propagate topology changes to
         other Ports."
    REFERENCE   "13.27.65"
    ::= { ieee8021MstpCistPortEntry 13 }

ieee8021MstpCistPortRole OBJECT-TYPE
    SYNTAX      INTEGER {
                    root(1),
                    alternate(2),
                    designated(3),
                    backup(4)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The current Port Role for the Port (i.e., Root, Alternate,
         Designated, or Backup), for the CIST."
    REFERENCE   "12.8.2.1.3 v)"
    ::= { ieee8021MstpCistPortEntry 14 }

ieee8021MstpCistPortDisputed OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The current value of the disputed variable for the CIST for
```

```
         the Port.  A value of true(1) indicates that the disputed
         variable is set.  A value of false(2) indicates that the
         agreed variable is cleared."
    REFERENCE   "13.27.22"
    ::= { ieee8021MstpCistPortEntry 15 }

ieee8021MstpCistPortCistRegionalRootId OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the CIST Regional Root Identifier, i.e., the
         Bridge Identifier of the current CIST Regional Root, for the CIST."
    REFERENCE   "13.9:c, 13.10, 13.27.47"
    ::= { ieee8021MstpCistPortEntry 16 }

ieee8021MstpCistPortCistPathCost OBJECT-TYPE
    SYNTAX      Unsigned32 (0..2147483647)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Port's Port Path Cost
        parameter value for the CIST."
    REFERENCE   "13.27.25, 17.13.11 of IEEE Std 802.1D"
    ::= { ieee8021MstpCistPortEntry 17 }

ieee8021MstpCistPortProtocolMigration OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the current value of the mcheck variable for
         the Port.  A value of true(1) forces the state machine to
         perform functions as per 13.27.38."
    REFERENCE   "13.27.38"
    ::= { ieee8021MstpCistPortEntry 18 }

ieee8021MstpCistPortEnableBPDURx OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the enableBPDUrx parameter value.  A value
        of false(2) indicates that BPDUs are ignored."
    REFERENCE   "13.27.38"
    DEFVAL { true }
    ::= { ieee8021MstpCistPortEntry 19 }

ieee8021MstpCistPortEnableBPDUTx OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the enableBPDUtx parameter value.  A value
        of false(2) indicates that BPDUs are not transmitted."
    REFERENCE   "13.27.24"
    DEFVAL { true }
    ::= { ieee8021MstpCistPortEntry 20 }

ieee8021MstpCistPortPseudoRootId OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the pseudoRootId parameter value."
    REFERENCE   "13.27.51"
    ::= { ieee8021MstpCistPortEntry 21 }

ieee8021MstpCistPortIsL2Gp OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
```

```
    DESCRIPTION
        "In an MSTP Bridge, the isL2gp parameter value.  A value of
        true(1) indicates this is an L2GP port."
    REFERENCE   "13.27.26"
    DEFVAL { false }
    ::= { ieee8021MstpCistPortEntry 22 }

-- ============================================================
-- ieee8021MstpPortTable:
-- ============================================================

ieee8021MstpPortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The MSTP Port Table. Each row in the Table represents information
         regarding a specific Port within the Bridge's Bridge Protocol
         Entity, for a given MSTI.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.8.2.2, 12.8.2.4"
    ::= { ieee8021MstpObjects 4 }

ieee8021MstpPortEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A MSTP Port Table entry."
    INDEX { ieee8021MstpPortComponentId,
            ieee8021MstpPortMstId,
            ieee8021MstpPortNum }
    ::= { ieee8021MstpPortTable 1 }

Ieee8021MstpPortEntry ::= SEQUENCE {
      ieee8021MstpPortComponentId       IEEE8021PbbComponentIdentifier,
      ieee8021MstpPortMstId             IEEE8021MstIdentifier,
      ieee8021MstpPortNum               IEEE8021BridgePortNumber,
      ieee8021MstpPortUptime            TimeTicks,
      ieee8021MstpPortState             INTEGER,
      ieee8021MstpPortPriority          Integer32,
      ieee8021MstpPortPathCost          Integer32,
      ieee8021MstpPortDesignatedRoot    BridgeId,
      ieee8021MstpPortDesignatedCost    Integer32,
      ieee8021MstpPortDesignatedBridge  BridgeId,
      ieee8021MstpPortDesignatedPort    IEEE8021BridgePortNumber,
      ieee8021MstpPortRole              INTEGER,
      ieee8021MstpPortDisputed          TruthValue,
      ieee8021MstpPortAdminPathCost     Integer32
}

ieee8021MstpPortComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpPortEntry 1 }

ieee8021MstpPortMstId OBJECT-TYPE
    SYNTAX      IEEE8021MstIdentifier
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, this parameter is the MSTID, i.e., the
         identifier of a Spanning Tree (or MST) Instance."
    ::= { ieee8021MstpPortEntry 2 }

ieee8021MstpPortNum OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Port's Port Number parameter value for
         the MSTI, i.e., the number of the Bridge Port for the MSTI."
    ::= { ieee8021MstpPortEntry 3 }

ieee8021MstpPortUptime OBJECT-TYPE
    SYNTAX      TimeTicks
    UNITS       "centi-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Port's Uptime parameter value for the
         MSTI, i.e., the count in seconds of the time elapsed since the
         Port was last reset or initialized (BEGIN, Annex E)."
    ::= { ieee8021MstpPortEntry 4 }

ieee8021MstpPortState OBJECT-TYPE
    SYNTAX      INTEGER {
                    disabled(1),
                    listening(2),
                    learning(3),
                    forwarding(4),
                    blocking(5)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the current state of the Port (i.e., Disabled,
         Listening, Learning, Forwarding, or Blocking), for the MSTI."
    REFERENCE   "13.38"
    ::= { ieee8021MstpPortEntry 5 }

ieee8021MstpPortPriority OBJECT-TYPE
    SYNTAX      Integer32 (0..240)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Port's Port Priority parameter value for
         the MSTI, i.e., the priority field for the Port Identifier for the
         Port for the MSTI."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpPortEntry 6 }

ieee8021MstpPortPathCost OBJECT-TYPE
    SYNTAX      Integer32 (1..200000000)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Port's Port Path Cost parameter value for
         the MSTI."
    REFERENCE   "13.27.33"
    ::= { ieee8021MstpPortEntry 7 }

ieee8021MstpPortDesignatedRoot OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Regional Root Identifier component of the
         Port's MSTI port priority vector, as defined in 13.11, for the MSTI."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpPortEntry 8 }
```

```
ieee8021MstpPortDesignatedCost OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Internal Root Path Cost component of the
         Port's MSTI port priority vector, as defined in 13.11, for the MSTI."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpPortEntry 9 }

ieee8021MstpPortDesignatedBridge OBJECT-TYPE
    SYNTAX      BridgeId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Designated Bridge Identifier component of
         the Port's MSTI port priority vector, as defined in 13.11, for
         the MSTI."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpPortEntry 10 }

ieee8021MstpPortDesignatedPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Designated Port Identifier component of the
         Port's MSTI port priority vector, as defined in 13.11, for the MSTI."
    REFERENCE   "13.27.47"
    ::= { ieee8021MstpPortEntry 11 }

ieee8021MstpPortRole OBJECT-TYPE
    SYNTAX      INTEGER {
                    root(1),
                    alternate(2),
                    designated(3),
                    backup(4)
                }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the current Port Role for the Port (i.e., Root,
         Alternate, Designated, or Backup), for the MSTI."
    ::= { ieee8021MstpPortEntry 12 }

ieee8021MstpPortDisputed OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the current value of the disputed variable for
         the MSTI for the Port."
    REFERENCE   "13.27.22"
    ::= { ieee8021MstpPortEntry 13 }


ieee8021MstpPortAdminPathCost OBJECT-TYPE
    SYNTAX      Integer32 (1..200000000)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the administrative value of the Port's
         Port Path Cost parameter value for the MSTI.

         Writing a value of '0' assigns the automatically calculated
         default Path Cost value to the Port.  If the default Path
         Cost is being used, this object returns '0' when read.

         This complements the object ieee8021MstpPortPathCost,
         which returns the operational value of the path cost.
```

```
         The value of this object MUST be retained across
         reinitializations of the management system."
    REFERENCE   "13.27.33"
    ::= { ieee8021MstpPortEntry 14 }

-- ============================================================
-- ieee8021MstpFidToMstiTable  deprecated
-- see ieee8021MstpFidToMstiV2Table below
-- ============================================================

ieee8021MstpFidToMstiTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpFidToMstiEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, the fixed-length FID to MSTID Allocation Table
         entry. Each entry in the Table corresponds to a FID, and the value
         of the entry specifies the MSTID of the spanning tree to which the
         set of VLANs supported by that FID are assigned. A value of zero
         in an entry specifies that the set of VLANs supported by that FID
         are assigned to the CST.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.12.2"
    ::= { ieee8021MstpObjects 5 }

ieee8021MstpFidToMstiEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpFidToMstiEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, a FID to MSTID Allocation Table entry."
    INDEX { ieee8021MstpFidToMstiComponentId, ieee8021MstpFidToMstiFid }
    ::= { ieee8021MstpFidToMstiTable 1 }

Ieee8021MstpFidToMstiEntry ::= SEQUENCE {
      ieee8021MstpFidToMstiComponentId  IEEE8021PbbComponentIdentifier,
      ieee8021MstpFidToMstiFid          Unsigned32,
      ieee8021MstpFidToMstiMstId        IEEE8021MstIdentifier
}

ieee8021MstpFidToMstiComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpFidToMstiEntry 1 }

ieee8021MstpFidToMstiFid OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4094)
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, the FID of the entry in the FID to MSTID
         Allocation Table."
    ::= { ieee8021MstpFidToMstiEntry 2 }

ieee8021MstpFidToMstiMstId OBJECT-TYPE
    SYNTAX      IEEE8021MstIdentifier
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
```

```
        "In an MSTP Bridge, the MSTID to which the FID (of the entry in
         the FID to MSTID Allocation Table) is to be allocated."
    ::= { ieee8021MstpFidToMstiEntry 3 }

-- ============================================================
-- ieee8021MstpFidToMstiV2Table
-- ============================================================

ieee8021MstpFidToMstiV2Table OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpFidToMstiV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the fixed-length FID to MSTID Allocation Table
         entry. Each entry in the Table corresponds to a FID, and the value
         of the entry specifies the MSTID of the spanning tree to which the
         set of VLANs supported by that FID are assigned. A value of zero
         in an entry specifies that the set of VLANs supported by that FID
         are assigned to the CST.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.12.2"
    ::= { ieee8021MstpObjects 9 }

ieee8021MstpFidToMstiV2Entry OBJECT-TYPE
    SYNTAX      Ieee8021MstpFidToMstiV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, a FID to MSTID Allocation Table entry."
    INDEX { ieee8021MstpFidToMstiV2ComponentId, ieee8021MstpFidToMstiV2Fid }
    ::= { ieee8021MstpFidToMstiV2Table 1 }

Ieee8021MstpFidToMstiV2Entry ::= SEQUENCE {
      ieee8021MstpFidToMstiV2ComponentId  IEEE8021PbbComponentIdentifier,
      ieee8021MstpFidToMstiV2Fid          Unsigned32,
      ieee8021MstpFidToMstiV2MstId        Unsigned32
}

ieee8021MstpFidToMstiV2ComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpFidToMstiV2Entry 1 }

ieee8021MstpFidToMstiV2Fid OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4095)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the FID of the entry in the FID to MSTID
         Allocation Table."
    ::= { ieee8021MstpFidToMstiV2Entry 2 }

ieee8021MstpFidToMstiV2MstId OBJECT-TYPE
    SYNTAX      Unsigned32 (0..4095)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the MSTID to which the FID (of the entry in
         the FID to MSTID Allocation Table) is to be allocated.
```

```
         In an SPT Bridge, the value 4095 is used to indicate unused
         (non-filtering) FIDs."
    ::= { ieee8021MstpFidToMstiV2Entry 3 }

-- ============================================================
-- ieee8021MstpVlanTable  deprecated
-- see ieee8021MstpVlanV2Table below
-- ============================================================

ieee8021MstpVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, the fixed-length (4094 elements), read-only,
         MST Configuration Table. Its elements are derived from other
         configuration information held by the Bridge; specifically, the
         current state of the VID to FID Allocation Table (8.8.8,
         12.10.1),and the FID to MSTID Allocation Table (8.9.3, 12.12.2).
         Hence, changes made to either of these Tables can in turn affect
         the contents of the MST Configuration Table, and also affect the
         value of the digest element of the MST Configuration Identifier.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.12.3.1"
    ::= { ieee8021MstpObjects 6 }

ieee8021MstpVlanEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, a MST Configuration Table entry."
    INDEX { ieee8021MstpVlanComponentId, ieee8021MstpVlanId }
    ::= { ieee8021MstpVlanTable 1 }

Ieee8021MstpVlanEntry ::= SEQUENCE {
      ieee8021MstpVlanComponentId  IEEE8021PbbComponentIdentifier,
      ieee8021MstpVlanId           IEEE8021VlanIndex,
      ieee8021MstpVlanMstId        IEEE8021MstIdentifier
}

ieee8021MstpVlanComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpVlanEntry 1 }

ieee8021MstpVlanId OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "In an MSTP Bridge, the VID of the entry in the MST
         Configuration Table."
    ::= { ieee8021MstpVlanEntry 2 }

ieee8021MstpVlanMstId OBJECT-TYPE
    SYNTAX      IEEE8021MstIdentifier
    MAX-ACCESS  read-only
    STATUS      deprecated
```

```
    DESCRIPTION
        "In an MSTP Bridge, the MSTID value corresponding to the VID
         of the entry in the MST Configuration Table."
    ::= { ieee8021MstpVlanEntry 3 }

-- ================================================================
-- ieee8021MstpVlanV2Table
-- ================================================================

ieee8021MstpVlanV2Table OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpVlanV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the fixed-length (4094 elements), read-only,
         MST Configuration Table. Its elements are derived from other
         configuration information held by the Bridge; specifically, the
         current state of the VID to FID Allocation Table (8.8.8,
         12.10.1),and the FID to MSTID Allocation Table (8.9.3, 12.12.2).
         Hence, changes made to either of these Tables can in turn affect
         the contents of the MST Configuration Table, and also affect the
         value of the digest element of the MST Configuration Identifier.

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.12.3.1"
    ::= { ieee8021MstpObjects 10 }

ieee8021MstpVlanV2Entry OBJECT-TYPE
    SYNTAX      Ieee8021MstpVlanV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, a MST Configuration Table entry."
    INDEX { ieee8021MstpVlanV2ComponentId, ieee8021MstpVlanV2Id }
    ::= { ieee8021MstpVlanV2Table 1 }

Ieee8021MstpVlanV2Entry ::= SEQUENCE {
      ieee8021MstpVlanV2ComponentId  IEEE8021PbbComponentIdentifier,
      ieee8021MstpVlanV2Id           IEEE8021VlanIndex,
      ieee8021MstpVlanV2MstId        Unsigned32
}

ieee8021MstpVlanV2ComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpVlanV2Entry 1 }

ieee8021MstpVlanV2Id OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the VID of the entry in the MST
         Configuration Table."
    ::= { ieee8021MstpVlanV2Entry 2 }

ieee8021MstpVlanV2MstId OBJECT-TYPE
    SYNTAX      Unsigned32 (0..4095)
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
        "In an MSTP Bridge, the MSTID value corresponding to the VID
         of the entry in the MST Configuration Table.
         In an SPT Bridge, a value of 4095 is used to indicate
         SPVIDs."
    ::= { ieee8021MstpVlanV2Entry 3 }

-- ============================================================
-- MST Configuration Identifier Table
-- ============================================================

ieee8021MstpConfigIdTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpConfigIdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing the MST Configuration Identifier for each
         virtual Bridge.  In simple situations where there is only
         a single component, there will only be a single entry in
         this table (i.e., only a single MST Configuration Identifier).

         The values of all writable objects in this table MUST be
         retained across reinitializations of the management system.

         Note that entries will exist in this table only for Bridge
         components for which the corresponding instance of
         ieee8021SpanningTreeVersion (from the IEEE8021-SPANNING-TREE-MIB)
         has a value of mstp(3)."
    REFERENCE   "12.12.3.3, 12.12.3.4"
    ::= { ieee8021MstpObjects 7 }

ieee8021MstpConfigIdEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpConfigIdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry containing the MST Configuration Identifier of a Bridge."
    INDEX { ieee8021MstpConfigIdComponentId }
    ::= { ieee8021MstpConfigIdTable 1 }

Ieee8021MstpConfigIdEntry ::= SEQUENCE {
    ieee8021MstpConfigIdComponentId      IEEE8021PbbComponentIdentifier,
    ieee8021MstpConfigIdFormatSelector   Integer32,
    ieee8021MstpConfigurationName        SnmpAdminString,
    ieee8021MstpRevisionLevel            Unsigned32,
    ieee8021MstpConfigurationDigest      OCTET STRING
}

ieee8021MstpConfigIdComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The component identifier is used to distinguish between the
        multiple virtual Bridge instances within a PBB.  In simple
        situations where there is only a single component the default
        value is 1."
    ::= { ieee8021MstpConfigIdEntry 1 }

ieee8021MstpConfigIdFormatSelector OBJECT-TYPE
    SYNTAX      Integer32 (0..0)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Configuration Identifier Format Selector
         in use by the Bridge, in the MST Configuration Identifier. This
         has a value of 0 to indicate the format specified in IEEE Std 802.1Q."
    REFERENCE   "13.8:1"
    ::= { ieee8021MstpConfigIdEntry 2 }

ieee8021MstpConfigurationName OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(32))
```

```
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Configuration Name in the MST
         Configuration Identifier."
    REFERENCE   "13.8:2"
    ::= { ieee8021MstpConfigIdEntry 3 }

ieee8021MstpRevisionLevel OBJECT-TYPE
    SYNTAX      Unsigned32 (0..65535)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Revision Level in the MST
         Configuration Identifier."
    REFERENCE   "13.8:3"
    ::= { ieee8021MstpConfigIdEntry 4 }

ieee8021MstpConfigurationDigest OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(16))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "In an MSTP Bridge, the Configuration Digest in the MST
         Configuration Identifier."
    REFERENCE   "13.8:4"
    ::= { ieee8021MstpConfigIdEntry 5 }


-- ============================================================
-- Ieee8021MstpCistPortExtensionTable:
-- ============================================================

ieee8021MstpCistPortExtensionTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021MstpCistPortExtensionEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The CIST Port Extensions Table. Each row in the Table represents information
         regarding a specific Port within the Bridge's Bridge Protocol
         Entity, for the CIST."
    REFERENCE   "12.8.2"
    ::= { ieee8021MstpObjects 8 }

ieee8021MstpCistPortExtensionEntry OBJECT-TYPE
    SYNTAX      Ieee8021MstpCistPortExtensionEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of additional objects containing information
         maintained by every port about the CIST
         state for that port."
   AUGMENTS { ieee8021MstpCistPortEntry}
    ::= { ieee8021MstpCistPortExtensionTable 1 }

Ieee8021MstpCistPortExtensionEntry ::=
    SEQUENCE {
        ieee8021MstpCistPortAutoEdgePort
            TruthValue,
        ieee8021MstpCistPortAutoIsolatePort
            TruthValue
    }

ieee8021MstpCistPortAutoEdgePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the Auto Edge Port parameter.
         A value of true(1) indicates if the Bridge detection state
         machine (BDM, 13.33) is to detect other Bridges
         attached to the LAN, and set
```

```
          ieee8021SpanningTreeRstpPortOperEdgePort automatically.
          The default value is true(1)

          This is optional and provided only by implementations
          that support the automatic identification of edge ports.

          The value of this object MUST be retained across
          reinitializations of the management system."
    REFERENCE   "12.8.2.1.3 )"
    ::= { ieee8021MstpCistPortExtensionEntry 1 }

ieee8021MstpCistPortAutoIsolatePort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the Isolate Port parameter.

        A value of true(1) indicates a Designated Port will
        transition to discarding if both
        ieee8021SpanningTreeRstpPortAdminEdgePort and
        ieee8021SpanningTreeRstpPortAutoEdgePort are FALSE and
        the other Bridge presumed to be attached to the same
        point-to-point LAN does not transmit periodic BPDUs.

        This is optional and provided only by implementations
        that support the automatic identification of fragile
         Bridges."
    REFERENCE   "12.8.2.1.3"
    ::= { ieee8021MstpCistPortExtensionEntry 2 }


-- ============================================================
-- Conformance Information
-- ============================================================

ieee8021MstpGroups
    OBJECT IDENTIFIER ::= { ieee8021MstpConformance 1 }
ieee8021MstpCompliances
    OBJECT IDENTIFIER ::= { ieee8021MstpConformance 2 }

-- ============================================================
-- Units of conformance
-- ============================================================

ieee8021MstpCistGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpCistBridgeIdentifier,
        ieee8021MstpCistTopologyChange,
        ieee8021MstpCistRegionalRootIdentifier,
        ieee8021MstpCistPathCost,
        ieee8021MstpCistMaxHops
    }
    STATUS      current
    DESCRIPTION
        "Objects for the CIST group"
    ::= { ieee8021MstpGroups 1 }

ieee8021MstpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpBridgeId,
        ieee8021MstpTimeSinceTopologyChange,
        ieee8021MstpTopologyChanges,
        ieee8021MstpTopologyChange,
        ieee8021MstpDesignatedRoot,
        ieee8021MstpRootPathCost,
        ieee8021MstpRootPort,
        ieee8021MstpBridgePriority,
        ieee8021MstpVids0,
        ieee8021MstpVids1,
        ieee8021MstpVids2,
        ieee8021MstpVids3,
```

```
        ieee8021MstpRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Objects for the MST group"
    ::= { ieee8021MstpGroups 2 }

ieee8021MstpCistPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpCistPortUptime,
        ieee8021MstpCistPortAdminPathCost,
        ieee8021MstpCistPortDesignatedRoot,
        ieee8021MstpCistPortTopologyChangeAck,
        ieee8021MstpCistPortHelloTime,
        ieee8021MstpCistPortAdminEdgePort,
        ieee8021MstpCistPortOperEdgePort,
        ieee8021MstpCistPortMacEnabled,
        ieee8021MstpCistPortMacOperational,
        ieee8021MstpCistPortRestrictedRole,
        ieee8021MstpCistPortRestrictedTcn,
        ieee8021MstpCistPortRole,
        ieee8021MstpCistPortDisputed,
        ieee8021MstpCistPortCistRegionalRootId,
        ieee8021MstpCistPortCistPathCost,
        ieee8021MstpCistPortProtocolMigration,
        ieee8021MstpCistPortEnableBPDURx,
        ieee8021MstpCistPortEnableBPDUTx,
        ieee8021MstpCistPortPseudoRootId,
        ieee8021MstpCistPortIsL2Gp
    }
    STATUS      current
    DESCRIPTION
        "Objects for the CIST Port group"
    ::= { ieee8021MstpGroups 3 }

ieee8021MstpPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpPortUptime,
        ieee8021MstpPortState,
        ieee8021MstpPortPriority,
        ieee8021MstpPortPathCost,
        ieee8021MstpPortDesignatedRoot,
        ieee8021MstpPortDesignatedCost,
        ieee8021MstpPortDesignatedBridge,
        ieee8021MstpPortDesignatedPort,
        ieee8021MstpPortRole,
        ieee8021MstpPortDisputed,
        ieee8021MstpPortAdminPathCost
    }
    STATUS      current
    DESCRIPTION
        "Objects for the MST Port group"
    ::= { ieee8021MstpGroups 4 }

ieee8021MstpFidToMstiGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpFidToMstiMstId
    }
    STATUS      deprecated
    DESCRIPTION
        "Objects for the MST FID to MSTID Allocation Table group"
    ::= { ieee8021MstpGroups 5 }

ieee8021MstpVlanGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpVlanMstId
    }
    STATUS      deprecated
    DESCRIPTION
        "Objects for the MST Configuration Table group"
    ::= { ieee8021MstpGroups 6 }
```

```
ieee8021MstpConfigIdGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpConfigIdFormatSelector,
        ieee8021MstpConfigurationName,
        ieee8021MstpRevisionLevel,
        ieee8021MstpConfigurationDigest
    }
    STATUS      current
    DESCRIPTION
        "Objects for the MST Configuration Identifier group"
    ::= { ieee8021MstpGroups 7 }


ieee8021MstpCistPortExtensionGroup OBJECT-GROUP
    OBJECTS {
        ieee8021MstpCistPortAutoEdgePort,
        ieee8021MstpCistPortAutoIsolatePort
    }
    STATUS      current
    DESCRIPTION
        "Objects for the CIST Port Extension group
         for fragile Bridges"
    ::= { ieee8021MstpGroups 8 }

ieee8021MstpFidToMstiV2Group OBJECT-GROUP
    OBJECTS {
        ieee8021MstpFidToMstiV2MstId
    }
    STATUS      current
    DESCRIPTION
        "Objects for the MST FID to MSTID Allocation Table group
        for SPB"
    ::= { ieee8021MstpGroups 9 }

ieee8021MstpVlanV2Group OBJECT-GROUP
    OBJECTS {
        ieee8021MstpVlanV2MstId
    }
    STATUS      current
    DESCRIPTION
        "Objects for the MST Configuration Table group for SPB"
    ::= { ieee8021MstpGroups 10 }

-- ============================================================
-- Compliance statements
-- ============================================================

ieee8021MstpCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for devices supporting Multiple
        Spanning Tree as defined in 13 of IEEE Std 802.1Q."

    MODULE
        MANDATORY-GROUPS {
            ieee8021MstpCistGroup,
            ieee8021MstpGroup,
            ieee8021MstpCistPortGroup,
            ieee8021MstpPortGroup,
            ieee8021MstpFidToMstiGroup,
            ieee8021MstpVlanGroup,
            ieee8021MstpConfigIdGroup
        }

    GROUP ieee8021MstpCistPortExtensionGroup
    DESCRIPTION
        "Implementation of this group is optional."

    ::= { ieee8021MstpCompliances 1 }

ieee8021MstpComplianceV2 MODULE-COMPLIANCE
```

```
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting Multiple
        Spanning Tree as defined in 13 of IEEE Std 802.1Q."

    MODULE
        MANDATORY-GROUPS {
            ieee8021MstpCistGroup,
            ieee8021MstpGroup,
            ieee8021MstpCistPortGroup,
            ieee8021MstpPortGroup,
            ieee8021MstpFidToMstiV2Group,
            ieee8021MstpVlanV2Group,
            ieee8021MstpConfigIdGroup
        }

    GROUP ieee8021MstpCistPortExtensionGroup
    DESCRIPTION
        "Implementation of this group is optional."

    ::= { ieee8021MstpCompliances 2 }

END
```

17.7.7 Definitions for the CFM MIB modules

There are two modules for CFM as a result of the reindexing required with the addition of PBB (see 17.3.2). Since the IEEE8021-CFM-MIB module contains deprecated tables replaced by reindexed tables in IEEE8021-CFM-V2 MIB module, both modules are needed for CFM implementations.

17.7.7.1 Definitions for the IEEE8021-CFM-MIB module

```
IEEE8021-CFM-MIB DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE 802.1Q(TM) CFM MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    NOTIFICATION-TYPE,
    Integer32, Counter32,
    Unsigned32               FROM SNMPv2-SMI    -- [RFC2578]
    TEXTUAL-CONVENTION,
    TimeInterval,
    TimeStamp, RowStatus,
    TruthValue, MacAddress,
    TDomain, TAddress        FROM SNMPv2-TC     -- [RFC2579]
    MODULE-COMPLIANCE,
    OBJECT-GROUP,
    NOTIFICATION-GROUP       FROM SNMPv2-CONF   -- [RFC2580]
    InterfaceIndex,
    InterfaceIndexOrZero     FROM IF-MIB        -- [RFC2863]
    LldpChassisId,
    LldpChassisIdSubtype,
    LldpPortId,
    LldpPortIdSubtype        FROM LLDP-MIB      -- [IEEE Std 802.1AB]
    VlanIdOrNone, VlanId     FROM Q-BRIDGE-MIB  -- [RFC4363]
    ieee802dot1mibs,
    IEEE8021VlanIndex        FROM IEEE8021-TC-MIB
   ;

ieee8021CfmMib   MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
      "Connectivity Fault Management module.

       Unless otherwise indicated, the references in this MIB
       module are to IEEE Std 802.1Q-2022.

       Copyright (C) IEEE (2022).
       This version of this MIB module is part of IEEE Std 802.1Q-2022;
       see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201412150000Z" -- December 15, 2014
```

```
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Addition of support for ICC format and minor edits
         as part of 2011 revision of IEEE Std 802.1Q."

   REVISION       "200811180000Z" -- November 18, 2008
   DESCRIPTION

      "Added new columns to the dot1agCfmMepTable to support new
       MEP functionality required for PBB-TE support.  Modified
       dot1agCfmMepDbTable to support new functionality requried
       for PBB-TE.  Modified conformance clauses to indicate objects
       needed for PBB-TE support."

   REVISION       "200810150000Z" -- October 15, 2008
   DESCRIPTION
      "The IEEE8021-CFM-MIB Module was originally included in IEEE
       Std 802.1ag-2007. Some objects in this module are deprecated
       and replaced by objects in the IEEE8021-CFM-V2-MIB module
       defined in IEEE Std 802.1ap.

       This revision is included in IEEE Std 802.1ap."

   REVISION       "200706100000Z"    -- 06/10/2007 00:00GMT
   DESCRIPTION
      "Included in IEEE Std 802.1ag-2007."

    ::= { ieee802dot1mibs  8 }

dot1agNotifications      OBJECT IDENTIFIER ::= { ieee8021CfmMib 0 }
dot1agMIBObjects         OBJECT IDENTIFIER ::= { ieee8021CfmMib 1 }
dot1agCfmConformance     OBJECT IDENTIFIER ::= { ieee8021CfmMib 2 }

-- ********************************************************************
-- Groups in the CFM MIB Module
-- ********************************************************************
dot1agCfmStack           OBJECT IDENTIFIER ::= { dot1agMIBObjects 1 }
dot1agCfmDefaultMd       OBJECT IDENTIFIER ::= { dot1agMIBObjects 2 }
dot1agCfmVlan            OBJECT IDENTIFIER ::= { dot1agMIBObjects 3 }
dot1agCfmConfigErrorList OBJECT IDENTIFIER ::= { dot1agMIBObjects 4 }
dot1agCfmMd              OBJECT IDENTIFIER ::= { dot1agMIBObjects 5 }
dot1agCfmMa              OBJECT IDENTIFIER ::= { dot1agMIBObjects 6 }
dot1agCfmMep             OBJECT IDENTIFIER ::= { dot1agMIBObjects 7 }

-- ********************************************************************
-- Textual conventions
-- ********************************************************************

Dot1agCfmMaintDomainNameType ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "A value that represents a type (and thereby the format)
        of a Dot1agCfmMaintDomainName.  The value can be one of
        the following:


        ieeeReserved(0)   Reserved for definition by IEEE 802.1
                          recommend to not use zero unless
                          absolutely needed.
        none(1)           No format specified, usually because
                          there is not (yet) a Maintenance
                          Domain Name. In this case, a zero
                          length OCTET STRING for the Domain
                          Name field is acceptable.
        dnsLikeName(2)    Domain Name like string, globally unique
                          text string derived from a DNS name.
        macAddrAndUint(3) MAC address + 2-octet (unsigned) integer.
        charString(4)     RFC2579 DisplayString, except that the
```

```
                        character codes 0-31 (decimal) are not
                        used.
        ieeeReserved(xx)  Reserved for definition by IEEE 802.1
                        xx values can be [5..31] and [96..255]
        ituReserved(xx)   Reserved for definition by  ITU-T G.8013/Y.1731
                        xx values range from [32..63]
        ietfReserved(xx)  Reserved for definition by IETF.  xx values range
                        from [64..95].

        To support future extensions, the Dot1agCfmMaintDomainNameType
        textual convention SHOULD NOT be subtyped in object type
        definitions.  It MAY be subtyped in compliance statements in
        order to require only a subset of these address types for a
        compliant implementation.

        Implementations MUST ensure that Dot1agCfmMaintDomainNameType
        objects and any dependent objects (e.g.,
        Dot1agCfmMaintDomainName objects) are consistent.  An
        inconsistentValue error MUST be generated if an attempt to
        change an Dot1agCfmMaintDomainNameType object would, for
        example, lead to an undefined Dot1agCfmMaintDomainName value.
        In particular,
        Dot1agCfmMaintDomainNameType/Dot1agCfmMaintDomainName pairs
        MUST be changed together if the nameType changes.
       "
    REFERENCE
       "21.6.5, Table 21-18"
    SYNTAX      INTEGER {
                  none              (1),
                  dnsLikeName       (2),
                  macAddressAndUint (3),
                  charString        (4)
                }

Dot1agCfmMaintDomainName ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Denotes a generic Maintenance Domain Name.

        A Dot1agCfmMaintDomainName value is always interpreted within
        the context of a Dot1agCfmMaintDomainNameType value.  Every
        usage of the Dot1agCfmMaintDomainName textual convention is
        required to specify the Dot1agCfmMaintDomainNameType object
        that provides the context.  It is suggested that the
        Dot1agCfmMaintDomainNameType object be logically registered
        before the object(s) that use the Dot1agCfmMaintDomainName
        textual convention, if they appear in the same logical row.

        The value of a Dot1agCfmMaintDomainName object MUST always
        be consistent with the value of the associated
        Dot1agCfmMaintDomainNameType object. Attempts to set
        an Dot1agCfmMaintDomainName object to a value inconsistent
        with the associated Dot1agCfmMaintDomainNameType MUST fail
        with an inconsistentValue error.

        When this textual convention is used as the syntax of an
        index object, there may be issues with the limit of 128
        sub-identifiers specified in SMIv2, IETF STD 58.  In this
        case, the object definition MUST include a 'SIZE' clause
        to limit the number of potential instance sub-identifiers;
        otherwise the applicable constraints MUST be stated in
        the appropriate conceptual row DESCRIPTION clauses, or
        in the surrounding documentation if there is no single
        DESCRIPTION clause that is appropriate.

        A value of none(1) in the associated
        Dot1agCfmMaintDomainNameType object means that no Maintenance
        Domain name is present, and the contents of the
        Dot1agCfmMaintDomainName object are meaningless.

        See the DESCRIPTION of the Dot1agCfmMaintAssocNameType
        TEXTUAL-CONVENTION for a discussion of the length limits on
```

```
        the Maintenance Domain name and Maintenance Association name.
       "
    REFERENCE
         "21.6.5"
    SYNTAX      OCTET STRING (SIZE(1..43))

Dot1agCfmMaintAssocNameType ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "A value that represents a type (and thereby the format)
        of a Dot1agCfmMaintAssocName.  The value can be one of
        the following:

        ieeeReserved(0)   Reserved for definition by IEEE 802.1
                          recommend to not use zero unless
                          absolutely needed.
        primaryVid(1)     Primary VLAN ID.
                          12 bits represented in a 2-octet integer:
                          - least significant 4 bits of the first
                            byte contains the most significant
                            4 bits of the 12 bits primary VID
                          - second byte contains the least
                            significant 8 bits of the primary VID

                                0 1 2 3 4 5 6 7 8
                                +-+-+-+-+-+-+-+-+
                                |0 0 0 0| (MSB) |
                                +-+-+-+-+-+-+-+-+
                                |  VID   LSB    |
                                +-+-+-+-+-+-+-+-+

        charString(2)     RFC2579 DisplayString, except that the
                          character codes 0-31 (decimal) are not
                          used. (1..45) octets
        unsignedInt16 (3) 2-octet integer/big endian
        rfc2685VpnId(4)   RFC 2685 VPN ID
                          3 octet VPN authority Organizationally
                          Unique Identifier (OUI) or Company ID (CID)
                          followed by 4 octet VPN index identifying VPN
                          according to the OUI or CID:

                                0 1 2 3 4 5 6 7 8
                                +-+-+-+-+-+-+-+-+
                                |VPN OUI/CID MSB|
                                +-+-+-+-+-+-+-+-+
                                |VPN OUI/CID    |
                                +-+-+-+-+-+-+-+-+
                                |VPN OUI/CID LSB|
                                +-+-+-+-+-+-+-+-+
                                |VPN Index (MSB)|
                                +-+-+-+-+-+-+-+-+
                                |  VPN Index    |
                                +-+-+-+-+-+-+-+-+
                                |  VPN Index    |
                                +-+-+-+-+-+-+-+-+
                                |VPN Index (LSB)|
                                +-+-+-+-+-+-+-+-+

        ieeeReserved(xx)  Reserved for definition by IEEE 802.1
                          xx values can be [5..31] and [96..255]
        iccFormat(32)     ICC-based format as specified in ITU-T G.8013/Y.1731
        ituReserved(xx)   Reserved for definition by  ITU-T G.8013/Y.1731
                          xx values range from [33..63]
        ietfReserved(xx)  Reserved for definition by IETF
                          xx values range from [64..95]

        To support future extensions, the Dot1agCfmMaintAssocNameType
        textual convention SHOULD NOT be subtyped in object type
        definitions.  It MAY be subtyped in compliance statements in
        order to require only a subset of these address types for a
        compliant implementation.
```

```
        Implementations MUST ensure that Dot1agCfmMaintAssocNameType
        objects and any dependent objects (e.g.,
        Dot1agCfmMaintAssocName objects) are consistent.  An
        inconsistentValue error MUST be generated if an attempt to
        change an Dot1agCfmMaintAssocNameType object would, for
        example, lead to an undefined Dot1agCfmMaintAssocName value.
        In particular,
        Dot1agCfmMaintAssocNameType/Dot1agCfmMaintAssocName pairs
        MUST be changed together if the nameType changes.

        The Maintenance Domain name and Maintenance Association name,
        when put together into the CCM PDU, MUST total 48 octets or
        less.  If the Dot1agCfmMaintDomainNameType object contains
        none(1), then the Dot1agCfmMaintAssocName object MUST be
        45 octets or less in length.  Otherwise, the length of
        the Dot1agCfmMaintDomainName object plus the length of the
        Dot1agCfmMaintAssocName object, added together, MUST total
        less than or equal to 44 octets.
       "
    REFERENCE
       "21.6.5.4, Table 21-19"
    SYNTAX      INTEGER {
                  primaryVid        (1),
                  charString        (2),
                  unsignedInt16     (3),
                  rfc2865VpnId      (4),
                  iccFormat         (32)
                }

Dot1agCfmMaintAssocName ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Denotes a generic Maintenance Association Name. It is the
        part of the Maintenance Association Identifier that is
        unique within the Maintenance Domain Name and is appended
        to the Maintenance Domain Name to form the Maintenance
        Association Identifier (MAID).

        A Dot1agCfmMaintAssocName value is always interpreted within
        the context of a Dot1agCfmMaintAssocNameType value.  Every
        usage of the Dot1agCfmMaintAssocName textual convention is
        required to specify the Dot1agCfmMaintAssocNameType object
        that provides the context.  It is suggested that the
        Dot1agCfmMaintAssocNameType object be logically registered
        before the object(s) that use the Dot1agCfmMaintAssocName
        textual convention, if they appear in the same logical row.

        The value of a Dot1agCfmMaintAssocName object MUST
        always be consistent with the value of the associated
        Dot1agCfmMaintAssocNameType object. Attempts to set
        an Dot1agCfmMaintAssocName object to a value inconsistent
        with the associated Dot1agCfmMaintAssocNameType MUST fail
        with an inconsistentValue error.

        When this textual convention is used as the syntax of an
        index object, there may be issues with the limit of 128
        sub-identifiers specified in SMIv2, IETF STD 58.  In this
        case, the object definition MUST include a 'SIZE' clause
        to limit the number of potential instance sub-identifiers;
        otherwise the applicable constraints MUST be stated in
        the appropriate conceptual row DESCRIPTION clauses, or
        in the surrounding documentation if there is no single
        DESCRIPTION clause that is appropriate.
       "
    REFERENCE
       "21.6.5.4, 21.6.5.5, 21.6.5.6"
    SYNTAX      OCTET STRING (SIZE(1..45))


Dot1agCfmMDLevel ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
```

```
    DESCRIPTION
       "Integer identifying the Maintenance Domain Level (MD Level).
        Higher numbers correspond to higher Maintenance Domains,
        those with the greatest physical reach, with the highest
        values for customers' CFM PDUs.  Lower numbers correspond
        to lower Maintenance Domains, those with more limited
        physical reach, with the lowest values for CFM PDUs
        protecting single Bridges or physical links.
       "
    REFERENCE
       "18.3, 21.4.1"
    SYNTAX      Integer32 (0..7)

Dot1agCfmMDLevelOrNone ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
       "Integer identifying the Maintenance Domain Level (MD Level).
        Higher numbers correspond to higher Maintenance Domains,
        those with the greatest physical reach, with the highest
        values for customers' CFM frames.  Lower numbers correspond
        to lower Maintenance Domains, those with more limited
        physical reach, with the lowest values for CFM PDUs
        protecting single Bridges or physical links.

        The value (-1) is reserved to indicate that no MA Level has
        been assigned.
       "
    REFERENCE
       "18.3, 12.14.3.1.3:c"
    SYNTAX      Integer32 (-1 | 0..7)

Dot1agCfmMpDirection ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Indicates the direction in which the Maintenance
        association (MEP or MIP) faces on the Bridge Port:

        down(1)    Sends Continuity Check Messages away from the
                   MAC Relay Entity.
        up(2)      Sends Continuity Check Messages towards the
                   MAC Relay Entity.
       "
    REFERENCE
       "12.14.6.3.2:c"
    SYNTAX      INTEGER {
                  down  (1),
                  up    (2)
                }

Dot1agCfmPortStatus ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "An enumerated value from the Port Status TLV from the last CCM
        received from the last MEP. It indicates the ability of the
        Bridge Port on which the transmitting MEP resides to pass
        ordinary data, regardless of the status of the MAC
        (Table 21-9).

        psNoPortStateTLV(0) Indicates either that no CCM has been
                            received or that no port status TLV was
                            present in the last CCM received.

        psBlocked(1)        Ordinary data cannot pass freely through
                            the port on which the remote MEP resides.
                            Value of enableRmepDefect is equal to
                            false.

        psUp(2):            Ordinary data can pass freely through
                            the port on which the remote MEP resides.
                            Value of enableRmepDefect is equal to
                            true.
```

```
        NOTE: A 0 value is used for psNoPortStateTLV, so that
              additional code points can be added in a manner
              consistent with the Dot1agCfmInterfaceStatus textual
              convention.
      "
    REFERENCE
      "12.14.7.6.3:f, 20.19.3, 21.5.4"
    SYNTAX      INTEGER {
                  psNoPortStateTLV  (0),
                  psBlocked         (1),
                  psUp              (2)
                }

Dot1agCfmInterfaceStatus ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
      "An enumerated value from the Interface Status TLV from the
       last CCM received from the last MEP. It indicates the status
       of the Interface within which the MEP transmitting the CCM
       is configured, or the next lower Interface in the Interface
       Stack, if the MEP is not configured within an Interface.

    isNoInterfaceStatusTLV(0)  Indicates either that no CCM has been
                          received or that no interface status TLV
                          was present in the last CCM received.

    isUp(1)               The interface is ready to pass frames.

    isDown(2)             The interface cannot pass frames.

    isTesting(3)          The interface is in some test mode.

    isUnknown(4)          The interface status cannot be determined
                          for some reason.

    isDormant(5)          The interface is not in a state to pass
                          frames but is in a pending state, waiting
                          for some external event.

    isNotPresent(6)       Some component of the interface is missing

    isLowerLayerDown(7)   The interface is down due to state of the
                          lower layer interfaces

        NOTE: A 0 value is used for isNoInterfaceStatusTLV, so that
              these code points can be kept consistent with new code
              points added to ifOperStatus in the IF-MIB.

      "
    REFERENCE
      "12.14.7.6.3:g, 20.19.4, 21.5.5"
    SYNTAX      INTEGER {
                  isNoInterfaceStatusTLV  (0),
                  isUp                    (1),
                  isDown                  (2),
                  isTesting               (3),
                  isUnknown               (4),
                  isDormant               (5),
                  isNotPresent            (6),
                  isLowerLayerDown        (7)
                }

Dot1agCfmHighestDefectPri ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
      "An enumerated value, equal to the contents of the variable
       highestDefect (20.35.9 and Table 20-1), indicating the
       highest-priority defect that has been present since the MEP
       Fault Notification Generator State Machine was last in the
       FNG_RESET state, either:
```

```
        none(0)           no defects since FNG_RESET
        defRDICCM(1)      DefRDICCM
        defMACstatus(2)   DefMACstatus
        defRemoteCCM(3)   DefRemoteCCM
        defErrorCCM(4)    DefErrorCCM
        defXconCCM(5)     DefXconCCM

        The value 0 is used for no defects so that additional higher
        priority values can be added, if needed, at a later time, and
        so that these values correspond with those in
        Dot1agCfmLowestAlarmPri.
       "
    REFERENCE
       "12.14.7.7.2, 20.1.2, 20.35.9 "
    SYNTAX      INTEGER {
                  none              (0),
                  defRDICCM         (1),
                  defMACstatus      (2),
                  defRemoteCCM      (3),
                  defErrorCCM       (4),
                  defXconCCM        (5)
                }

Dot1agCfmLowestAlarmPri ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "An integer value specifying the lowest priority defect
        that is allowed to generate a Fault Alarm (20.9.5), either:

        allDef(1)           DefRDICCM, DefMACstatus, DefRemoteCCM,
                            DefErrorCCM, and DefXconCCM;
        macRemErrXcon(2)    Only DefMACstatus, DefRemoteCCM,
                            DefErrorCCM, and DefXconCCM (default);
        remErrXcon(3)       Only DefRemoteCCM, DefErrorCCM,
                            and DefXconCCM;
        errXcon(4)          Only DefErrorCCM and DefXconCCM;
        xcon(5)             Only DefXconCCM; or
        noXcon(6)           No defects DefXcon or lower are to be
                            reported;
       "
    REFERENCE
       "12.14.7.1.3:k, 20.9.5"
    SYNTAX      INTEGER {
                  allDef            (1),
                  macRemErrXcon     (2),
                  remErrXcon        (3),
                  errXcon           (4),
                  xcon              (5),
                  noXcon            (6)
                }

Dot1agCfmMepId ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
       "Maintenance association Endpoint Identifier (MEPID): A small
        integer, unique over a given Maintenance Association,
        identifying a specific MEP.
       "
    REFERENCE
       "3.133, 19.2.1"
    SYNTAX      Unsigned32 (1..8191)

Dot1agCfmMepIdOrZero ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS       current
    DESCRIPTION
       "Maintenance association Endpoint Identifier (MEPID): A small
        integer, unique over a given Maintenance Association,
        identifying a specific MEP.

        The special value 0 is allowed to indicate special cases, for
```

```
        example that no MEPID is configured.

        Whenever an object is defined with this SYNTAX, then the
        DESCRIPTION clause of such an object MUST specify what the
        special value of 0 means.
       "
    REFERENCE
       "19.2.1"
    SYNTAX      Unsigned32 (0 | 1..8191)

Dot1agCfmMhfCreation ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Indicates if the Management Entity can create MHFs.
        The valid values are:

        defMHFnone(1)      No MHFs can be created for this VID.
        defMHFdefault(2)   MHFs can be created on this VID on any
                           Bridge port through which this VID can
                           pass.
        defMHFexplicit(3)  MHFs can be created for this VID only on
                           Bridge ports through which this VID can
                           pass, and only if a MEP is created at some
                           lower MD Level.
        defMHFdefer(4)     The creation of MHFs is determined by the
                           corresponding Maintenance Domain variable
                           (dot1agCfmMaCompMhfCreation).
       "
    REFERENCE
       "12.14.5.1.3:c, 22.2.3"
    SYNTAX      INTEGER {
                  defMHFnone     (1),
                  defMHFdefault  (2),
                  defMHFexplicit (3),
                  defMHFdefer    (4)
                }

Dot1agCfmIdPermission ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Indicates what, if anything, is to be included in the Sender
        ID TLV transmitted in CCMs, LBMs, LTMs, and LTRs.  The valid
        values are:

        sendIdNone(1)      The Sender ID TLV is not to be sent.
        sendIdChassis(2)   The Chassis ID Length, Chassis ID
                           Subtype, and Chassis ID fields of  the
                           Sender ID TLV are to be sent.
        sendIdManage(3)    The Management Address Length and
                           Management Address of the Sender ID TLV
                           are to be sent.
        sendIdChassisManage(4) The Chassis ID Length, Chassis ID
                           Subtype, Chassis ID, Management Address
                           Length and Management Address fields are
                           all to be sent.
        sendIdDefer(5)     The contents of the Sender ID TLV are
                           determined by the corresponding
                           Maintenance Domain variable
                           (dot1agCfmMaCompIdPermission).
       "
    REFERENCE
       "12.14.6.1.3:d, 21.5.3"
    SYNTAX      INTEGER {
                  sendIdNone          (1),
                  sendIdChassis       (2),
                  sendIdManage        (3),
                  sendIdChassisManage (4),
                  sendIdDefer         (5)
                }

Dot1agCfmCcmInterval ::= TEXTUAL-CONVENTION
    STATUS      current
```

```
    DESCRIPTION
       "Indicates the interval at which CCMs are sent by a MEP.
        The possible values are:
        intervalInvalid(0) No CCMs are sent (disabled).
        interval300Hz(1)   CCMs are sent every 3 1/3 milliseconds
                           (300Hz).
        interval10ms(2)    CCMs are sent every 10 milliseconds.
        interval100ms(3)   CCMs are sent every 100 milliseconds.
        interval1s(4)      CCMs are sent every 1 second.
        interval10s(5)     CCMs are sent every 10 seconds.
        interval1min(6)    CCMs are sent every minute.
        interval10min(7)   CCMs are sent every 10 minutes.

        Note: enumerations start at zero to match the 'CCM Interval
              field' protocol field.
       "
    REFERENCE
       "12.14.6.1.3:e, 20.8.1, 21.6.1.3"
    SYNTAX      INTEGER {
                  intervalInvalid   (0),
                  interval300Hz     (1),
                  interval10ms      (2),
                  interval100ms     (3),
                  interval1s        (4),
                  interval10s       (5),
                  interval1min      (6),
                  interval10min     (7)
                }

Dot1agCfmFngState ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Indicates the different states of the MEP Fault Notification
        Generator State Machine.

        fngReset(1)            No defect has been present since the
                               dot1agCfmMepFngResetTime timer
                               expired, or since the state machine
                               was last reset.

        fngDefect(2)           A defect is present, but not for a
                               long enough time to be reported
                               (dot1agCfmMepFngAlarmTime).

        fngReportDefect(3)     A momentary state during which the
                               defect is reported by sending a
                               dot1agCfmFaultAlarm notification,
                               if that action is enabled.

        fngDefectReported(4)   A defect is present, and some defect
                               has been reported.

        fngDefectClearing(5)   No defect is present, but the
                               dot1agCfmMepFngResetTime timer has
                               not yet expired.
       "
    REFERENCE
       "12.14.7.1.3:f, 20.35"
    SYNTAX      INTEGER {
                  fngReset          (1),
                  fngDefect         (2),
                  fngReportDefect   (3),
                  fngDefectReported (4),
                  fngDefectClearing (5)
                }

Dot1agCfmRelayActionFieldValue ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Possible values the Relay action field can take."
    REFERENCE
       "12.14.7.5.3:g, 20.41.2.5, 21.9.5, Table 21-26"
```

```
    SYNTAX      INTEGER {
                  rlyHit     (1),
                  rlyFdb     (2),
                  rlyMpdb    (3)
                }

Dot1agCfmIngressActionFieldValue ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Possible values returned in the ingress action field."
    REFERENCE
       "12.14.7.5.3:g, 20.41.2.6, 21.9.8.1, Table 21-29"
    SYNTAX      INTEGER {
                  ingNoTlv    (0),
                  ingOk       (1),
                  ingDown     (2),
                  ingBlocked  (3),
                  ingVid      (4)
                }

Dot1agCfmEgressActionFieldValue ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Possible values returned in the egress action field"
    REFERENCE
       "12.14.7.5.3:o, 20.41.2.10, 21.9.9.1, Table 21-31"
    SYNTAX      INTEGER {
                  egrNoTlv    (0),
                  egrOK       (1),
                  egrDown     (2),
                  egrBlocked  (3),
                  egrVid      (4)
                }

Dot1agCfmRemoteMepState::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "Operational state of the remote MEP state machine.  This
        state machine monitors the reception of valid CCMs from a
        remote MEP with a specific MEPID.  It uses a timer that
        expires in 3.5 times the length of time indicated by the
        dot1agCfmMaNetCcmInterval object.

        rMepIdle(1)            Momentary state during reset.

        rMepStart(2)           The timer has not expired since the
                               state machine was reset, and no valid
                               CCM has yet been received.

        rMepFailed(3)          The timer has expired, both since the
                               state machine was reset, and since a
                               valid CCM was received.

        rMepOk(4)              The timer has not expired since a
                               valid CCM was received.
"
    REFERENCE
       "12.14.7.6.3:b, 20.22"
    SYNTAX      INTEGER {
                  rMepIdle    (1),
                  rMepStart   (2),
                  rMepFailed  (3),
                  rMepOk      (4)
                }

Dot1afCfmIndexIntegerNextFree ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
      "An integer that may be used as a new Index in a table.

       The special value of 0 indicates that no more new entries can
```

```
        be created in the relevant table.

        When a MIB is used for configuration, an object with this
        SYNTAX always contains a legal value (if non-zero) for an
        index that is not currently used in the relevant table. The
        Command Generator (Network Management Application) reads this
        variable and uses the (non-zero) value read when creating a
        new row with an SNMP SET.  When the SET is performed, the
        Command Responder (agent) MUST determine whether the value is
        indeed still unused; Two Network Management Applications may
        attempt to create a row (configuration entry) simultaneously
        and use the same value. If it is currently unused, the SET
        succeeds and the Command Responder (agent) changes the value
        of this object, according to an implementation-specific
        algorithm.  If the value is in use, however, the SET fails.
        The Network Management Application MUST then re-read this
        variable to obtain a new usable value.

        An OBJECT-TYPE definition using this SYNTAX MUST specify the
        relevant table for which the object is providing this
        functionality.
       "
    SYNTAX      Unsigned32 (0..4294967295)

Dot1agCfmMepDefects ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "A MEP can detect and report a number of defects, and multiple
        defects can be present at the same time. These defects are:

        bDefRDICCM(0) A remote MEP is reported the RDI bit in its
                      last CCM.
        bDefMACstatus(1) Either some remote MEP is reporting its
                      Interface Status TLV as not isUp, or all remote
                      MEPs are reporting a Port Status TLV that
                      contains some value other than psUp.
        bDefRemoteCCM(2) The MEP is not receiving valid CCMs from at
                      least one of the remote MEPs.
        bDefErrorCCM(3) The MEP has received at least one invalid CCM
                      whose CCM Interval has not yet timed out.
        bDefXconCCM(4) The MEP has received at least one CCM from
                      either another MAID or a lower MD Level whose
                      CCM Interval has not yet timed out.
       "
    REFERENCE
       "12.14.7.1.3:o, 12.14.7.1.3:p, 12.14.7.1.3:q,
        12.14.7.1.3:r, 12.14.7.1.3:s."
    SYNTAX BITS {
                bDefRDICCM(0),
                bDefMACstatus(1),
                bDefRemoteCCM(2),
                bDefErrorCCM(3),
                bDefXconCCM(4)
               }

Dot1agCfmConfigErrors ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
       "While making the MIP creation evaluation described in
        22.2.3, the management entity can encounter errors in
        the configuration. These are possible errors that can be
        encountered:

        CFMleak(0)   MA x is associated with a specific VID list,
                     one or more of the VIDs in MA x can pass through
                     the Bridge Port, no Down MEP is configured on
                     any Bridge Port for MA x, and some other MA y,
                     at a higher MD Level than MA x, and associated
                     with at least one of the VID(s) also in MA x,
                     does have a MEP configured on the Bridge Port.

        conflictingVids(1)  MA x is associated with a specific VID
```

```
                    list, an Up MEP is configured on MA x on the
                    Bridge Port, and some other MA y, associated
                    with at least one of the VID(s) also in MA x,
                    also has an Up MEP configured on some Bridge
                    Port.

        ExcessiveLevels(2)  The number of different MD Levels at
                    which MIPs are to be created on this port
                    exceeds the Bridge's capabilities (22.3).

        OverlappedLevels(3) A MEP is created for one VID at one MD
                    Level, but a MEP is configured on another
                    VID at that MD Level or higher, exceeding
                    the Bridge's capabilities.
       "
    REFERENCE
       "12.14.4.1.3:b, 22.2.3, 22.2.4"
    SYNTAX BITS {
                cfmLeak(0),
                conflictingVids(1),
                excessiveLevels(2),
                overlappedLevels(3)
                }

Dot1agCfmPbbComponentIdentifier
::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
       "A Provider Backbone Bridge (PBB) can comprise a number of
        components, each of which can be managed in a manner
        essentially equivalent to an IEEE 802.1Q Bridge.  In order to
        access these components easily, an index is used in a number of
        tables.  If any two tables are indexed by
        Dot1agCfmPbbComponentIdentifier, then entries in those tables
        indexed by the same value of Dot1agCfmPbbComponentIdentifier
        correspond to the same component.
       "
    REFERENCE
       "12.3 l)"
    SYNTAX      Unsigned32 (1..4294967295)

-- ****************************************************************
-- The Stack Object. This group will contain all the MIBs objects
-- needed to access the Stack managed object.
-- ****************************************************************

-- ****************************************************************
-- The CFM Stack Table
-- ****************************************************************

dot1agCfmStackTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmStackEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "There is one CFM Stack table per Bridge. It permits
        the retrieval of information about the Maintenance Points
        configured on any given interface.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.2"
    ::= { dot1agCfmStack 1 }

dot1agCfmStackEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmStackEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Stack table entry
```

```
        **NOTE: this object is deprecated due to re-indexing of the
    table.
"
    INDEX { dot1agCfmStackifIndex, dot1agCfmStackVlanIdOrNone,
            dot1agCfmStackMdLevel, dot1agCfmStackDirection
          }
    ::= { dot1agCfmStackTable 1 }

Dot1agCfmStackEntry ::= SEQUENCE {
      dot1agCfmStackifIndex       InterfaceIndex,
      dot1agCfmStackVlanIdOrNone  VlanIdOrNone,
      dot1agCfmStackMdLevel       Dot1agCfmMDLevel,
      dot1agCfmStackDirection     Dot1agCfmMpDirection,
      dot1agCfmStackMdIndex       Unsigned32,
      dot1agCfmStackMaIndex       Unsigned32,
      dot1agCfmStackMepId         Dot1agCfmMepIdOrZero,
      dot1agCfmStackMacAddress    MacAddress
    }

dot1agCfmStackifIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "This object represents the  Bridge Port or aggregated port
        on which MEPs or MHFs might be configured.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this variable, and  rearrange the
        dot1agCfmStackTable, so that it indexes the entry in the
        interface table with the same value of ifAlias that it
        indexed before the system restart.  If no such entry exists,
        then the system SHALL delete all entries in the
        dot1agCfmStackTable with the interface index.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.2.1.2:a"
    ::= { dot1agCfmStackEntry 1 }

dot1agCfmStackVlanIdOrNone OBJECT-TYPE
    SYNTAX      VlanIdOrNone
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "VLAN ID to which the MP is attached, or 0, if none.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.2.1.2:d, 22.1.7"
    ::= { dot1agCfmStackEntry 2 }

dot1agCfmStackMdLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevel
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "MD Level of the Maintenance Point.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.2.1.2:b"
    ::= { dot1agCfmStackEntry 3 }

dot1agCfmStackDirection OBJECT-TYPE
    SYNTAX      Dot1agCfmMpDirection
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
```

```
        "Direction in which the MP faces on the Bridge Port
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    REFERENCE
        "12.14.2.1.2:c"
    ::= { dot1agCfmStackEntry 4 }

dot1agCfmStackMdIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "The index of the Maintenance Domain in the dot1agCfmMdTable
         to which the MP is associated, or 0, if none.
        "
    REFERENCE
        "12.14.2.1.3:b"
    ::= { dot1agCfmStackEntry 5 }

dot1agCfmStackMaIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "The index of the MA in the dot1agCfmMaNetTable and
         dot1agCfmMaCompTable to which the MP is associated, or 0, if
         none.
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    REFERENCE
        "12.14.2.1.3:c"
    ::= { dot1agCfmStackEntry 6 }

dot1agCfmStackMepId OBJECT-TYPE
    SYNTAX      Dot1agCfmMepIdOrZero
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "If an MEP is configured, the MEPID, else 0"
    REFERENCE
        "12.14.2.1.3:d
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    ::= { dot1agCfmStackEntry 7 }

dot1agCfmStackMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
        "MAC address of the MP.
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    REFERENCE
      "12.14.2.1.3:e"
    ::= { dot1agCfmStackEntry 8 }

-- ********************************************************************
-- The VLAN Table
-- ********************************************************************

dot1agCfmVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
        "This table defines the association of VIDs into VLANs.  There
         is an entry in this table, for each component of the Bridge,
```

```
        for each VID that is:
            a) a VID belonging to a VLAN associated with more than
               one VID; and
            b) not the Primary VLAN of that VID.
        The entry in this table contains the Primary VID of the VLAN.

        By default, this table is empty, meaning that every VID is
        the Primary VID of a single-VID VLAN.

        VLANs that are associated with only one VID SHOULD NOT have
        an entry in this table.

        The writable objects in this table need to be persistent
        upon reboot or restart of a device.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3.1.3:a, 12.14.3.2.2:a, 12.14.5.3.2:c,
        12.14.6.1.3:b, 22.1.5."
    ::= { dot1agCfmVlan 1 }

dot1agCfmVlanEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The VLAN table entry.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    INDEX { dot1agCfmVlanComponentId, dot1agCfmVlanVid }
    ::= { dot1agCfmVlanTable 1 }

Dot1agCfmVlanEntry ::= SEQUENCE {
      dot1agCfmVlanComponentId Dot1agCfmPbbComponentIdentifier,
      dot1agCfmVlanVid         VlanId,
      dot1agCfmVlanPrimaryVid  VlanId,
      dot1agCfmVlanRowStatus   RowStatus
    }

dot1agCfmVlanComponentId OBJECT-TYPE
    SYNTAX      Dot1agCfmPbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this dot1agCfmVlanEntry applies.  If the system is not a
        Bridge, or if only one component is present in the Bridge, then
        this variable (index) MUST be equal to 1.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.3 l)"
    ::= { dot1agCfmVlanEntry 1 }

dot1agCfmVlanVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "This is a VLAN ID belonging to a VLAN that is associated with
        more than one VLAN ID, and this is not the Primary VID of the
        VLAN.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    ::= { dot1agCfmVlanEntry 2 }

dot1agCfmVlanPrimaryVid OBJECT-TYPE
    SYNTAX      VlanId
```

```
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
       "This is the Primary VLAN ID of the VLAN with which this
        entry's dot1agCfmVlanVid is associated.  This value MUST not
        equal the value of dot1agCfmVlanVid.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    ::= { dot1agCfmVlanEntry 3 }

dot1agCfmVlanRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    ::= { dot1agCfmVlanEntry 4 }

-- ********************************************************************
-- The Default MD Level object. This group will contain all the
-- MIB objects needed to access and modify default MD level
-- managed objects.
-- ********************************************************************

dot1agCfmDefaultMdDefLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevel
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A value indicating the MD Level at which MHFs are to be
        created, and Sender ID TLV transmission by those MHFs is to
        be controlled, for each dot1agCfmDefaultMdEntry whose
        dot1agCfmDefaultMdLevel object contains the value -1.

        After this initialization, this object needs to be persistent
        upon reboot or restart of a device.
        "
    REFERENCE
       "12.14.3.1.3:c, 12.14.3.2.2:b"
    DEFVAL {0}
    ::= { dot1agCfmDefaultMd 1 }

dot1agCfmDefaultMdDefMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation {
                  defMHFnone     (1),
                  defMHFdefault  (2),
                  defMHFexplicit (3)
                }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A value indicating if the Management entity can create MHFs
        (MIP Half Function) for the VID, for each
        dot1agCfmDefaultMdEntry whose dot1agCfmDefaultMdMhfCreation
        object contains the value defMHFdefer.  Since, in this
        variable, there is no encompassing Maintenance Domain, the
        value defMHFdefer is not allowed.

        After this initialization, this object needs to be persistent
        upon reboot or restart of a device.
       "
    REFERENCE
       "12.14.3.1.3:d"
    DEFVAL {defMHFnone}
```

```
    ::= { dot1agCfmDefaultMd 2 }

dot1agCfmDefaultMdDefIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission {
                  sendIdNone          (1),
                  sendIdChassis       (2),
                  sendIdManage        (3),
                  sendIdChassisManage (4)
                }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "Enumerated value indicating what, if anything, is to be
        included in the Sender ID TLV (21.5.3) transmitted by MHFs
        created by the Default Maintenance Domain, for each
        dot1agCfmDefaultMdEntry whose dot1agCfmDefaultMdIdPermission
        object contains the value sendIdDefer.  Since, in this
        variable, there is no encompassing Maintenance Domain, the
        value sendIdDefer is not allowed.

        After this initialization, this object needs to be persistent
        upon reboot or restart of a device.
       "
    REFERENCE
       "12.14.3.1.3:e"
    DEFVAL { sendIdNone }
    ::= { dot1agCfmDefaultMd 3 }

-- ********************************************************************
-- The Default MD Level Table
-- ********************************************************************

dot1agCfmDefaultMdTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmDefaultMdEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "For each Bridge component, the Default MD Level Managed Object
        controls MHF creation for VIDs that are not attached to a
        specific Maintenance Association Managed Object, and Sender ID
        TLV transmission by those MHFs.

        For each Bridge Port, and for each VLAN ID whose data can
        pass through that Bridge Port, an entry in this table is
        used by the algorithm in 22.2.3 only if there is no
        entry in the Maintenance Association table defining an MA
        for the same VLAN ID and MD Level as this table's entry, and
        on which MA an Up MEP is defined.  If there exists such an
        MA, that MA's objects are used by the algorithm in
        22.2.3 in place of this table entry's objects.  The
        agent maintains the value of dot1agCfmDefaultMdStatus to
        indicate whether this entry is overridden by an MA.

        When first initialized, the agent creates this table
        automatically with entries for all VLAN IDs,
        with the default values specified for each object.

        After this initialization, the writable objects in this
        table need to be persistent upon reboot or restart of a
        device.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3"
    ::= { dot1agCfmDefaultMd 4 }

dot1agCfmDefaultMdEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmDefaultMdEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
```

```
       "The Default MD Level table entry.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    INDEX { dot1agCfmDefaultMdComponentId,
            dot1agCfmDefaultMdPrimaryVid }
    ::= { dot1agCfmDefaultMdTable 1 }

Dot1agCfmDefaultMdEntry ::= SEQUENCE {
      dot1agCfmDefaultMdComponentId  Dot1agCfmPbbComponentIdentifier,
      dot1agCfmDefaultMdPrimaryVid   VlanId,
      dot1agCfmDefaultMdStatus       TruthValue,
      dot1agCfmDefaultMdLevel        Dot1agCfmMDLevelOrNone,
      dot1agCfmDefaultMdMhfCreation  Dot1agCfmMhfCreation,
      dot1agCfmDefaultMdIdPermission Dot1agCfmIdPermission
    }

dot1agCfmDefaultMdComponentId OBJECT-TYPE
    SYNTAX      Dot1agCfmPbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this dot1agCfmDefaultMdEntry applies.  If the system is not
        a Bridge, or if only one component is present in the Bridge,
        then this variable (index) MUST be equal to 1.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.3 l)"
    ::= { dot1agCfmDefaultMdEntry 1 }

dot1agCfmDefaultMdPrimaryVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Primary VID of the VLAN to which this entry's objects
        apply.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    ::= { dot1agCfmDefaultMdEntry 2 }

dot1agCfmDefaultMdStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
       "State of this Default MD Level table entry.  True if there is
        no entry in the Maintenance Association table defining an MA
        for the same VLAN ID and MD Level as this table's entry, and
        on which MA an Up MEP is defined, else false.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3.1.3:b"
    ::= { dot1agCfmDefaultMdEntry 3 }

dot1agCfmDefaultMdLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevelOrNone
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
       "A value indicating the MD Level at which MHFs are to be
        created, and Sender ID TLV transmission by those MHFs is to
        be controlled, for the VLAN to which this entry's objects
        apply.  If this object has the value -1, the MD Level for MHF
        creation for this VLAN is controlled by
        dot1agCfmDefaultMdDefLevel.
```

```
         **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3.1.3:c, 12.14.3.2.2:b"
    DEFVAL {-1}
    ::= { dot1agCfmDefaultMdEntry 4 }

dot1agCfmDefaultMdMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
       "A value indicating if the Management entity can create MHFs
        (MIP Half Function) for this VID at this MD Level.  If this
        object has the value defMHFdefer, MHF creation for this VLAN
        is controlled by dot1agCfmDefaultMdDefMhfCreation.

        The value of this variable is meaningless if the values of
        dot1agCfmDefaultMdStatus is false.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3.1.3:d"
    DEFVAL {defMHFdefer}
    ::= { dot1agCfmDefaultMdEntry 5 }

dot1agCfmDefaultMdIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION
       "Enumerated value indicating what, if anything, is to be
        included in the Sender ID TLV (21.5.3) transmitted by MHFs
        created by the Default Maintenance Domain.  If this object
        has the value sendIdDefer, Sender ID TLV transmission for
        this VLAN is controlled by dot1agCfmDefaultMdDefIdPermission.

        The value of this variable is meaningless if the values of
        dot1agCfmDefaultMdStatus is false.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.3.1.3:e"
    DEFVAL { sendIdDefer }
    ::= { dot1agCfmDefaultMdEntry 6 }

-- ********************************************************************
-- The CFM configuration error list managed object. This group will
-- contain all the MIB objects used to read the interfaces and VIDs
-- configured incorrectly.
-- ********************************************************************

-- ********************************************************************
-- The CFM Configuration Error List Table
-- ********************************************************************

dot1agCfmConfigErrorListTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmConfigErrorListEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The CFM Configuration Error List table provides a list of
        Interfaces and VIDs that are incorrectly configured.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.4"
    ::= {dot1agCfmConfigErrorList 1}
```

```
dot1agCfmConfigErrorListEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmConfigErrorListEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Config Error List Table  entry
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    INDEX { dot1agCfmConfigErrorListVid,
            dot1agCfmConfigErrorListIfIndex
          }
    ::= { dot1agCfmConfigErrorListTable 1}

Dot1agCfmConfigErrorListEntry ::= SEQUENCE {
      dot1agCfmConfigErrorListVid         VlanId,
      dot1agCfmConfigErrorListIfIndex     InterfaceIndex,
      dot1agCfmConfigErrorListErrorType   Dot1agCfmConfigErrors
    }


dot1agCfmConfigErrorListVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The VLAN ID of the VLAN with interfaces in error.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.4.1.2:a"
    ::= { dot1agCfmConfigErrorListEntry 1 }

dot1agCfmConfigErrorListIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "This object is the IfIndex of the interface.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this variable so that it indexes the
        entry in the interface table with the same value of ifAlias
        that it indexed before the system restart.  If no such
        entry exists, then the system SHALL delete any entries in
        dot1agCfmConfigErrorListTable indexed by that
        InterfaceIndex value.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.4.1.2:b"
    ::= { dot1agCfmConfigErrorListEntry 2 }

dot1agCfmConfigErrorListErrorType OBJECT-TYPE
    SYNTAX      Dot1agCfmConfigErrors
    MAX-ACCESS  read-only
    STATUS      deprecated
    DESCRIPTION
       "A vector of Boolean error conditions from 22.2.4, any of
        which may be true:

        0) CFMleak;
        1) ConflictingVids;
        2) ExcessiveLevels;
        3) OverlappedLevels.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
```

```
       "12.14.4.1.3:b"
    ::= { dot1agCfmConfigErrorListEntry 3 }

-- ********************************************************************
-- The Maintenance Domain Managed Object.  This group contains all
-- the MIB objects used to maintain Maintenance Domains.
-- ********************************************************************

dot1agCfmMdTableNextIndex OBJECT-TYPE
    SYNTAX      Dot1afCfmIndexIntegerNextFree
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object contains an unused value for dot1agCfmMdIndex in
        the dot1agCfmMdTable, or a zero to indicate that none exist.
       "
    ::= { dot1agCfmMd 1 }

-- ********************************************************************
-- The Maintenance Domain Table
-- ********************************************************************

dot1agCfmMdTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Maintenance Domain table. Each row in the table
        represents a different Maintenance Domain.

        A Maintenance Domain is described 3.136 as the
        network or the part of the network for which faults in
        connectivity are to be managed. The boundary of a Maintenance
        Domain is defined by a set of DSAPs, each of which can become
        a point of connectivity to a service instance.
       "
    REFERENCE
       "3.136, 18.1"
    ::= { dot1agCfmMd 2 }

dot1agCfmMdEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Maintenance Domain table entry. This entry is not lost
        upon reboot. It is backed up by stable storage.
       "
    INDEX {dot1agCfmMdIndex }
    ::= { dot1agCfmMdTable 1 }

Dot1agCfmMdEntry ::= SEQUENCE {
      dot1agCfmMdIndex               Unsigned32,
      dot1agCfmMdFormat              Dot1agCfmMaintDomainNameType,
      dot1agCfmMdName                Dot1agCfmMaintDomainName,
      dot1agCfmMdMdLevel             Dot1agCfmMDLevel,
      dot1agCfmMdMhfCreation         Dot1agCfmMhfCreation,
      dot1agCfmMdMhfIdPermission     Dot1agCfmIdPermission,
      dot1agCfmMdMaNextIndex         Dot1afCfmIndexIntegerNextFree,
      dot1agCfmMdRowStatus           RowStatus
    }

dot1agCfmMdIndex OBJECT-TYPE
    SYNTAX      Unsigned32(1..4294967295)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The index to the Maintenance Domain table.

        dot1agCfmMdTableNextIndex needs to be inspected to find an
        available index for row-creation.
```

```
        Referential integrity is required, i.e., the index needs to be
        persistent upon a reboot or restart of a device.  The index
        can never be reused for other Maintenance Domain.  The index
        value SHOULD keep increasing up to the time that they wrap
        around. This is to facilitate access control based on OID.
       "
    ::= { dot1agCfmMdEntry 1 }

dot1agCfmMdFormat OBJECT-TYPE
    SYNTAX      Dot1agCfmMaintDomainNameType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The type (and thereby format) of the Maintenance Domain Name."
    REFERENCE
       "21.6.5.1"
    DEFVAL { charString }
    ::= { dot1agCfmMdEntry 2 }

dot1agCfmMdName OBJECT-TYPE
    SYNTAX      Dot1agCfmMaintDomainName
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Maintenance Domain name. The type/format of this object
        is determined by the value of the dot1agCfmMdNameType object.

        Each Maintenance Domain has unique name among all those
        used or available to a service provider or operator.  It
        facilitates easy identification of administrative
        responsibility for each Maintenance Domain.

        3.141 defines a Maintenance Domain name as the
        identifier, unique over the domain for which CFM is to
        protect against accidental concatenation of Service
        Instances, of a particular Maintenance Domain.
       "
    REFERENCE
       "3.141, 12.14.5, 21.6.5.3"
    DEFVAL { "DEFAULT" }
    ::= { dot1agCfmMdEntry 3 }

dot1agCfmMdMdLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevel
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Maintenance Domain Level."
    REFERENCE
       "12.14.5.1.3:b"
    DEFVAL { 0 }
    ::= { dot1agCfmMdEntry 4 }

dot1agCfmMdMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation {
                  defMHFnone     (1),
                  defMHFdefault  (2),
                  defMHFexplicit (3)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Enumerated value indicating whether the management entity can
        create MHFs (MIP Half Function) for this Maintenance Domain.
        Since, in this variable, there is no encompassing Maintenance
        Domain, the value defMHFdefer is not allowed.
       "
    REFERENCE
       "12.14.5.1.3:c"
    DEFVAL { defMHFnone }
    ::= { dot1agCfmMdEntry 5 }
```

```
dot1agCfmMdMhfIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission {
                  sendIdNone          (1),
                  sendIdChassis       (2),
                  sendIdManage        (3),
                  sendIdChassisManage (4)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Enumerated value indicating what, if anything, is to be
        included in the Sender ID TLV (21.5.3) transmitted by MPs
        configured in this Maintenance Domain.  Since, in this
        variable, there is no encompassing Maintenance Domain, the
        value sendIdDefer is not allowed.
       "
    REFERENCE
       "12.14.5.1.3:d"
    DEFVAL { sendIdNone }
    ::= { dot1agCfmMdEntry 6 }

dot1agCfmMdMaNextIndex OBJECT-TYPE
    SYNTAX      Dot1afCfmIndexIntegerNextFree
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Value to be used as the index of the MA table entries, both
        the dot1agCfmMaNetTable and the dot1agCfmMaCompTable, for
        this Maintenance Domain when the management entity wants to
        create a new row in those tables.
       "
   ::= { dot1agCfmMdEntry 7 }

dot1agCfmMdRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
       "
    ::= { dot1agCfmMdEntry 8 }

-- ********************************************************************
-- The Maintenance Association Object. This group contains all the
-- MIB objects used to read, create, modify, and delete Maintenance
-- Associations in the MIB.
-- ********************************************************************

-- ********************************************************************
-- The Maintenance Association (MA) Network Table
-- ********************************************************************

dot1agCfmMaNetTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMaNetEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Maintenance Association table.  Each row in the table
        represents an MA.  An MA is a set of MEPs, each configured
        with a single service instance.

        This is the part of the complete MA table that is constant
        across all Bridges in a Maintenance Domain, and across all
        components of a single Bridge.  That part of the MA table that
        can vary from Bridge component to Bridge component is contained
        in the dot1agCfmMaCompTable.

        Creation of a Service Instance establishes a connectionless
```

```
        association among the selected DSAPs.  Configuring a
        Maintenance association Endpoint (MEP) at each of the
        DSAPs creates a Maintenance Association (MA) to monitor
        that connectionless connectivity.  The MA is identified by a
        Short MA Name that is unique within the Maintenance Domain
        and chosen to facilitate easy identification of the Service
        Instance.  Together, the Maintenance Domain Name and the
        Short MA Name form the Maintenance Association Identifier
        (MAID) that is carried in CFM Messages to identify
        incorrect connectivity among Service Instances.  A small
        integer, the Maintenance association Endpoint Identifier
        (MEPID), identifies each MEP among those configured on a
        single MA (3.133, 18.2).

        This table uses two indices, first index is the index of the
        Maintenance Domain table.  The second index is the same as the
        index of the dot1agCfmMaCompEntry for the same MA.

        The writable objects in this table need to be persistent
        upon reboot or restart of a device.

       "
    REFERENCE
       "18.2"
    ::= { dot1agCfmMa 1 }

dot1agCfmMaNetEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMaNetEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The MA table entry."
    INDEX {dot1agCfmMdIndex, dot1agCfmMaIndex }
    ::= { dot1agCfmMaNetTable 1 }

Dot1agCfmMaNetEntry ::= SEQUENCE {
      dot1agCfmMaIndex                  Unsigned32,
      dot1agCfmMaNetFormat              Dot1agCfmMaintAssocNameType,
      dot1agCfmMaNetName                Dot1agCfmMaintAssocName,
      dot1agCfmMaNetCcmInterval         Dot1agCfmCcmInterval,
      dot1agCfmMaNetRowStatus           RowStatus
    }

dot1agCfmMaIndex OBJECT-TYPE
    SYNTAX      Unsigned32(1..4294967295)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION

       "Index of the MA table dot1agCfmMdMaNextIndex needs to
        be inspected to find an available index for row-creation.
       "
    ::= { dot1agCfmMaNetEntry 1 }

dot1agCfmMaNetFormat OBJECT-TYPE
    SYNTAX      Dot1agCfmMaintAssocNameType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The type (and thereby format) of the Maintenance Association
        Name.
       "
    REFERENCE
       "21.6.5.4"
    ::= { dot1agCfmMaNetEntry 2 }

dot1agCfmMaNetName OBJECT-TYPE
    SYNTAX      Dot1agCfmMaintAssocName
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Short Maintenance Association name. The type/format of
```

```
         this object is determined by the value of the
         dot1agCfmMaNetNameType object.  This name MUST be unique within
         a maintenance domain.
        "
    REFERENCE
       "21.6.5.6, Table 21-19"
    ::= { dot1agCfmMaNetEntry 3 }

dot1agCfmMaNetCcmInterval OBJECT-TYPE
    SYNTAX      Dot1agCfmCcmInterval
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Interval between CCM transmissions to be used by all MEPs
        in the MA.
       "
    REFERENCE
       "12.14.6.1.3:e"
    DEFVAL { interval1s }
    ::= { dot1agCfmMaNetEntry 4 }

dot1agCfmMaNetRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
       "
    ::= { dot1agCfmMaNetEntry 5 }

-- ********************************************************************
-- The Maintenance Association (MA) Component Table
-- ********************************************************************

dot1agCfmMaCompTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMaCompEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Maintenance Association table.  Each row in the table
        represents an MA.  An MA is a set of MEPs, each configured
        with a single service instance.

        This is the part of the complete MA table that is variable
        across the Bridges in a Maintenance Domain, or across the
        components of a single Bridge.  That part of the MA table that
        is constant across the Bridges and their components in a
        Maintenance Domain is contained in the dot1agCfmMaNetTable.

        This table uses three indices, first index is the
        Dot1agCfmPbbComponentIdentifier that identifies the component
        within the Bridge for which the information in the
        dot1agCfmMaCompEntry applies.  The second is the index of the
        Maintenance Domain table.  The third index is the same as the
        index of the dot1agCfmMaNetEntry for the same MA.

        The writable objects in this table need to be persistent
        upon reboot or restart of a device.

        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "18.2"
    ::= { dot1agCfmMa 2 }

dot1agCfmMaCompEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMaCompEntry
```

```
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The MA table entry.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    INDEX {dot1agCfmMaComponentId,
           dot1agCfmMdIndex, dot1agCfmMaIndex }
    ::= { dot1agCfmMaCompTable 1 }

Dot1agCfmMaCompEntry ::= SEQUENCE {
      dot1agCfmMaComponentId         Dot1agCfmPbbComponentIdentifier,
      dot1agCfmMaCompPrimaryVlanId   VlanIdOrNone,
      dot1agCfmMaCompMhfCreation     Dot1agCfmMhfCreation,
      dot1agCfmMaCompIdPermission    Dot1agCfmIdPermission,
      dot1agCfmMaCompNumberOfVids    Unsigned32,
      dot1agCfmMaCompRowStatus       RowStatus
    }

dot1agCfmMaComponentId OBJECT-TYPE
    SYNTAX      Dot1agCfmPbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this dot1agCfmMaCompEntry applies.  If the system is not a
        Bridge, or if only one component is present in the Bridge, then
        this variable (index) MUST be equal to 1.
    **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.3 l)"
    ::= { dot1agCfmMaCompEntry 1 }

dot1agCfmMaCompPrimaryVlanId OBJECT-TYPE
    SYNTAX      VlanIdOrNone
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
       "The Primary VLAN ID with which the Maintenance Association is
        associated, or 0 if the MA is not attached to any VID.  If
        the MA is associated with more than one VID, the
        dot1agCfmVlanTable lists them.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.6.1.3:b"
    ::= { dot1agCfmMaCompEntry 2 }

dot1agCfmMaCompMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
       "Indicates if the Management entity can create MHFs (MIP Half
        Function) for this MA.
        **NOTE: this object is deprecated due to re-indexing of the
    table.
       "
    REFERENCE
       "12.14.6.1.3:c"
    DEFVAL { defMHFdefer }
    ::= { dot1agCfmMaCompEntry 3 }

dot1agCfmMaCompIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
```

```
        "Enumerated value indicating what, if anything, is to be
         included in the Sender ID TLV (21.5.3) transmitted by MPs
         configured in this MA.
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    REFERENCE
        "12.14.6.1.3:d"
    DEFVAL { sendIdDefer }
    ::= { dot1agCfmMaCompEntry 4 }

dot1agCfmMaCompNumberOfVids OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The number of VIDs associated with the MA.
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    REFERENCE
        "12.14.6.1.3:b"
    ::= { dot1agCfmMaCompEntry 5 }

dot1agCfmMaCompRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "The status of the row.

         The writable columns in a row cannot be changed if the row
         is active. All columns MUST have a valid value before a row
         can be activated.
         **NOTE: this object is deprecated due to re-indexing of the
    table.
        "
    ::= { dot1agCfmMaCompEntry 6 }

-- ********************************************************************
-- The list of known MEPs for a given MA
-- ********************************************************************

dot1agCfmMaMepListTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMaMepListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "List of MEPIDs that belong to this MA.

         12.14.6.1.3 specifies that a list of MEPIDs in all
         Bridges in that MA, but since SNMP SMI does not allow to
         state in a MIB that an object in a table is an array, the
         information has to be stored in another table with two
         indices, being the first index, the index of the table that
         contains the list or array.

         For all Bridges in which the same MAID {dot1agCfmMdFormat,
         dot1agCfmMdName, dot1agCfmMaNetFormat, and dot1agCfmMaNetName}
         is configured, the same set of dot1agCfmMaMepListIdentifiers
         MUST be configured in the Bridges' dot1agCfmMaMepListTables.
         This allows each MEP to determine whether or not it is
         receiving CCMs from all of the other MEPs in the MA.

         For example, if one were creating a new MA whose MAID were
         {charString, 'Dom1', charString, 'MA1'}, that had 2 MEPs, whose
         MEPIDs were 1 and 3, one could, in Bridge A:
          1. Get a new MD index d from dot1agCfmMdTableNextIndex.
          2. Create the Maintenance Domain {charString, 'Dom1'}.
          3. Get a new MA index a from dot1agCfmMdMaNextIndex [d].
          4. Create the Maintenance Association {charString, 'MA1'}.
          5. Create a new dot1agCfmMaMepListEntry for each of the MEPs
```

```
            in the MA: [d, a, 1] and [d, a, 3].
         6. Create one of the new MEPs, say [d, a, 1].
        Then, in Bridge B:
         7. Do all of these steps 1-6, except for using the other MEPID
            for the new MEP in Step 6, in this example, MEPID 3.
        Note that, when creating the MA, MEP List Table, and MEP
        entries in the second Bridge, the indices 'd' and 'a'
        identifying the MAID {charString, 'Dom1', charString, 'MA1'}
        may have different values than those in the first Bridge.
       "
    REFERENCE
       "12.14.6.1.3:g"
    ::= { dot1agCfmMa 3 }

dot1agCfmMaMepListEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMaMepListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The known MEPS table entry."
    INDEX { dot1agCfmMdIndex,
            dot1agCfmMaIndex,
            dot1agCfmMaMepListIdentifier
          }
    ::= { dot1agCfmMaMepListTable 1 }

Dot1agCfmMaMepListEntry ::= SEQUENCE {
      dot1agCfmMaMepListIdentifier  Dot1agCfmMepId,
      dot1agCfmMaMepListRowStatus   RowStatus
    }

dot1agCfmMaMepListIdentifier OBJECT-TYPE
    SYNTAX      Dot1agCfmMepId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "MEPID"
    REFERENCE
       "12.14.6.1.3:g"
    ::= { dot1agCfmMaMepListEntry 1 }

dot1agCfmMaMepListRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row. Read SNMPv2-TC (RFC1903) for an
        explanation of the possible values this object can take.
       "
    ::= { dot1agCfmMaMepListEntry 2 }

-- ********************************************************************
-- The MEP Object.  This object represents a Maintenance End
-- Point as described in IEEE Std 802.1Q.
-- ********************************************************************

-- ********************************************************************
-- The MEP Table
-- ********************************************************************

dot1agCfmMepTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMepEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Maintenance Association Endpoint (MEP) table.

        Each row in the table represents a different MEP.  A MEP is
        an actively managed CFM entity, associated with a specific
        DSAP of a Service Instance, which can generate and receive
        CFM PDUs and track any responses.  It is an endpoint of a
        single Maintenance Association, and is an endpoint of a
```

```
separate Maintenance Entity for each of the other MEPs in
the same Maintenance Association (3.133).

This table uses three indices. The first two indices are the
indices of the Maintenance Domain and MA tables, the reason
being that a MEP is always related to an MA and Maintenance
Domain.

The MEP table also stores all the managed objects for sending
LBM and LTM.

*LBM Managed objects

LBM Managed objects in the MEP table
enables the management entity to initiate
transmission of Loopback messages.  It will signal the MEP
that it SHOULD transmit some number of Loopback messages
and detect the detection (or lack thereof) of the
corresponding Loopback messages.

Steps to use entries in this table:

1) Wait for dot1agCfmMepTransmitLbmStatus value to be
   false.  To do this do this sequence:
   a. an SNMP GET for both SnmpSetSerialNo and
      dot1agCfmMepTransmitLbmStatus objects (in same SNMP
      PDU).
   b. Check if value for dot1agCfmMepTransmitLbmStatus is false.
      - if not, wait x seconds, go to step a above.
      - if yes, save the value of SnmpSetSerialNo and go
        to step 2) below
2) Change dot1agCfmMepTransmitLbmStatus value from false to
   true to ensure no other management entity will use
   the service. In order to not disturb a possible other NMS
   do this by sending an SNMP SET for both SnmpSetSerialNo
   and dot1agCfmMepTransmitLbmStatus objects (in same SNMP
   PDU,  and make sure SNmpSetSerialNo is the first varBind).
   For the SnmpSetSerialNo varBind, use the value that you
   obtained in step 1)a.. This ensures that two cooperating
   NMSes will not step on each others toes.
   Setting this MIB object does not set the corresponding
   LBIactive state machine variable.
3) Setup the different data to be sent (number of messages,
   optional TLVs,...), except do not set
   dot1agCfmMepTransmitLbmMessages.
4) Record the current values of dot1agCfmMepLbrIn,
   dot1agCfmMepLbrInOutOfOrder, and dot1agCfmMepLbrBadMsdu.
6) Set dot1agCfmMepTransmitLbmMessages to a non-zero value to
   initiate transmission of Loopback messages.
   The dot1agCfmMepTransmitLbmMessages indicates the
   number of LBMs to be sent and is not decremented as
   loopbacks are actually sent. dot1agCfmMepTransmitLbmMessages
   is not equivalent to the LBMsToSend state machine variable.
7) Check the value of dot1agCfmMepTransmitLbmResultOK to
   find out if the operation was successfully initiated or
   not.
8) Monitor the value of dot1agCfmMepTransmitLbmStatus.
   When it is reset to false, the last LBM has been transmitted.
   Wait an additional 5 seconds to ensure that all LBRs have
   been returned.
9) Compare dot1agCfmMepLbrIn, dot1agCfmMepLbrInOutOfOrder,
   and dot1agCfmMepLbrBadMsdu to their old values from step
   4, above, to get the results of the test.

*LTM Managed objects
The LTM Managed objects in the MEP table are used in a manner
similar to that described for LBM transmission, above. A SET
operation to the variable dot1agCfmMepTransmitLtmFlags
triggers the transmission of an LTM. Then, the variables
dot1agCfmMepTransmitLtmSeqNumber and
dot1agCfmMepTransmitLtmEgressIdentifier return the information
required to recover the results of the LTM from the
```

```
        dot1agCfmLtrTable.
       "
    REFERENCE
       "12.14.7, 19.2"
    ::= { dot1agCfmMep 1 }

dot1agCfmMepEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMepEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The MEP table entry"
    INDEX { dot1agCfmMdIndex,
            dot1agCfmMaIndex,
            dot1agCfmMepIdentifier
          }
    ::= { dot1agCfmMepTable 1 }

Dot1agCfmMepEntry ::= SEQUENCE {
      dot1agCfmMepIdentifier                  Dot1agCfmMepId,
      dot1agCfmMepIfIndex                     InterfaceIndexOrZero,
      dot1agCfmMepDirection                   Dot1agCfmMpDirection,
      dot1agCfmMepPrimaryVid                  Unsigned32,
      dot1agCfmMepActive                      TruthValue,
      dot1agCfmMepFngState                    Dot1agCfmFngState,
      dot1agCfmMepCciEnabled                  TruthValue,
      dot1agCfmMepCcmLtmPriority              Unsigned32,
      dot1agCfmMepMacAddress                  MacAddress,
      dot1agCfmMepLowPrDef                Dot1agCfmLowestAlarmPri,
      dot1agCfmMepFngAlarmTime                TimeInterval,
      dot1agCfmMepFngResetTime                TimeInterval,
      dot1agCfmMepHighestPrDefect         Dot1agCfmHighestDefectPri,
      dot1agCfmMepDefects                     Dot1agCfmMepDefects,
      dot1agCfmMepErrorCcmLastFailure         OCTET STRING,
      dot1agCfmMepXconCcmLastFailure          OCTET STRING,
      dot1agCfmMepCcmSequenceErrors           Counter32,
      dot1agCfmMepCciSentCcms                 Counter32,
      dot1agCfmMepNextLbmTransId              Unsigned32,
      dot1agCfmMepLbrIn                       Counter32,
      dot1agCfmMepLbrInOutOfOrder             Counter32,
      dot1agCfmMepLbrBadMsdu                  Counter32,
      dot1agCfmMepLtmNextSeqNumber            Unsigned32,
      dot1agCfmMepUnexpLtrIn                  Counter32,
      dot1agCfmMepLbrOut                      Counter32,
      dot1agCfmMepTransmitLbmStatus           TruthValue,
      dot1agCfmMepTransmitLbmDestMacAddress   MacAddress,
      dot1agCfmMepTransmitLbmDestMepId        Dot1agCfmMepIdOrZero,
      dot1agCfmMepTransmitLbmDestIsMepId      TruthValue,
      dot1agCfmMepTransmitLbmMessages         Integer32,
      dot1agCfmMepTransmitLbmDataTlv          OCTET STRING,
      dot1agCfmMepTransmitLbmVlanPriority     Integer32,
      dot1agCfmMepTransmitLbmVlanDropEnable   TruthValue,
      dot1agCfmMepTransmitLbmResultOK         TruthValue,
      dot1agCfmMepTransmitLbmSeqNumber        Unsigned32,
      dot1agCfmMepTransmitLtmStatus           TruthValue,
      dot1agCfmMepTransmitLtmFlags            BITS,
      dot1agCfmMepTransmitLtmTargetMacAddress MacAddress,
      dot1agCfmMepTransmitLtmTargetMepId      Dot1agCfmMepIdOrZero,
      dot1agCfmMepTransmitLtmTargetIsMepId    TruthValue,
      dot1agCfmMepTransmitLtmTtl              Unsigned32,
      dot1agCfmMepTransmitLtmResult           TruthValue,
      dot1agCfmMepTransmitLtmSeqNumber        Unsigned32,
      dot1agCfmMepTransmitLtmEgressIdentifier OCTET STRING,
      dot1agCfmMepRowStatus                   RowStatus,
      dot1agCfmMepPbbTeCanReportPbbTePresence    TruthValue,
      dot1agCfmMepPbbTeTrafficMismatchDefect     TruthValue,
      dot1agCfmMepPbbTransmitLbmLtmReverseVid    IEEE8021VlanIndex,
      dot1agCfmMepPbbTeMismatchAlarm             TruthValue,
      dot1agCfmMepPbbTeLocalMismatchDefect       TruthValue,
      dot1agCfmMepPbbTeMismatchSinceReset        TruthValue
    }
```

```
dot1agCfmMepIdentifier OBJECT-TYPE
    SYNTAX      Dot1agCfmMepId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Integer that is unique among all the MEPs in the same MA.
        Other definition is: a small integer, unique over a given
        Maintenance Association, identifying a specific Maintenance
        association Endpoint (3.133).

        MEP Identifier is also known as the MEPID.
       "
    REFERENCE
       "3.133, 19.2, 12.14.7"
    ::= { dot1agCfmMepEntry 1 }

dot1agCfmMepIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "This object is the interface index of the interface either a
        Bridge Port, or an aggregated IEEE 802.1 link within a Bridge
        port, to which the MEP is attached.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this variable so that it indexes the
        entry in the interface table with the same value of ifAlias
        that it indexed before the system restart.  If no such
        entry exists, then the system SHALL set this variable to 0.
       "
    REFERENCE
       "12.14.7.1.3:b"
    ::= { dot1agCfmMepEntry 2 }

dot1agCfmMepDirection OBJECT-TYPE
    SYNTAX      Dot1agCfmMpDirection
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The direction in which the MEP faces on the Bridge port."
    REFERENCE
       "12.14.7.1.3:c, 19.2"
    ::= { dot1agCfmMepEntry 3 }

dot1agCfmMepPrimaryVid OBJECT-TYPE
    SYNTAX      Unsigned32(0..16777215)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "An integer indicating the Primary VID of the MEP, always
        one of the VIDs assigned to the MEP's MA.  The value 0
        indicates that either the Primary VID is that of the
        MEP's MA, or that the MEP's MA is associated with no VID."
   REFERENCE
       "12.14.7.1.3:d"
   DEFVAL { 0 }
    ::= { dot1agCfmMepEntry 4 }

dot1agCfmMepActive OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Administrative state of the MEP

        A Boolean indicating the administrative state of the MEP.

        True indicates that the MEP is to function normally, and
        false that it is to cease functioning."
   REFERENCE
       "12.14.7.1.3:e, 20.9.1"
```

```
   DEFVAL { false }
   ::= { dot1agCfmMepEntry 5 }

dot1agCfmMepFngState OBJECT-TYPE
    SYNTAX      Dot1agCfmFngState
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Current state of the MEP Fault Notification Generator
        State Machine.
       "
    REFERENCE
       "12.14.7.1.3:f, 20.35"
    DEFVAL { fngReset }
    ::= { dot1agCfmMepEntry 6 }

dot1agCfmMepCciEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "If set to true, the MEP will generate CCM messages."
    REFERENCE
       "12.14.7.1.3:g, 20.10.1"
    DEFVAL { false }
    ::= { dot1agCfmMepEntry 7 }

dot1agCfmMepCcmLtmPriority OBJECT-TYPE
    SYNTAX      Unsigned32 (0..7)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The priority value for CCMs and LTMs transmitted by the MEP.
        Default Value is the highest priority value allowed to pass
        through the Bridge Port for any of this MEPs VIDs.
        The management entity can obtain the default value for this
        variable from the priority regeneration table by extracting the
        highest priority value in this table on this MEPs Bridge Port.
        (1 is lowest, then 2, then 0, then 3-7).
       "
    REFERENCE
       "12.14.7.1.3:h"
    ::= { dot1agCfmMepEntry 8 }

dot1agCfmMepMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "MAC address of the MEP."
    REFERENCE
      "12.14.7.1.3:i, 19.4"
    ::= { dot1agCfmMepEntry 9 }

dot1agCfmMepLowPrDef OBJECT-TYPE
    SYNTAX      Dot1agCfmLowestAlarmPri
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "An integer value specifying the lowest priority defect
        that is allowed to generate fault alarm.
       "
    REFERENCE
       "12.14.7.1.3:k, 20.9.5, Table 20-1"
    DEFVAL { macRemErrXcon }
    ::= { dot1agCfmMepEntry 10}

dot1agCfmMepFngAlarmTime OBJECT-TYPE
    SYNTAX      TimeInterval (250..1000)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
```

```
        "The time that defects MUST be present before a Fault Alarm is
         issued (fngAlarmTime, 20.3.3) (default 2.5s).
        "
    REFERENCE
        "12.14.7.1.3:l, 20.3.3"
    DEFVAL { 250 }
    ::= { dot1agCfmMepEntry 11 }

dot1agCfmMepFngResetTime OBJECT-TYPE
    SYNTAX      TimeInterval (250..1000)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The time that defects MUST be absent before resetting a
         Fault Alarm (fngResetTime, 20.35.4) (default 10s).
        "
    REFERENCE
        "12.14.7.1.3:m, 20.35.4"
    DEFVAL { 1000 }
    ::= { dot1agCfmMepEntry 12 }

dot1agCfmMepHighestPrDefect OBJECT-TYPE
    SYNTAX   Dot1agCfmHighestDefectPri
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The highest priority defect that has been present since the
         MEPs Fault Notification Generator State Machine was last in
         the FNG_RESET state.
        "
    REFERENCE
        "12.14.7.1.3:n, 20.35.9, Table 20-1"
    ::= { dot1agCfmMepEntry 13 }

dot1agCfmMepDefects OBJECT-TYPE
    SYNTAX      Dot1agCfmMepDefects
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A vector of Boolean error conditions from Table 20-1, any of
         which may be true:

         DefRDICCM(0)
         DefMACstatus(1)
         DefRemoteCCM(2)
         DefErrorCCM(3)
         DefXconCCM(4)
        "
    REFERENCE
        "12.14.7.1.3:o, 12.14.7.1.3:p, 12.14.7.1.3:q,
         12.14.7.1.3:r, 12.14.7.1.3:s, 20.21.3, 20.23.3, 20.35.5,
         20.35.6, 20.35.7."
    ::= { dot1agCfmMepEntry 14 }

dot1agCfmMepErrorCcmLastFailure OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(1..1522))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The last-received CCM that triggered an DefErrorCCM fault."
    REFERENCE
        "12.14.7.1.3:t, 20.21.2"
    ::= { dot1agCfmMepEntry 15 }

dot1agCfmMepXconCcmLastFailure OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(1..1522))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The last-received CCM that triggered a DefXconCCM fault."
    REFERENCE
        "12.14.7.1.3:u, 20.23.2"
```

```
    ::= { dot1agCfmMepEntry 16 }

dot1agCfmMepCcmSequenceErrors OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The total number of out-of-sequence CCMs received from all
        remote MEPs.
       "
    REFERENCE
       "12.14.7.1.3:v, 20.16.12"
    ::= { dot1agCfmMepEntry 17 }

dot1agCfmMepCciSentCcms OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Total number of Continuity Check messages transmitted."
    REFERENCE
       "12.14.7.1.3:w, 20.10.2"
    ::= { dot1agCfmMepEntry 18 }

dot1agCfmMepNextLbmTransId OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Next sequence number/transaction identifier to be sent in a
        Loopback message. This sequence number can be zero because
        it wraps around.
       "
    REFERENCE
       "12.14.7.1.3:x, 20.28.2"
    ::= { dot1agCfmMepEntry 19 }

dot1agCfmMepLbrIn OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Total number of valid, in-order Loopback Replies received."
    REFERENCE
       "12.14.7.1.3:y, 20.31.1"
    ::= { dot1agCfmMepEntry 20 }

dot1agCfmMepLbrInOutOfOrder OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The total number of valid, out-of-order Loopback Replies
        received.
       "
    REFERENCE
       "12.14.7.1.3:z, 20.31.1"
    ::= { dot1agCfmMepEntry 21 }

dot1agCfmMepLbrBadMsdu OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The total number of LBRs received whose
        mac_service_data_unit did not match (except for the OpCode)
        that of the corresponding LBM (20.2.3).
       "
    REFERENCE
       "12.14.7.1.3:aa, 20.2.3"
    ::= { dot1agCfmMepEntry 22}
```

```
dot1agCfmMepLtmNextSeqNumber OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Next transaction identifier/sequence number to be sent in a
        Linktrace message. This sequence number can be zero because
        it wraps around.
       "
    REFERENCE
       "12.14.7.1.3:ab, 20.41.1"
    ::= { dot1agCfmMepEntry 23 }

dot1agCfmMepUnexpLtrIn OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The total number of unexpected LTRs received (20.39.1).
       "
    REFERENCE
       "12.14.7.1.3:ac,  20.44.1"
    ::= { dot1agCfmMepEntry 24 }

dot1agCfmMepLbrOut OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Total number of Loopback Replies transmitted."
    REFERENCE
       "12.14.7.1.3:ad, 20.28.2"
    ::= { dot1agCfmMepEntry 25 }

dot1agCfmMepTransmitLbmStatus OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-create
   STATUS      current
   DESCRIPTION
      "A Boolean flag set to true by the MEP Loopback Initiator State
       Machine or an MIB manager to indicate
       that another LBM is being transmitted.
       Reset to false by the MEP Loopback Initiator State Machine."
   DEFVAL { false }
   ::= { dot1agCfmMepEntry 26 }

dot1agCfmMepTransmitLbmDestMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Target MAC Address Field to be transmitted: A unicast
        destination MAC address.
        This address will be used if the value of the column
        dot1agCfmMepTransmitLbmDestIsMepId is 'false'.
       "
    REFERENCE
       "12.14.7.3.2:b"
    ::= { dot1agCfmMepEntry 27 }

dot1agCfmMepTransmitLbmDestMepId OBJECT-TYPE
    SYNTAX      Dot1agCfmMepIdOrZero
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Maintenance association Endpoint Identifier of another
        MEP in the same Maintenance Association to which the LBM is
        to be sent.
        This address will be used if the value of the column
        dot1agCfmMepTransmitLbmDestIsMepId is 'true'.
       "
    REFERENCE
```

```
        "12.14.7.3.2:b"
    ::= { dot1agCfmMepEntry 28 }

dot1agCfmMepTransmitLbmDestIsMepId OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "True indicates that MEPID of the target MEP is used for
         Loopback transmission.
         False indicates that unicast destination MAC address of the
         target MEP is used for Loopback transmission.
        "
    REFERENCE
        "12.14.7.3.2:b"
    ::= {dot1agCfmMepEntry 29 }

dot1agCfmMepTransmitLbmMessages OBJECT-TYPE
    SYNTAX      Integer32(1..1024)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The number of Loopback messages to be transmitted."
    REFERENCE
        "12.14.7.3.2:c"
    DEFVAL { 1 }
    ::= {dot1agCfmMepEntry 30 }

dot1agCfmMepTransmitLbmDataTlv OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "An arbitrary amount of data to be included in the Data TLV,
         if the Data TLV is selected to be sent.  The intent is to be able
         to fill the frame carrying the CFM PDU to its maximum length.
         This may lead to fragmentation in some cases.
        "
    REFERENCE
        "12.14.7.3.2:d"
    ::= { dot1agCfmMepEntry 31 }

dot1agCfmMepTransmitLbmVlanPriority OBJECT-TYPE
    SYNTAX      Integer32(0..7)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Priority. 3 bit value to be used in the VLAN tag, if present
         in the transmitted frame.

         The default value is CCM priority.
        "
    REFERENCE
        "12.14.7.3.2:e"
    ::= { dot1agCfmMepEntry 32 }

dot1agCfmMepTransmitLbmVlanDropEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Drop Enable bit value to be used in the VLAN tag, if present
         in the transmitted frame.

         For more information about VLAN Drop Enable, check
         IEEE Std 802.1ad.
        "
    REFERENCE
        "12.14.7.3.2:e"
    DEFVAL { false }
    ::= { dot1agCfmMepEntry 33 }
```

```
dot1agCfmMepTransmitLbmResultOK OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Indicates the result of the operation:

        - true       The Loopback Message(s) will be
                     (or has been) sent.
        - false      The Loopback Message(s) will not
                     be sent.
       "
    REFERENCE
       "12.14.7.3.3:a"
    DEFVAL { true }
    ::= { dot1agCfmMepEntry 34 }

dot1agCfmMepTransmitLbmSeqNumber OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Loopback Transaction Identifier
       (dot1agCfmMepNextLbmTransId) of the first LBM (to be) sent.
        The value returned is undefined if
        dot1agCfmMepTransmitLbmResultOK is false.
       "
    REFERENCE
       "12.14.7.3.3:a"
    ::= { dot1agCfmMepEntry 35 }

dot1agCfmMepTransmitLtmStatus OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-create
   STATUS      current
   DESCRIPTION
      "A Boolean flag set to true by the Bridge Port to indicate
       that another LTM may be transmitted.
       Reset to false by the MEP Linktrace Initiator State Machine."
   DEFVAL { true }
   ::= { dot1agCfmMepEntry 36 }

dot1agCfmMepTransmitLtmFlags OBJECT-TYPE
    SYNTAX      BITS {
                  useFDBonly   (0)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The flags field for LTMs transmitted by the MEP."
    REFERENCE
       "12.14.7.4.2:b, 20.42.1"
    DEFVAL { {useFDBonly } }
    ::= { dot1agCfmMepEntry 37 }

dot1agCfmMepTransmitLtmTargetMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Target MAC Address Field to be transmitted: A unicast
        destination MAC address.
        This address will be used if the value of the column
        dot1agCfmMepTransmitLtmTargetIsMepId is 'false'.
       "
    REFERENCE
       "12.14.7.4.2:c"
    ::= { dot1agCfmMepEntry 38 }

dot1agCfmMepTransmitLtmTargetMepId OBJECT-TYPE
    SYNTAX      Dot1agCfmMepIdOrZero
    MAX-ACCESS  read-create
```

```
    STATUS      current
    DESCRIPTION
       "An indication of the Target MAC Address Field to be
        transmitted:
        The Maintenance association Endpoint Identifier of
        another MEP in the same Maintenance Association
        This address will be used if the value of the column
        dot1agCfmMepTransmitLtmTargetIsMepId is 'true'.
       "
    REFERENCE
       "12.14.7.4.2:c"
    ::= { dot1agCfmMepEntry 39 }

dot1agCfmMepTransmitLtmTargetIsMepId OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "True indicates that MEPID of the target MEP is used for
        Linktrace transmission.
        False indicates that unicast destination MAC address of the
        target MEP is used for Loopback transmission.
       "
    REFERENCE
       "12.14.7.4.2:c"
    ::= { dot1agCfmMepEntry 40 }

dot1agCfmMepTransmitLtmTtl OBJECT-TYPE
    SYNTAX      Unsigned32 (0..255)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The LTM TTL field. Default value, if not specified, is 64.
        The TTL field indicates the number of hops remaining to the
        LTM.  Decremented by 1 by each Linktrace Responder that
        handles the LTM.  The value returned in the LTR is one less
        than that received in the LTM.  If the LTM TTL is 0 or 1, the
        LTM is not forwarded to the next hop, and if 0, no LTR is
        generated.
       "
    REFERENCE
       "12.14.7.4.2:d, 21.8.4"
    DEFVAL {64}
    ::= { dot1agCfmMepEntry 41 }

dot1agCfmMepTransmitLtmResult OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Indicates the result of the operation:

        - true    The Linktrace Message will be (or has been) sent.
        - false   The Linktrace Message will not be sent"
    REFERENCE
       "12.14.7.4.3:a"
    DEFVAL { true }
    ::= { dot1agCfmMepEntry 42 }

dot1agCfmMepTransmitLtmSeqNumber OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The LTM Transaction Identifier
        (dot1agCfmMepLtmNextSeqNumber) of the LTM sent.
        The value returned is undefined if
        dot1agCfmMepTransmitLtmResult is false.
       "
    REFERENCE
       "12.14.7.4.3:a"
    ::= { dot1agCfmMepEntry 43 }
```

```
dot1agCfmMepTransmitLtmEgressIdentifier OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(8))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Identifies the MEP Linktrace Initiator that is originating,
        or the Linktrace Responder that is forwarding, this LTM.
        The low-order six octets contain a 48-bit IEEE MAC address
        unique to the system in which the MEP Linktrace Initiator
        or Linktrace Responder resides.  The high-order two octets
        contain a value sufficient to uniquely identify the MEP
        Linktrace Initiator or Linktrace Responder within that system.

        For most Bridges, the address of any MAC attached to the
        Bridge will suffice for the low-order six octets, and 0 for
        the high-order octets.  In some situations, e.g., if multiple
        virtual Bridges utilizing emulated LANs are implemented in a
        single physical system, the high-order two octets can be used
        to differentiate among the transmitting entities.

        The value returned is undefined if
        dot1agCfmMepTransmitLtmResult is false.
       "
    REFERENCE
       "12.14.7.4.3:b, 21.8.8"
    ::= { dot1agCfmMepEntry 44 }

dot1agCfmMepRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
       "
   ::= { dot1agCfmMepEntry 45 }

dot1agCfmMepPbbTeCanReportPbbTePresence OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-create
   STATUS       current
   DESCRIPTION
      "A Boolean valued parameter that is set to true if the system
       has the capability to report the presence of traffic and that
       the capability is enabled. Traffic presence reporting is an
       optional PBB-TE feature."
   REFERENCE
      "12.14.7.1.3:af, 21.6.1.4"
   DEFVAL { false }
   ::= { dot1agCfmMepEntry 46 }

dot1agCfmMepPbbTeTrafficMismatchDefect OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION
      "A Boolean valued parameter that is set to true if the system
       has detected a traffic field mismatch defect.  Mismatch detection
        is an optional PBB-TE feature."
   REFERENCE
      "12.14.7.1.3:ah, 21.6.1.4"
   ::= { dot1agCfmMepEntry 47 }

dot1agCfmMepPbbTransmitLbmLtmReverseVid OBJECT-TYPE
   SYNTAX       IEEE8021VlanIndex
   MAX-ACCESS   read-create
   STATUS       current
   DESCRIPTION
```

```
      "This column specifies the value to use in the Reverse VID value
       field of PBB-TE MIP TLVs contained within TransmitLTM pdus."
   REFERENCE
      "12.14.7.4.2"
   ::= { dot1agCfmMepEntry 48 }

dot1agCfmMepPbbTeMismatchAlarm OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-create
   STATUS       current
   DESCRIPTION
      "A Boolean valued parameter that is set to true if the system
       is to allow a mismatch defect to generate a fault alarm."
   REFERENCE
      "12.14.7.1.3:ag, 21.6.1.4"
   DEFVAL { false }
   ::= { dot1agCfmMepEntry 49 }

dot1agCfmMepPbbTeLocalMismatchDefect OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION
      "A Boolean valued parameter that is set to true if the system
       has detected a local mismatch defect.  Mismatch detection
       is an optional PBB-TE feature."
   REFERENCE
      "12.14.7.1.3:ai, 21.6.1.4"
   ::= { dot1agCfmMepEntry 50 }

dot1agCfmMepPbbTeMismatchSinceReset OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION
      "A Boolean valued parameter indicating if the mismatch defect
       has been present since the MEP Mismatch Fault Notification
       Generator was last in the MFNG_RESET state."
   REFERENCE
      "12.14.7.1.3:aj"
   ::= { dot1agCfmMepEntry 51 }



-- ********************************************************************
-- The Linktrace Reply Table
-- ********************************************************************

dot1agCfmLtrTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmLtrEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This table extends the MEP table and contains a list of
        Linktrace replies received by a specific MEP in response to
        a linktrace message.

        SNMP SMI does not allow to state in a MIB that an object in
        a table is an array.  The solution is to take the index (or
        indices) of the first table and add one or more indices.
       "
    REFERENCE
       "12.14.7.5"
    ::= { dot1agCfmMep 2 }

dot1agCfmLtrEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmLtrEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Linktrace Reply table entry."
    INDEX { dot1agCfmMdIndex,
```

```
            dot1agCfmMaIndex,
            dot1agCfmMepIdentifier,
            dot1agCfmLtrSeqNumber,
            dot1agCfmLtrReceiveOrder
          }
    ::= { dot1agCfmLtrTable 1 }

Dot1agCfmLtrEntry ::= SEQUENCE {
      dot1agCfmLtrSeqNumber            Unsigned32,
      dot1agCfmLtrReceiveOrder         Unsigned32,
      dot1agCfmLtrTtl                  Unsigned32,
      dot1agCfmLtrForwarded            TruthValue,
      dot1agCfmLtrTerminalMep          TruthValue,
      dot1agCfmLtrLastEgressIdentifier OCTET STRING,
      dot1agCfmLtrNextEgressIdentifier OCTET STRING,
      dot1agCfmLtrRelay            Dot1agCfmRelayActionFieldValue,
      dot1agCfmLtrChassisIdSubtype     LldpChassisIdSubtype,
      dot1agCfmLtrChassisId            LldpChassisId,
      dot1agCfmLtrManAddressDomain     TDomain,
      dot1agCfmLtrManAddress           TAddress,
      dot1agCfmLtrIngress          Dot1agCfmIngressActionFieldValue,
      dot1agCfmLtrIngressMac           MacAddress,
      dot1agCfmLtrIngressPortIdSubtype LldpPortIdSubtype,
      dot1agCfmLtrIngressPortId        LldpPortId,
      dot1agCfmLtrEgress           Dot1agCfmEgressActionFieldValue,
      dot1agCfmLtrEgressMac            MacAddress,
      dot1agCfmLtrEgressPortIdSubtype  LldpPortIdSubtype,
      dot1agCfmLtrEgressPortId         LldpPortId,
      dot1agCfmLtrOrganizationSpecificTlv  OCTET STRING
    }

dot1agCfmLtrSeqNumber OBJECT-TYPE
    SYNTAX      Unsigned32 (0..4294967295)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Transaction identifier/Sequence number returned by a previous
        transmit linktrace message command, indicating which LTM's
        response is going to be returned.
       "
    REFERENCE
       "12.14.7.5.2:b"
    ::= { dot1agCfmLtrEntry 1}

dot1agCfmLtrReceiveOrder OBJECT-TYPE
    SYNTAX      Unsigned32(1..4294967295)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "An index to distinguish among multiple LTRs with the same LTR
        Transaction Identifier field value.  dot1agCfmLtrReceiveOrder
        are assigned sequentially from 1, in the order that the
        Linktrace Initiator received the LTRs.
       "
    REFERENCE
       "12.14.7.5.2:c"
    ::= { dot1agCfmLtrEntry 2 }

dot1agCfmLtrTtl OBJECT-TYPE
    SYNTAX      Unsigned32 (0..255)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "TTL field value for a returned LTR."
    REFERENCE
       "12.14.7.5, 20.41.2.2"
    ::= { dot1agCfmLtrEntry 3 }

dot1agCfmLtrForwarded OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
       "Indicates if a LTM was forwarded by the responding MP, as
        returned in the 'FwdYes' flag of the flags field.
       "
    REFERENCE
       "12.14.7.5.3:c, 20.41.2.1"
    ::= { dot1agCfmLtrEntry 4 }

dot1agCfmLtrTerminalMep OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "A Boolean value stating whether the forwarded LTM reached a
        MEP enclosing its MA, as returned in the Terminal MEP flag of
        the Flags field.
       "
    REFERENCE
       "12.14.7.5.3:d, 20.41.2.1"
    ::= { dot1agCfmLtrEntry 5 }

dot1agCfmLtrLastEgressIdentifier OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(8))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "An octet field holding the Last Egress Identifier returned
        in the LTR Egress Identifier TLV of the LTR.
        The Last Egress Identifier identifies the MEP Linktrace
        Initiator that originated, or the Linktrace Responder that
        forwarded, the LTM to which this LTR is the response.  This
        is the same value as the Egress Identifier TLV of that LTM.
       "
    REFERENCE
       "12.14.7.5.3:e, 20.41.2.3"
    ::= { dot1agCfmLtrEntry 6 }

dot1agCfmLtrNextEgressIdentifier OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(8))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "An octet field holding the Next Egress Identifier returned
        in the LTR Egress Identifier TLV of the LTR.  The Next Egress
        Identifier Identifies the Linktrace Responder that
        transmitted this LTR, and can forward the LTM to the next
        hop.  This is the same value as the Egress Identifier TLV of
        the forwarded LTM, if any. If the FwdYes bit of the Flags
        field is false, the contents of this field are undefined,
        i.e., any value can be transmitted, and the field is ignored
        by the receiver.
       "
    REFERENCE
       "12.14.7.5.3:f, 20.41.2.4"
    ::= { dot1agCfmLtrEntry 7 }

dot1agCfmLtrRelay OBJECT-TYPE
    SYNTAX      Dot1agCfmRelayActionFieldValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Value returned in the Relay Action field."
    REFERENCE
       "12.14.7.5.3:g, 20.41.2.5"
    ::= { dot1agCfmLtrEntry 8 }

dot1agCfmLtrChassisIdSubtype OBJECT-TYPE
    SYNTAX      LldpChassisIdSubtype
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object specifies the format of the Chassis ID returned
```

```
        in the Sender ID TLV of the LTR, if any.  This value is
        meaningless if the dot1agCfmLtrChassisId has a length of 0."
    REFERENCE
       "12.14.7.5.3:h, 21.5.3.2"
    ::= { dot1agCfmLtrEntry 9 }

dot1agCfmLtrChassisId OBJECT-TYPE
    SYNTAX      LldpChassisId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Chassis ID returned in the Sender ID TLV of the LTR, if
        any. The format of this object is determined by the
        value of the dot1agCfmLtrChassisIdSubtype object.
       "
    REFERENCE
       "12.14.7.5.3:i, 21.5.3.2"
    ::= { dot1agCfmLtrEntry 10 }

dot1agCfmLtrManAddressDomain OBJECT-TYPE
    SYNTAX      TDomain
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The TDomain that identifies the type and format of
        the related dot1agCfmMepDbManAddress object, used to access
        the SNMP agent of the system transmitting the LTR.  Received
        in the LTR Sender ID TLV from that system.

        Typical values will be one of (not all inclusive) list:


           snmpUDPDomain          (from SNMPv2-TM, RFC3417)
           snmpIeee802Domain      (from SNMP-IEEE802-TM-MIB, RFC4789)

        The value 'zeroDotZero' (from RFC2578) indicates 'no management
        address was present in the LTR', in which case the related
        object dot1agCfmMepDbManAddress MUST have a zero-length OCTET
        STRING as a value.
       "
    REFERENCE
       "12.14.7.5.3:j, 21.5.3.5, 21.9.6"
    ::= { dot1agCfmLtrEntry 11 }

dot1agCfmLtrManAddress OBJECT-TYPE
    SYNTAX      TAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The TAddress that can be used to access the SNMP
        agent of the system transmitting the CCM, received in the CCM
        Sender ID TLV from that system.

        If the related object dot1agCfmLtrManAddressDomain contains
        the value 'zeroDotZero', this object dot1agCfmLtrManAddress
        MUST have a zero-length OCTET STRING as a value.
      "
    REFERENCE
       "12.14.7.5.3:j, 21.5.3.7, 21.9.6"
    ::= { dot1agCfmLtrEntry 12 }

dot1agCfmLtrIngress OBJECT-TYPE
    SYNTAX      Dot1agCfmIngressActionFieldValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The value returned in the Ingress Action Field of the LTM.
        The value ingNoTlv(0) indicates that no Reply Ingress TLV was
        returned in the LTM."
    REFERENCE
       "12.14.7.5.3:k, 20.41.2.6"
    ::= { dot1agCfmLtrEntry 13 }
```

```
dot1agCfmLtrIngressMac OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "MAC address returned in the ingress MAC address field.
        If the dot1agCfmLtrIngress object contains the value
        ingNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:l, 20.41.2.7"
    ::= { dot1agCfmLtrEntry 14 }

dot1agCfmLtrIngressPortIdSubtype OBJECT-TYPE
    SYNTAX      LldpPortIdSubtype
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Format of the Ingress Port ID.
        If the dot1agCfmLtrIngress object contains the value
        ingNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:m, 20.41.2.8"
   ::= { dot1agCfmLtrEntry 15 }

dot1agCfmLtrIngressPortId OBJECT-TYPE
    SYNTAX      LldpPortId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Ingress Port ID. The format of this object is determined by
        the value of the dot1agCfmLtrIngressPortIdSubtype object.
        If the dot1agCfmLtrIngress object contains the value
        ingNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:n, 20.41.2.9"
    ::= { dot1agCfmLtrEntry 16 }

dot1agCfmLtrEgress OBJECT-TYPE
    SYNTAX      Dot1agCfmEgressActionFieldValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The value returned in the Egress Action Field of the LTM.
        The value egrNoTlv(0) indicates that no Reply Egress TLV was
        returned in the LTM."
    REFERENCE
       "12.14.7.5.3:o, 20.41.2.10"
    ::= { dot1agCfmLtrEntry 17 }

dot1agCfmLtrEgressMac OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "MAC address returned in the egress MAC address field.
        If the dot1agCfmLtrEgress object contains the value
        egrNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:p, 20.41.2.11"
    ::= { dot1agCfmLtrEntry 18 }

dot1agCfmLtrEgressPortIdSubtype OBJECT-TYPE
    SYNTAX      LldpPortIdSubtype
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Format of the egress Port ID.
        If the dot1agCfmLtrEgress object contains the value
        egrNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:q, 20.41.2.12"
```

```
    ::= { dot1agCfmLtrEntry 19 }

dot1agCfmLtrEgressPortId OBJECT-TYPE
    SYNTAX      LldpPortId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Egress Port ID. The format of this object is determined by
        the value of the dot1agCfmLtrEgressPortIdSubtype object.
        If the dot1agCfmLtrEgress object contains the value
        egrNoTlv(0), then the contents of this object are meaningless."
    REFERENCE
       "12.14.7.5.3:r, 20.41.2.13"
    ::= { dot1agCfmLtrEntry 20 }

dot1agCfmLtrOrganizationSpecificTlv OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0|4..1500))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "All Organization specific TLVs returned in the LTR, if
        any.  Includes all octets including and following the TLV
        Length field of each TLV, concatenated together."
    REFERENCE
       "12.14.7.5.3:s, 21.5.2"
    ::= { dot1agCfmLtrEntry 21 }

-- ********************************************************************
-- The MEP Database Table
-- ********************************************************************

dot1agCfmMepDbTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Dot1agCfmMepDbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The MEP Database. A database, maintained by every MEP, that
        maintains received information about other MEPs in the
        Maintenance Domain.

        The SMI does not allow to state in a MIB that an object in
        a table is an array. The solution is to take the index (or
        indices) of the first table and add one or more indices.
       "
    REFERENCE
       "19.2.15"
    ::= { dot1agCfmMep 3 }

dot1agCfmMepDbEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMepDbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The MEP Database table entry."
    INDEX { dot1agCfmMdIndex,
            dot1agCfmMaIndex,
            dot1agCfmMepIdentifier,
            dot1agCfmMepDbRMepIdentifier
          }
    ::= { dot1agCfmMepDbTable 1 }

Dot1agCfmMepDbEntry ::= SEQUENCE {
      dot1agCfmMepDbRMepIdentifier         Dot1agCfmMepId,
      dot1agCfmMepDbRMepState              Dot1agCfmRemoteMepState,
      dot1agCfmMepDbRMepFailedOkTime       TimeStamp,
      dot1agCfmMepDbMacAddress             MacAddress,
      dot1agCfmMepDbRdi                    TruthValue,
      dot1agCfmMepDbPortStatusTlv          Dot1agCfmPortStatus,
      dot1agCfmMepDbInterfaceStatusTlv     Dot1agCfmInterfaceStatus,
      dot1agCfmMepDbChassisIdSubtype       LldpChassisIdSubtype,
      dot1agCfmMepDbChassisId              LldpChassisId,
      dot1agCfmMepDbManAddressDomain       TDomain,
```

```
      dot1agCfmMepDbManAddress             TAddress,
      dot1agCfmMepDbRMepIsActive           TruthValue
    }

dot1agCfmMepDbRMepIdentifier OBJECT-TYPE
    SYNTAX      Dot1agCfmMepId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Maintenance association Endpoint Identifier of a remote MEP
        whose information from the MEP Database is to be returned.
       "
    REFERENCE
       "12.14.7.6.2:b"
    ::= { dot1agCfmMepDbEntry 1 }

dot1agCfmMepDbRMepState OBJECT-TYPE
    SYNTAX      Dot1agCfmRemoteMepState
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The operational state of the remote MEP IFF State machines."
    REFERENCE
       "12.14.7.6.3:b, 20.22"
    ::= { dot1agCfmMepDbEntry 2}

dot1agCfmMepDbRMepFailedOkTime OBJECT-TYPE
    SYNTAX      TimeStamp
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The time (SysUpTime) at which the IFF Remote MEP state machine
        last entered either the RMEP_FAILED or RMEP_OK state.
       "
    REFERENCE
       "12.14.7.6.3:c"
    ::= { dot1agCfmMepDbEntry 3 }

dot1agCfmMepDbMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The MAC address of the remote MEP."
    REFERENCE
       "12.14.7.6.3:d, 20.19.7"
    ::= { dot1agCfmMepDbEntry 4 }

dot1agCfmMepDbRdi OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "State of the RDI bit in the last received CCM (true for
        RDI=1), or false if none has been received.
       "
    REFERENCE
       "12.14.7.6.3:e, 20.19.2"
    ::= { dot1agCfmMepDbEntry 5 }

dot1agCfmMepDbPortStatusTlv OBJECT-TYPE
    SYNTAX      Dot1agCfmPortStatus
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "An enumerated value of the Port status TLV received in the
        last CCM from the remote MEP or the default value
        psNoPortStateTLV indicating either no CCM has been received,
        or that nor port status TLV was received in the last CCM.
       "
    REFERENCE
       "12.14.7.6.3:f, 20.19.3"
```

```
    DEFVAL { psNoPortStateTLV }
    ::= { dot1agCfmMepDbEntry 6}

dot1agCfmMepDbInterfaceStatusTlv OBJECT-TYPE
    SYNTAX      Dot1agCfmInterfaceStatus
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "An enumerated value of the Interface status TLV received
        in the last CCM from the remote MEP or the default value
        isNoInterfaceStatus TLV indicating either no CCM has been
        received, or that no interface status TLV was received in
        the last CCM.
       "
    REFERENCE
       "12.14.7.6.3:g, 20.19.4"
    DEFVAL { isNoInterfaceStatusTLV }
    ::= { dot1agCfmMepDbEntry 7}

dot1agCfmMepDbChassisIdSubtype OBJECT-TYPE
    SYNTAX      LldpChassisIdSubtype
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object specifies the format of the Chassis ID received
        in the last CCM."
    REFERENCE
       "12.14.7.6.3:h, 21.5.3.2"
    ::= { dot1agCfmMepDbEntry 8 }

dot1agCfmMepDbChassisId OBJECT-TYPE
    SYNTAX      LldpChassisId
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Chassis ID. The format of this object is determined by the
        value of the dot1agCfmLtrChassisIdSubtype object.
       "
    REFERENCE
       "12.14.7.6.3:h, 21.5.3.3"
    ::= { dot1agCfmMepDbEntry 9 }

dot1agCfmMepDbManAddressDomain OBJECT-TYPE
    SYNTAX      TDomain
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The TDomain that identifies the type and format of
        the related dot1agCfmMepDbManAddress object, used to access
        the SNMP agent of the system transmitting the CCM.  Received
        in the CCM Sender ID TLV from that system.

        Typical values will be one of (not all inclusive) list:


           snmpUDPDomain          (from SNMPv2-TM, RFC3417)
           snmpIeee802Domain      (from SNMP-IEEE802-TM-MIB, RFC4789)

        The value 'zeroDotZero' (from RFC2578) indicates 'no management
        address was present in the LTR', in which case the related
        object dot1agCfmMepDbManAddress MUST have a zero-length OCTET
        STRING as a value.
       "
    REFERENCE
       "12.14.7.6.3:h, 21.5.3.5, 21.6.7"
    ::= { dot1agCfmMepDbEntry 10 }

dot1agCfmMepDbManAddress OBJECT-TYPE
    SYNTAX      TAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
```

```
        "The TAddress that can be used to access the SNMP
         agent of the system transmitting the CCM, received in the CCM
         Sender ID TLV from that system.

         If the related object dot1agCfmMepDbManAddressDomain contains
         the value 'zeroDotZero', this object dot1agCfmMepDbManAddress
         MUST have a zero-length OCTET STRING as a value.
        "
    REFERENCE
       "12.14.7.6.3:h, 21.5.3.7, 21.6.7"
    ::= { dot1agCfmMepDbEntry 11 }

dot1agCfmMepDbRMepIsActive OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A Boolean value stating if the remote MEP is active."
    REFERENCE
       "12.14.7.1.3:ae"
    ::= { dot1agCfmMepDbEntry 12 }

-- ********************************************************************
-- NOTIFICATIONS (TRAPS)
-- These notifications will be sent to the management entity
-- whenever a MEP loses/restores contact with one or more other MEPs.
-- ********************************************************************

dot1agCfmFaultAlarm NOTIFICATION-TYPE
    OBJECTS     { dot1agCfmMepHighestPrDefect
                }
    STATUS      current
    DESCRIPTION
       "A MEP has a persistent defect condition. A notification
        (fault alarm) is sent to the management entity with the OID
        of the MEP that has detected the fault.

        Whenever a MEP has a persistent defect,
        it may or may not generate a Fault Alarm to warn the system
        administrator of the problem, as controlled by the MEP
        Fault Notification Generator State Machine and associated
        Managed Objects. Only the highest-priority defect, as shown
        in Table 20-1, is reported in the Fault Alarm.

        If a defect with a higher priority is raised after a Fault
        Alarm has been issued, another Fault Alarm is issued.

        The management entity receiving the notification can identify
        the system from the network source address of the
        notification, and can identify the MEP reporting the defect
        by the indices in the OID of the dot1agCfmMepHighestPrDefect
        variable in the notification:

           dot1agCfmMdIndex - Also the index of the MEP's
                              Maintenance Domain table entry
                              (dot1agCfmMdTable).
           dot1agCfmMaIndex - Also an index (with the MD table index)
                              of the MEP's Maintenance Association
                              network table entry
                              (dot1agCfmMaNetTable), and (with the MD
                              table index and component ID) of the
                              MEP's MA component table entry
                              (dot1agCfmMaCompTable).
           dot1agCfmMepIdentifier - MEP Identifier and final index
                              into the MEP table (dot1agCfmMepTable).
       "
    REFERENCE
       "12.14.7.7"
    ::= { dot1agNotifications 1 }

-- ********************************************************************
-- CFM MIB Module - Conformance Information
```

```
-- ****************************************************************

dot1agCfmCompliances OBJECT IDENTIFIER ::= { dot1agCfmConformance 1 }
dot1agCfmGroups      OBJECT IDENTIFIER ::= { dot1agCfmConformance 2 }

-- ****************************************************************
-- Units of conformance
-- ****************************************************************
dot1agCfmStackGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmStackMdIndex,
      dot1agCfmStackMaIndex,
      dot1agCfmStackMepId,
      dot1agCfmStackMacAddress
    }
    STATUS      deprecated
    DESCRIPTION
       "Objects for the Stack group."
    ::= { dot1agCfmGroups 1 }

dot1agCfmDefaultMdGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmDefaultMdDefLevel,
      dot1agCfmDefaultMdDefMhfCreation,
      dot1agCfmDefaultMdDefIdPermission,
      dot1agCfmDefaultMdStatus,
      dot1agCfmDefaultMdLevel,
      dot1agCfmDefaultMdMhfCreation,
      dot1agCfmDefaultMdIdPermission
    }
    STATUS      deprecated
    DESCRIPTION
       "Objects for the Default MD Level group."
    ::= { dot1agCfmGroups 2 }

dot1agCfmVlanIdGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmVlanPrimaryVid,
      dot1agCfmVlanRowStatus
   }
    STATUS      deprecated
    DESCRIPTION
       "Objects for the VLAN ID group."
    ::= { dot1agCfmGroups 3 }

dot1agCfmConfigErrorListGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmConfigErrorListErrorType
    }
    STATUS deprecated
    DESCRIPTION
       "Objects for the CFM Configuration Error List Group."
    ::= {dot1agCfmGroups 4 }

dot1agCfmMdGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMdTableNextIndex,
      dot1agCfmMdName,
      dot1agCfmMdFormat,
      dot1agCfmMdMdLevel,
      dot1agCfmMdMhfCreation,
      dot1agCfmMdMhfIdPermission,
      dot1agCfmMdMaNextIndex,
      dot1agCfmMdRowStatus
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Maintenance Domain Group."
    ::={dot1agCfmGroups 5 }

dot1agCfmMaGroup OBJECT-GROUP
    OBJECTS {
```

```
      dot1agCfmMaNetFormat,
      dot1agCfmMaNetName,
      dot1agCfmMaNetCcmInterval,
      dot1agCfmMaNetRowStatus,
      dot1agCfmMaCompPrimaryVlanId,
      dot1agCfmMaCompMhfCreation,
      dot1agCfmMaCompIdPermission,
      dot1agCfmMaCompRowStatus,
      dot1agCfmMaCompNumberOfVids,
      dot1agCfmMaMepListRowStatus
    }
    STATUS      deprecated
    DESCRIPTION
       "Objects for the MA group."
    ::= { dot1agCfmGroups 6 }

dot1agCfmMepGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMepIfIndex,
      dot1agCfmMepDirection,
      dot1agCfmMepPrimaryVid,
      dot1agCfmMepActive,
      dot1agCfmMepFngState,
      dot1agCfmMepCciEnabled,
      dot1agCfmMepCcmLtmPriority,
      dot1agCfmMepMacAddress,
      dot1agCfmMepLowPrDef,
      dot1agCfmMepFngAlarmTime,
      dot1agCfmMepFngResetTime,
      dot1agCfmMepHighestPrDefect,
      dot1agCfmMepDefects,
      dot1agCfmMepErrorCcmLastFailure,
      dot1agCfmMepXconCcmLastFailure,
      dot1agCfmMepCcmSequenceErrors,
      dot1agCfmMepCciSentCcms,
      dot1agCfmMepNextLbmTransId,
      dot1agCfmMepLbrIn,
      dot1agCfmMepLbrInOutOfOrder,
      dot1agCfmMepLbrBadMsdu,
      dot1agCfmMepLtmNextSeqNumber,
      dot1agCfmMepUnexpLtrIn,
      dot1agCfmMepLbrOut,
      dot1agCfmMepTransmitLbmStatus,
      dot1agCfmMepTransmitLbmDestMacAddress,
      dot1agCfmMepTransmitLbmDestMepId,
      dot1agCfmMepTransmitLbmDestIsMepId,
      dot1agCfmMepTransmitLbmMessages,
      dot1agCfmMepTransmitLbmDataTlv,
      dot1agCfmMepTransmitLbmVlanPriority,
      dot1agCfmMepTransmitLbmVlanDropEnable,
      dot1agCfmMepTransmitLbmResultOK,
      dot1agCfmMepTransmitLbmSeqNumber,
      dot1agCfmMepTransmitLtmStatus,
      dot1agCfmMepTransmitLtmFlags,
      dot1agCfmMepTransmitLtmTargetMacAddress,
      dot1agCfmMepTransmitLtmTargetMepId,
      dot1agCfmMepTransmitLtmTargetIsMepId,
      dot1agCfmMepTransmitLtmTtl,
      dot1agCfmMepTransmitLtmResult,
      dot1agCfmMepTransmitLtmSeqNumber,
      dot1agCfmMepTransmitLtmEgressIdentifier,
      dot1agCfmMepRowStatus,
      dot1agCfmLtrForwarded,
      dot1agCfmLtrRelay,
      dot1agCfmLtrChassisIdSubtype,
      dot1agCfmLtrChassisId,
      dot1agCfmLtrManAddress,
      dot1agCfmLtrManAddressDomain,
      dot1agCfmLtrIngress,
      dot1agCfmLtrIngressMac,
      dot1agCfmLtrIngressPortIdSubtype,
      dot1agCfmLtrIngressPortId,
```

```
      dot1agCfmLtrEgress,
      dot1agCfmLtrEgressMac,
      dot1agCfmLtrEgressPortIdSubtype,
      dot1agCfmLtrEgressPortId,
      dot1agCfmLtrTerminalMep,
      dot1agCfmLtrLastEgressIdentifier,
      dot1agCfmLtrNextEgressIdentifier,
      dot1agCfmLtrTtl,
      dot1agCfmLtrOrganizationSpecificTlv
    }
    STATUS      current
    DESCRIPTION
       "Objects for the MEP group."
    ::= { dot1agCfmGroups 7 }

dot1agCfmMepDbGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMepDbRMepState,
      dot1agCfmMepDbRMepFailedOkTime,
      dot1agCfmMepDbMacAddress,
      dot1agCfmMepDbRdi,
      dot1agCfmMepDbPortStatusTlv,
      dot1agCfmMepDbInterfaceStatusTlv,
      dot1agCfmMepDbChassisIdSubtype,
      dot1agCfmMepDbChassisId,
      dot1agCfmMepDbManAddressDomain,
      dot1agCfmMepDbManAddress
    }
    STATUS      current
    DESCRIPTION
       "Objects for the MEP group."
    ::= { dot1agCfmGroups 8 }

dot1agCfmNotificationsGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
      dot1agCfmFaultAlarm
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Notifications group."
    ::= { dot1agCfmGroups 9 }


ieee8021CfmMaNetGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMaNetFormat,
      dot1agCfmMaNetName,
      dot1agCfmMaNetCcmInterval,
      dot1agCfmMaNetRowStatus,
      dot1agCfmMaMepListRowStatus

    }
    STATUS      current
    DESCRIPTION
       "Objects for the MA Net group."
    ::= { dot1agCfmGroups 10 }

ieee8021CfmDefaultMdDefGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmDefaultMdDefLevel,
      dot1agCfmDefaultMdDefMhfCreation,
      dot1agCfmDefaultMdDefIdPermission
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Default MD default Level group."
    ::= { dot1agCfmGroups 11 }

ieee8021CfmPbbTeExtensionGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMepDbRMepIsActive,
      dot1agCfmMepPbbTransmitLbmLtmReverseVid
```

```
    }
    STATUS     current
    DESCRIPTION
       "Objects needed for systems that support PBB-TE CFM functionality."
    ::= { dot1agCfmGroups 12 }

ieee8021CfmPbbTeTrafficBitGroup OBJECT-GROUP
    OBJECTS {
      dot1agCfmMepDbManAddress,
      dot1agCfmMepPbbTeCanReportPbbTePresence,
      dot1agCfmMepPbbTeMismatchAlarm,
      dot1agCfmMepPbbTeTrafficMismatchDefect,
      dot1agCfmMepPbbTeLocalMismatchDefect,
      dot1agCfmMepPbbTeMismatchSinceReset
    }
    STATUS     current
    DESCRIPTION
       "Objects needed for PBB-TE supporting systems that support the
        optional traffic bit."
    ::= { dot1agCfmGroups 13 }

-- ****************************************************************
-- MIB Module Compliance statements
-- ****************************************************************

dot1agCfmCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
       "The compliance statement for support of the CFM MIB module."
    MODULE
        MANDATORY-GROUPS {
            dot1agCfmStackGroup,
            dot1agCfmDefaultMdGroup,
            dot1agCfmConfigErrorListGroup,
            dot1agCfmMdGroup,
            dot1agCfmMaGroup,
            dot1agCfmMepGroup,
            dot1agCfmMepDbGroup,
            dot1agCfmNotificationsGroup
         }

    GROUP dot1agCfmVlanIdGroup
    DESCRIPTION "The VLAN ID group is optional."

    OBJECT dot1agCfmMepLbrBadMsdu
    MIN-ACCESS not-accessible
    DESCRIPTION "The dot1agCfmMepLbrBadMsdu variable is optional.  It
                 MUST not be present if the system cannot compare a
                 received LBR to the corresponding LBM."

    OBJECT dot1agCfmMdRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT dot1agCfmMaNetRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT dot1agCfmMaCompRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT dot1agCfmVlanRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
```

```
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT  dot1agCfmMaMepListRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT  dot1agCfmMepRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { dot1agCfmCompliances 1 }
END
```

17.7.7.2 Definitions for the IEEE8021-CFM-V2-MIB module

```
IEEE8021-CFM-V2-MIB DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE 802.1Q(TM) CFM MIB - V2
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32               FROM SNMPv2-SMI    -- [RFC2578]
    RowStatus,
    TruthValue, MacAddress
                             FROM SNMPv2-TC     -- [RFC2579]
    MODULE-COMPLIANCE,
    OBJECT-GROUP
                             FROM SNMPv2-CONF   -- [RFC2580]
    InterfaceIndex
                             FROM IF-MIB        -- [RFC2863]
    IEEE8021ServiceSelectorType,
    IEEE8021ServiceSelectorValue,
    IEEE8021ServiceSelectorValueOrNone,
    IEEE8021PbbComponentIdentifier,
    ieee802dot1mibs          FROM IEEE8021-TC-MIB
--cfm types
    Dot1agCfmMhfCreation,
    Dot1agCfmIdPermission,
    Dot1agCfmMDLevel,
    Dot1agCfmMpDirection,
    Dot1agCfmMepIdOrZero,
    Dot1agCfmMDLevelOrNone,
    Dot1agCfmConfigErrors,
-- cfm indexes
    dot1agCfmMdIndex,
    dot1agCfmMaIndex,
--cfm groups
    dot1agCfmStack,
    dot1agCfmDefaultMd,
    dot1agCfmVlan,
    dot1agCfmConfigErrorList,
    dot1agCfmMa,
-- cfm row items
    dot1agCfmMepLbrBadMsdu,
    dot1agCfmMdRowStatus,
    dot1agCfmMaNetRowStatus,
    dot1agCfmMaMepListRowStatus,
    dot1agCfmMepRowStatus,
--cfm conformance groups
    dot1agCfmCompliances,
    dot1agCfmGroups,
    dot1agCfmMdGroup,
    dot1agCfmMepGroup,
    dot1agCfmMepDbGroup,
    dot1agCfmNotificationsGroup,
    ieee8021CfmDefaultMdDefGroup,
    ieee8021CfmMaNetGroup,
    ieee8021CfmPbbTeExtensionGroup,
    ieee8021CfmPbbTeTrafficBitGroup             FROM IEEE8021-CFM-MIB
   ;

ieee8021CfmV2Mib   MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
           Contact: IEEE 802.1 Working Group Chair
            Postal: C/O IEEE 802.1 Working Group
                    IEEE Standards Association
                    445 Hoes Lane
```

```
                  Piscataway, NJ 08854
                  USA
           E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
      "Connectivity Fault Management V2 module.

       Unless otherwise indicated, the references in this MIB
       module are to IEEE Std 802.1Q-2022.

       Copyright (C) IEEE (2022).
       This version of this MIB module is part of IEEE Std 802.1Q-2022;
       see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
           "Published as part of IEEE Std 802.1Q-2022.
           Cross references and contact information updated."

    REVISION "201412150000Z" -- December 15, 2014

    DESCRIPTION
           "Published as part of IEEE Std 802.1Q 2014 revision.
           Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

   REVISION       "200811180000Z" -- November 18, 2008
   DESCRIPTION
      "Added a new compliance clause for utilization by systems
       that support CFM and PBB-TE."

   REVISION       "200810150000Z" -- October 15, 2008
   DESCRIPTION
      "The IEEE8021-CFM-V2-MIB Module contains objects that
       replace those deprecated in the IEEE8021-CFM-MIB module.

       This version is included in IEEE Std 802.1ap."

    ::= { ieee802dot1mibs 7 }


-- ********************************************************************
-- Note: Re-indexed IEEE 802.1ag tables
-- ********************************************************************
-- This section contains new tables replacing deprecated tables in
-- this version of the MIB

-- ********************************************************************
-- The CFM Stack Table
-- ********************************************************************

ieee8021CfmStackTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CfmStackEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "There is one CFM Stack table per Bridge. It permits
        the retrieval of information about the Maintenance Points
        configured on any given interface.
       "
    REFERENCE
       "12.14.2"
    ::= { dot1agCfmStack 2 }

ieee8021CfmStackEntry OBJECT-TYPE
    SYNTAX      Ieee8021CfmStackEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
       "The Stack table entry"
    INDEX { ieee8021CfmStackifIndex, ieee8021CfmStackServiceSelectorType,
            ieee8021CfmStackServiceSelectorOrNone,
            ieee8021CfmStackMdLevel, ieee8021CfmStackDirection
          }
    ::= { ieee8021CfmStackTable 1 }

Ieee8021CfmStackEntry ::= SEQUENCE {
      ieee8021CfmStackifIndex                   InterfaceIndex,
      ieee8021CfmStackServiceSelectorType       IEEE8021ServiceSelectorType,
      ieee8021CfmStackServiceSelectorOrNone     IEEE8021ServiceSelectorValueOrNone,
      ieee8021CfmStackMdLevel                   Dot1agCfmMDLevel,
      ieee8021CfmStackDirection                 Dot1agCfmMpDirection,
      ieee8021CfmStackMdIndex                   Unsigned32,
      ieee8021CfmStackMaIndex                   Unsigned32,
      ieee8021CfmStackMepId                     Dot1agCfmMepIdOrZero,
      ieee8021CfmStackMacAddress                MacAddress
    }

ieee8021CfmStackifIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object represents the  Bridge Port or aggregated port
        on which MEPs or MHFs might be configured.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this variable, and  rearrange the
        ieee8021CfmStackTable, so that it indexes the entry in the
        interface table with the same value of ifAlias that it
        indexed before the system restart.  If no such entry exists,
        then the system SHALL delete all entries in the
        ieee8021CfmStackTable with the interface index.
       "
    REFERENCE
       "12.14.2.1.2:a"
    ::= { ieee8021CfmStackEntry 1 }

ieee8021CfmStackServiceSelectorType OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorType
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
                      "Type   of   the   Service   Selector   identifier   indicated   by
ieee8021CfmStackServiceSelectorOrNone.
        See textual convention IEEE8021ServiceSelectorType for details.
       "
    REFERENCE
       "12.14.2.1.2:d, 22.1.7"
    ::= { ieee8021CfmStackEntry 2 }

ieee8021CfmStackServiceSelectorOrNone OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValueOrNone
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Service Selector identifier to which the MP is attached, or 0, if none.
        See textual convention IEEE8021ServiceSelectorValue for details.
       "
    REFERENCE
       "12.14.2.1.2:d, 22.1.7"
    ::= { ieee8021CfmStackEntry 3 }

ieee8021CfmStackMdLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevel
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "MD Level of the Maintenance Point."
    REFERENCE
       "12.14.2.1.2:b"
```

```
    ::= { ieee8021CfmStackEntry 4 }

ieee8021CfmStackDirection OBJECT-TYPE
    SYNTAX      Dot1agCfmMpDirection
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Direction in which the MP faces on the Bridge Port"
    REFERENCE
       "12.14.2.1.2:c"
    ::= { ieee8021CfmStackEntry 5 }

ieee8021CfmStackMdIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The index of the Maintenance Domain in the ieee8021CfmMdTable
        to which the MP is associated, or 0, if none."
    REFERENCE
       "12.14.2.1.3:b"
    ::= { ieee8021CfmStackEntry 6 }

ieee8021CfmStackMaIndex OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The index of the MA in the dot1agCfmMaNetTable and
        ieee8021CfmMaCompTable to which the MP is associated, or 0, if
        none."
    REFERENCE
       "12.14.2.1.3:c"
    ::= { ieee8021CfmStackEntry 7 }

ieee8021CfmStackMepId OBJECT-TYPE
    SYNTAX      Dot1agCfmMepIdOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "If an MEP is configured, the MEPID, else 0"
    REFERENCE
       "12.14.2.1.3:d"
    ::= { ieee8021CfmStackEntry 8 }

ieee8021CfmStackMacAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "MAC address of the MP."
    REFERENCE
      "12.14.2.1.3:e"
    ::= { ieee8021CfmStackEntry 9 }

-- ********************************************************************
-- The CFM VLAN Table
-- ********************************************************************

ieee8021CfmVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CfmVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This table defines the association of VIDs into VLANs.  There
        is an entry in this table, for each component of the Bridge,
        for each VID that is:
            a) a VID belonging to a VLAN associated with more than
               one VID; and
            b) not the Primary VID of that VLAN.
        The entry in this table contains the Primary VID of the VLAN.
```

```
        By default, this table is empty, meaning that every VID is
        the Primary VID of a single-VID VLAN.

        VLANs that are associated with only one VID SHOULD NOT have
        an entry in this table.

        The writable objects in this table need to be persistent
        upon reboot or restart of a device.
       "
    REFERENCE
       "12.14.3.1.3:a, 12.14.3.2.2:a, 12.14.5.3.2:c,
        12.14.6.1.3:b, 22.1.5"
    ::= { dot1agCfmVlan 2 }

ieee8021CfmVlanEntry OBJECT-TYPE
    SYNTAX      Ieee8021CfmVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The VLAN table entry."
    INDEX { ieee8021CfmVlanComponentId,
            ieee8021CfmVlanSelector}
    ::= { ieee8021CfmVlanTable 1 }

Ieee8021CfmVlanEntry ::= SEQUENCE {
      ieee8021CfmVlanComponentId               IEEE8021PbbComponentIdentifier,
      ieee8021CfmVlanSelector                  IEEE8021ServiceSelectorValue,
      ieee8021CfmVlanPrimarySelector           IEEE8021ServiceSelectorValue,
      ieee8021CfmVlanRowStatus                 RowStatus
    }

ieee8021CfmVlanComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CfmVlanEntry applies.  If the system is not a
        Bridge, or if only one component is present in the Bridge, then
        this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.3 l)"
    ::= { ieee8021CfmVlanEntry 1 }

ieee8021CfmVlanSelector OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This is a service ID belonging to a service that is associated
        with more than one Service Selector identifiers, and this is not the Primary
        Service ID of the service. The type of this Service Selector is the same
                          as   the   primary   Service   Selector's   type   defined   by
ieee8021CfmMaCompPrimarySelectorType
        in the ieee8021CfmMaCompTable.
       "
    ::= { ieee8021CfmVlanEntry 3 }

ieee8021CfmVlanPrimarySelector OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "This is the Primary Service selector for a Service that is associated
        with more than one Service Selector identifiers. This value MUST not
       equal the value of ieee8021CfmVlanSelector. The type of this Service Selector is the
same
                          as   the   primary   Service   Selector's   type   defined   by
ieee8021CfmMaCompPrimarySelectorType
        in the ieee8021CfmMaCompTable.
       "
```

```
    ::= { ieee8021CfmVlanEntry 5 }

ieee8021CfmVlanRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
       "
    ::= { ieee8021CfmVlanEntry 6 }


-- ********************************************************************
-- The CFM Default MD Level Table
-- ********************************************************************

ieee8021CfmDefaultMdTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CfmDefaultMdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "For each Bridge component, the Default MD Level Managed Object
        controls MHF creation for VIDs that are not attached to a
        specific Maintenance Association Managed Object, and Sender ID
        TLV transmission by those MHFs.

        For each Bridge Port, and for each VLAN ID whose data can
        pass through that Bridge Port, an entry in this table is
        used by the algorithm in 22.2.3 only if there is no
        entry in the Maintenance Association table defining an MA
        for the same VLAN ID and MD Level as this table's entry, and
        on which MA an Up MEP is defined.  If there exists such an
        MA, that MA's objects are used by the algorithm in
        22.2.3 in place of this table entry's objects.  The
        agent maintains the value of ieee8021CfmDefaultMdStatus to
        indicate whether this entry is overridden by an MA.

        When first initialized, the agent creates this table
        automatically with entries for all VLAN IDs,
        with the default values specified for each object.

        After this initialization, the writable objects in this
        table need to be persistent upon reboot or restart of a
        device.
       "
    REFERENCE
       "12.14.3"
    ::= { dot1agCfmDefaultMd 5 }

ieee8021CfmDefaultMdEntry OBJECT-TYPE
    SYNTAX      Ieee8021CfmDefaultMdEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Default MD Level table entry."
    INDEX { ieee8021CfmDefaultMdComponentId,
            ieee8021CfmDefaultMdPrimarySelectorType,
            ieee8021CfmDefaultMdPrimarySelector}
    ::= { ieee8021CfmDefaultMdTable 1 }

Ieee8021CfmDefaultMdEntry ::= SEQUENCE {
      ieee8021CfmDefaultMdComponentId            IEEE8021PbbComponentIdentifier,
      ieee8021CfmDefaultMdPrimarySelectorType    IEEE8021ServiceSelectorType,
      ieee8021CfmDefaultMdPrimarySelector        IEEE8021ServiceSelectorValue,
      ieee8021CfmDefaultMdStatus                 TruthValue,
      ieee8021CfmDefaultMdLevel                  Dot1agCfmMDLevelOrNone,
      ieee8021CfmDefaultMdMhfCreation            Dot1agCfmMhfCreation,
      ieee8021CfmDefaultMdIdPermission           Dot1agCfmIdPermission
```

```
    }

ieee8021CfmDefaultMdComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CfmDefaultMdEntry applies.  If the system is not
        a Bridge, or if only one component is present in the Bridge,
        then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.3 l)"
    ::= { ieee8021CfmDefaultMdEntry 1 }

ieee8021CfmDefaultMdPrimarySelectorType OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorType
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Type of the Primary Service Selector identifier indicated by
        ieee8021CfmDefaultMdPrimarySelector. See textual
        convention IEEE8021ServiceSelectorType for details.
       "
    ::= { ieee8021CfmDefaultMdEntry 2 }

ieee8021CfmDefaultMdPrimarySelector OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Primary Service Selector identifier of a Service Instance with
        no MA configured. See IEEE8021ServiceSelectorValue for details.
       "
    ::= { ieee8021CfmDefaultMdEntry 3 }

ieee8021CfmDefaultMdStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "State of this Default MD Level table entry.  True if there is
        no entry in the Maintenance Association table defining an MA
        for the same VLAN ID and MD Level as this table's entry, and
        on which MA an Up MEP is defined, else false.
       "
    REFERENCE
       "12.14.3.1.3:b"
    ::= { ieee8021CfmDefaultMdEntry 4 }

ieee8021CfmDefaultMdLevel OBJECT-TYPE
    SYNTAX      Dot1agCfmMDLevelOrNone
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A value indicating the MD Level at which MHFs are to be
        created, and Sender ID TLV transmission by those MHFs is to
        be controlled, for the VLAN to which this entry's objects
        apply.
       "
    REFERENCE
       "12.14.3.1.3:c, 12.14.3.2.2:b"
    DEFVAL {-1}
    ::= { ieee8021CfmDefaultMdEntry 5 }

ieee8021CfmDefaultMdMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A value indicating if the Management entity can create MHFs
```

```
        (MIP Half Function) for this VID at this MD Level.  If this
        object has the value defMHFdefer, MHF creation for this VLAN
        is controlled by ieee8021CfmDefaultMdDefMhfCreation.

        The value of this variable is meaningless if the values of
        ieee8021CfmDefaultMdStatus is false.
       "
    REFERENCE
       "12.14.3.1.3:d"
    DEFVAL {defMHFdefer}
    ::= { ieee8021CfmDefaultMdEntry 6 }

ieee8021CfmDefaultMdIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "Enumerated value indicating what, if anything, is to be
        included in the Sender ID TLV (21.5.3) transmitted by MHFs
        created by the Default Maintenance Domain.  If this object
        has the value sendIdDefer, Sender ID TLV transmission for
        this VLAN is controlled by ieee8021CfmDefaultMdDefIdPermission.

        The value of this variable is meaningless if the values of
        ieee8021CfmDefaultMdStatus is false.
       "
    REFERENCE
       "12.14.3.1.3:e"
    DEFVAL { sendIdDefer }
    ::= { ieee8021CfmDefaultMdEntry 7 }


-- ********************************************************************
-- The CFM Configuration Error List Table
-- ********************************************************************

ieee8021CfmConfigErrorListTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CfmConfigErrorListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The CFM Configuration Error List table provides a list of
        Interfaces and VIDs that are incorrectly configured.
       "
    REFERENCE
       "12.14.4"
    ::= {dot1agCfmConfigErrorList 2}

ieee8021CfmConfigErrorListEntry OBJECT-TYPE
    SYNTAX      Ieee8021CfmConfigErrorListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Config Error List Table  entry"
    INDEX { ieee8021CfmConfigErrorListSelectorType,
            ieee8021CfmConfigErrorListSelector,
            ieee8021CfmConfigErrorListIfIndex
          }
    ::= { ieee8021CfmConfigErrorListTable 1}

Ieee8021CfmConfigErrorListEntry ::= SEQUENCE {
      ieee8021CfmConfigErrorListSelectorType          IEEE8021ServiceSelectorType,
      ieee8021CfmConfigErrorListSelector              IEEE8021ServiceSelectorValue,
      ieee8021CfmConfigErrorListIfIndex               InterfaceIndex,
      ieee8021CfmConfigErrorListErrorType             Dot1agCfmConfigErrors
    }

ieee8021CfmConfigErrorListSelectorType OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorType
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
        "Type of the Service Selector identifier indicated by
         ieee8021CfmConfigErrorListSelector. See textual
         convention IEEE8021ServiceSelectorType for details.
        "
    REFERENCE
        "12.14.4.1.2:a"
    ::= { ieee8021CfmConfigErrorListEntry 1 }

ieee8021CfmConfigErrorListSelector OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Service Selector Identifier of the Service with interfaces
         in error. See IEEE8021ServiceSelectorValue for details.
        "
    REFERENCE
        "12.14.4.1.2:a"
    ::= { ieee8021CfmConfigErrorListEntry 2 }

ieee8021CfmConfigErrorListIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This object is the IfIndex of the interface.

         Upon a restart of the system, the system SHALL, if necessary,
         change the value of this variable so that it indexes the
         entry in the interface table with the same value of ifAlias
         that it indexed before the system restart.  If no such
         entry exists, then the system SHALL delete any entries in
         ieee8021CfmConfigErrorListTable indexed by that
         InterfaceIndex value.
        "
    REFERENCE
        "12.14.4.1.2:b"
    ::= { ieee8021CfmConfigErrorListEntry 3 }

ieee8021CfmConfigErrorListErrorType OBJECT-TYPE
    SYNTAX      Dot1agCfmConfigErrors
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A vector of Boolean error conditions from 22.2.4, any of
         which may be true:

         0) CFMleak;
         1) ConflictingVids;
         2) ExcessiveLevels;
         3) OverlappedLevels.
        "
    REFERENCE
        "12.14.4.1.3:b"
    ::= { ieee8021CfmConfigErrorListEntry 4 }

-- ********************************************************************
-- The CFM Maintenance Association (MA) Component Table
-- ********************************************************************

ieee8021CfmMaCompTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CfmMaCompEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Maintenance Association table.  Each row in the table
         represents an MA.  An MA is a set of MEPs, each configured
         with a single service instance.

         This is the part of the complete MA table that is variable
         across the Bridges in a Maintenance Domain, or across the
         components of a single Bridge.  That part of the MA table that
```

```
        is constant across the Bridges and their components in a
        Maintenance Domain is contained in the dot1agCfmMaNetTable.

        This table uses three indices, first index is the
        IEEE8021PbbComponentIdentifier that identifies the component
        within the Bridge for which the information in the
        ieee8021CfmMaCompEntry applies.  The second is the index of the
        Maintenance Domain table.  The third index is the same as the
        index of the ieee8021CfmMaNetEntry for the same MA.

        The writable objects in this table need to be persistent
        upon reboot or restart of a device.

       "
    REFERENCE
       "18.2"
    ::= { dot1agCfmMa 4 }

ieee8021CfmMaCompEntry OBJECT-TYPE
    SYNTAX      Ieee8021CfmMaCompEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The MA table entry."
    INDEX {ieee8021CfmMaComponentId,
           dot1agCfmMdIndex, dot1agCfmMaIndex }
    ::= { ieee8021CfmMaCompTable 1 }

Ieee8021CfmMaCompEntry ::= SEQUENCE {
      ieee8021CfmMaComponentId                IEEE8021PbbComponentIdentifier,
      ieee8021CfmMaCompPrimarySelectorType    IEEE8021ServiceSelectorType,
      ieee8021CfmMaCompPrimarySelectorOrNone  IEEE8021ServiceSelectorValueOrNone,
      ieee8021CfmMaCompMhfCreation            Dot1agCfmMhfCreation,
      ieee8021CfmMaCompIdPermission           Dot1agCfmIdPermission,
      ieee8021CfmMaCompNumberOfVids           Unsigned32,
      ieee8021CfmMaCompRowStatus              RowStatus
    }

ieee8021CfmMaComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CfmMaCompEntry applies.  If the system is not a
        Bridge, or if only one component is present in the Bridge, then
        this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.3 l)"
    ::= { ieee8021CfmMaCompEntry 1 }

ieee8021CfmMaCompPrimarySelectorType OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Type of the Service Selector identifiers indicated by
       ieee8021CfmMaCompPrimarySelectorOrNone. If the service
       instance is defined by more than one Service Selector, this
       parameter also indicates the type of the
       ieee8021CfmVlanPrimarySelector and ieee8021CfmVlanSelector
       in the ieee8021CfmVlanTable.
       In Services instances made of multiple Service Selector
       identifiers, ensures that the type of the Service selector
       identifiers is the same. See textual convention
        IEEE8021ServiceSelectorType for details.
       "
    REFERENCE
       "12.14.6.1.3:b"
    ::= { ieee8021CfmMaCompEntry 2 }
```

```
ieee8021CfmMaCompPrimarySelectorOrNone OBJECT-TYPE
    SYNTAX      IEEE8021ServiceSelectorValueOrNone
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Service Selector identifier to which the MP is attached,
       or 0, if none. If the MA is associated with more than one
       Service Selectors Identifiers, the ieee8021CfmVlanTable
       lists them.
       "
    REFERENCE
       "12.14.6.1.3:b"
    ::= { ieee8021CfmMaCompEntry 3 }


ieee8021CfmMaCompMhfCreation OBJECT-TYPE
    SYNTAX      Dot1agCfmMhfCreation
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Indicates if the Management entity can create MHFs (MIP Half
        Function) for this MA.
       "
    REFERENCE
       "12.14.6.1.3:c"
    DEFVAL { defMHFdefer }
    ::= { ieee8021CfmMaCompEntry 4 }

ieee8021CfmMaCompIdPermission OBJECT-TYPE
    SYNTAX      Dot1agCfmIdPermission
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Enumerated value indicating what, if anything, is to be
        included in the Sender ID TLV (21.5.3) transmitted by MPs
        configured in this MA.
       "
    REFERENCE
       "12.14.6.1.3:d"
    DEFVAL { sendIdDefer }
    ::= { ieee8021CfmMaCompEntry 5 }

ieee8021CfmMaCompNumberOfVids OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The number of VIDs associated with the MA.
       "
    REFERENCE
       "12.14.6.1.3:b"
    ::= { ieee8021CfmMaCompEntry 6 }

ieee8021CfmMaCompRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The status of the row.

        The writable columns in a row cannot be changed if the row
        is active. All columns MUST have a valid value before a row
        can be activated.
       "
    ::= { ieee8021CfmMaCompEntry 7 }

-- ****************************************************************
-- Units of conformance
-- ****************************************************************

ieee8021CfmStackGroup OBJECT-GROUP
    OBJECTS {
```

```
      ieee8021CfmStackMdIndex,
      ieee8021CfmStackMaIndex,
      ieee8021CfmStackMepId,
      ieee8021CfmStackMacAddress
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Stack group."
    ::= { dot1agCfmGroups 12 }

ieee8021CfmMaGroup OBJECT-GROUP
    OBJECTS {
      ieee8021CfmMaCompPrimarySelectorType,
      ieee8021CfmMaCompPrimarySelectorOrNone,
      ieee8021CfmMaCompMhfCreation,
      ieee8021CfmMaCompIdPermission,
      ieee8021CfmMaCompRowStatus,
      ieee8021CfmMaCompNumberOfVids
    }
    STATUS      current
    DESCRIPTION
       "Objects for the MA group."
    ::= { dot1agCfmGroups 13 }

ieee8021CfmDefaultMdGroup OBJECT-GROUP
    OBJECTS {
      ieee8021CfmDefaultMdStatus,
      ieee8021CfmDefaultMdLevel,
      ieee8021CfmDefaultMdMhfCreation,
      ieee8021CfmDefaultMdIdPermission
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Default MD Level group."
    ::= { dot1agCfmGroups 14 }

ieee8021CfmVlanIdGroup OBJECT-GROUP
    OBJECTS {
      ieee8021CfmVlanPrimarySelector,
      ieee8021CfmVlanRowStatus
   }
    STATUS      current
    DESCRIPTION
       "Objects for the VLAN ID group."
    ::= { dot1agCfmGroups 15 }

ieee8021CfmConfigErrorListGroup OBJECT-GROUP
    OBJECTS {
      ieee8021CfmConfigErrorListErrorType
    }
    STATUS current
    DESCRIPTION
       "Objects for the CFM Configuration Error List Group."
    ::= {dot1agCfmGroups 16 }

-- ****************************************************************
-- MIB Module Compliance statements
-- ****************************************************************

ieee8021CfmComplianceV2 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support of the CFM MIB module."

    MODULE
        MANDATORY-GROUPS {
            ieee8021CfmStackGroup,
            ieee8021CfmMaGroup,
            ieee8021CfmDefaultMdGroup,
            ieee8021CfmConfigErrorListGroup
         }
```

```
    GROUP ieee8021CfmVlanIdGroup
    DESCRIPTION "The VLAN ID group is optional."

    OBJECT ieee8021CfmMaCompRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021CfmVlanRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    MODULE IEEE8021-CFM-MIB
        MANDATORY-GROUPS {
            dot1agCfmMdGroup,
            dot1agCfmMepGroup,
            dot1agCfmMepDbGroup,
            dot1agCfmNotificationsGroup,
            ieee8021CfmDefaultMdDefGroup,
            ieee8021CfmMaNetGroup
         }

    OBJECT dot1agCfmMepLbrBadMsdu
    MIN-ACCESS not-accessible
    DESCRIPTION "The dot1agCfmMepLbrBadMsdu variable is optional.  It
                 MUST not be present if the system cannot compare a
                 received LBR to the corresponding LBM."

    OBJECT dot1agCfmMdRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT dot1agCfmMaNetRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

     OBJECT  dot1agCfmMaMepListRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT  dot1agCfmMepRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { dot1agCfmCompliances 2 }

dot1agCfmWithPbbTeCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support of the CFM MIB for
        systems that support PBB-TE."

    MODULE
        MANDATORY-GROUPS {
            ieee8021CfmStackGroup,
            ieee8021CfmMaGroup,
            ieee8021CfmDefaultMdGroup,
            ieee8021CfmConfigErrorListGroup
         }

    GROUP ieee8021CfmVlanIdGroup
```

```
    DESCRIPTION "The VLAN ID group is optional."

    OBJECT ieee8021CfmMaCompRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021CfmVlanRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    MODULE IEEE8021-CFM-MIB
        MANDATORY-GROUPS {
            dot1agCfmMdGroup,
            dot1agCfmMepGroup,
            dot1agCfmMepDbGroup,
            dot1agCfmNotificationsGroup,
            ieee8021CfmDefaultMdDefGroup,
            ieee8021CfmMaNetGroup,
        ieee8021CfmPbbTeExtensionGroup
         }

    GROUP  ieee8021CfmPbbTeTrafficBitGroup
    DESCRIPTION "The objects needed to support the traffic bit are optional
                 as traffic bit support, itself, is optional."

    OBJECT dot1agCfmMepLbrBadMsdu
    MIN-ACCESS not-accessible
    DESCRIPTION "The dot1agCfmMepLbrBadMsdu variable is optional.  It
                 MUST not be present if the system cannot compare a
                 received LBR to the corresponding LBM."

    OBJECT dot1agCfmMdRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT dot1agCfmMaNetRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

     OBJECT  dot1agCfmMaMepListRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT  dot1agCfmMepRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { dot1agCfmCompliances 3 }

END
```

17.7.8 Definitions for the IEEE8021-PBB-MIB module

```
IEEE8021-PBB-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q Provider Backbone Bridge Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Unsigned32, Integer32
        FROM SNMPv2-SMI
    RowStatus, StorageType, MacAddress, TruthValue
        FROM SNMPv2-TC
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber, IEEE8021PbbServiceIdentifier,
    IEEE8021PbbServiceIdentifierOrUnassigned, IEEE8021PbbIngressEgress,
    IEEE8021PriorityValue, IEEE8021PriorityCodePoint
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBasePortComponentId, ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    VlanId
        FROM Q-BRIDGE-MIB
    InterfaceIndex, InterfaceIndexOrZero
        FROM IF-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021PbbMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Provider Backbone Bridge (PBB) MIB module for managing
        devices that support PBB.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            ieee8021PbbVipType and ieee8021PbbCBPServiceMappingType
            deprecated."

    REVISION     "201102270000Z" -- February 27, 2011
```

```
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

    REVISION     "200811180000Z" -- November 18, 2008
    DESCRIPTION
        "Modified VIP table to support the enableConnectionIdentifier
         configuration option."

    REVISION     "200810150000Z" -- October 15, 2008
    DESCRIPTION
        "Initial version published in IEEE Std 802.1ap."
    ::= { ieee802dot1mibs 9 }

ieee8021PbbNotifications  OBJECT IDENTIFIER ::= { ieee8021PbbMib 0 }
ieee8021PbbObjects        OBJECT IDENTIFIER ::= { ieee8021PbbMib 1 }
ieee8021PbbConformance    OBJECT IDENTIFIER ::= { ieee8021PbbMib 2 }

--
-- IEEE 802.1ah MIB Objects
--

ieee8021PbbProviderBackboneBridge
    OBJECT IDENTIFIER ::= { ieee8021PbbObjects 1 }

-- ============================================================
-- 12.16.1.1/12.16.1.2 Backbone Edge Bridge (BEB) configuration
-- ============================================================
--    items a), b), c), e), and g), see below
--    d) ieee8021BridgeBaseBridgeAddress from IEEE8021-BRIDGE-MIB
--    f) ieee8021BridgeBaseBridgeAddress from IEEE8021-BRIDGE-MIB
--    i) and j)  ifPhysAddress from the IF-MIB, the correct instance
--        can be found using ieee8021BridgeBasePortIfIndex
--        from the IEEE8021-BRIDGE-MIB
-- ============================================================

ieee8021PbbBackboneEdgeBridgeObjects
    OBJECT IDENTIFIER ::= { ieee8021PbbProviderBackboneBridge 1 }

ieee8021PbbBackboneEdgeBridgeAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The MAC Address used by the BEB when it must be refered
         to in a unique fashion."
    REFERENCE   "12.16.1.1.3 a)"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 1 }

ieee8021PbbBackboneEdgeBridgeName OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE (0..32))
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "A text string of locally determined significance.  This value
         must be persistent over power up restart/reboot."
    REFERENCE   "12.16.1.1.3 b), 12.16.1.2.2"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 2 }

ieee8021PbbNumberOfIComponents OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of I-components in this BEB."
    REFERENCE   "12.16.1.1.3 c)"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 3 }

ieee8021PbbNumberOfBComponents OBJECT-TYPE
    SYNTAX      Unsigned32 (0..1)
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
        "The number of B-components in this BEB."
    REFERENCE   "12.16.1.1.3 e)"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 4 }

ieee8021PbbNumberOfBebPorts OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of CNPs, PIPs, CBPs, and PNPs in this BEB."
    REFERENCE   "12.16.1.1.3 g)"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 5 }

ieee8021PbbNextAvailablePipIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This object provides an available ifIndex value that can
        be used for creation of a PIP."
    REFERENCE   "12.16.4.1, 12.16.4.2"
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 6 }

-- ============================================================
-- 12.16.3.1/2 Virtual Instance Port (VIP) configuration table
-- ============================================================

ieee8021PbbVipTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbVipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table lists the additional PBB parameters for each
         VIP.  Entries in this table must be persistent over power
         up restart/reboot."
    REFERENCE   "12.16.3.1, 12.16.3.2"
    ::= { ieee8021PbbProviderBackboneBridge 2 }

ieee8021PbbVipEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbVipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Each entry consists of the name string, I-SID, Default
         Destination MAC, Service Type, and possible B-MAC."
    INDEX       { ieee8021BridgeBasePortComponentId,
                  ieee8021BridgeBasePort }
    ::= { ieee8021PbbVipTable 1 }

Ieee8021PbbVipEntry ::=
    SEQUENCE {
        ieee8021PbbVipPipIfIndex
            InterfaceIndexOrZero,
        ieee8021PbbVipISid
            IEEE8021PbbServiceIdentifierOrUnassigned,
        ieee8021PbbVipDefaultDstBMAC
            MacAddress,
        ieee8021PbbVipType
            IEEE8021PbbIngressEgress,
        ieee8021PbbVipRowStatus
            RowStatus,
        ieee8021PbbVipEnableConnectionId
        TruthValue
    }

ieee8021PbbVipPipIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndexOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Identifies the PIP associated with this VIP within the BEB.
```

```
         A value of zero indicates the VIP is not currently associated
         with any PIP.

        The value of this object must be persistent across
        reinitializations of the management system."
    DEFVAL      { 0 }
    ::= { ieee8021PbbVipEntry 1 }

ieee8021PbbVipISid OBJECT-TYPE
    SYNTAX      IEEE8021PbbServiceIdentifierOrUnassigned
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The I-SID for this VIP.

         Within an I-Component, an VIP can only be serviced
         by one I-SID. And the ISID is a configurable parameter
         of the VIP.

        The value of this object must be persistent across
        reinitializations of the management system."
    DEFVAL { 1 }
    ::= { ieee8021PbbVipEntry 2 }

ieee8021PbbVipDefaultDstBMAC OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Default Destination B-MAC for this VIP."
    DEFVAL { '001e83000001'h }
    ::= { ieee8021PbbVipEntry 3 }

ieee8021PbbVipType OBJECT-TYPE
    SYNTAX      IEEE8021PbbIngressEgress
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "This feature is used to support asymmetric VLANs.

        The value of this object must be persistent across
        reinitializations of the management system."
    DEFVAL { { egress, ingress } }
    ::= { ieee8021PbbVipEntry 4 }

ieee8021PbbVipRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This indicates the status of an entry in this table, and is
        used to create/delete entries.

        It is an implementation specific decision as to whether any
        column in this table may be set while the corresponding
        instance of this object is valid(1).

        The value of this object must be persistent across
        reinitializations of the management system."
    ::= { ieee8021PbbVipEntry 5 }

ieee8021PbbVipEnableConnectionId OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "This indicates if the connection_identifier parameter is allowed
         to learn associations between a backbone MAC address and a customer
         MAC address.  The default value is true, indicating that such
         learning is allowed.  This parameter should be configured to false
         at the root node of a Point-to-multipoint TE service instance."
    DEFVAL      { true }
```

```
    ::= { ieee8021PbbVipEntry 6 }

-- ============================================================
-- 12.16.3.1/12.16.3.2 I-SID to VIP cross-reference table
-- ============================================================

ieee8021PbbISidToVipTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbISidToVipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table contains a cross-reference of I-SID values
         to the VIPs with which they are associated.  This allows
         VIPs to be located easily by their associated I-SID."
    REFERENCE   "12.16.3.1, 12.16.3.2"
    ::= { ieee8021PbbProviderBackboneBridge 3 }

ieee8021PbbISidToVipEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbISidToVipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A mapping from an I-SID to the VIP with which it is
         associated.  An entry will exist for each entry in
         the ieee8021PbbVipTable."
    INDEX       { ieee8021PbbISidToVipISid }
    ::= { ieee8021PbbISidToVipTable 1 }

Ieee8021PbbISidToVipEntry ::=
    SEQUENCE {
        ieee8021PbbISidToVipISid
            IEEE8021PbbServiceIdentifier,
        ieee8021PbbISidToVipComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021PbbISidToVipPort
            IEEE8021BridgePortNumber
    }

ieee8021PbbISidToVipISid OBJECT-TYPE
    SYNTAX      IEEE8021PbbServiceIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The I-SID of a VIP."
    ::= { ieee8021PbbISidToVipEntry 1 }

ieee8021PbbISidToVipComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The component identifier of the VIP to which this I-SID
        is associated."
    ::= { ieee8021PbbISidToVipEntry 2 }

ieee8021PbbISidToVipPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The port number of the VIP to which this I-SID is associated."
    ::= { ieee8021PbbISidToVipEntry 3 }

-- ============================================================
-- 12.16.4.1/12.16.4.2 Provider Instance Port (PIP) configuration
--             table
-- ============================================================

ieee8021PbbPipTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbPipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
        "This table contains the parameters for each PIP, and
         can be used to configure the PIP port names.  Entries
         in this table must be persistent over power up
         restart/reboot."
    REFERENCE   "12.16.4.1, 12.16.4.2"
    ::= { ieee8021PbbProviderBackboneBridge 4 }

ieee8021PbbPipEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbPipEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The parameters for a PIP.   "
    INDEX       { ieee8021PbbPipIfIndex }
    ::= { ieee8021PbbPipTable 1 }

Ieee8021PbbPipEntry ::=
    SEQUENCE {
        ieee8021PbbPipIfIndex
            InterfaceIndex,
        ieee8021PbbPipBMACAddress
            MacAddress,
        ieee8021PbbPipName
            SnmpAdminString,
        ieee8021PbbPipIComponentId
            IEEE8021PbbComponentIdentifier,
        ieee8021PbbPipVipMap
            OCTET STRING,
        ieee8021PbbPipVipMap1
            OCTET STRING,
        ieee8021PbbPipVipMap2
            OCTET STRING,
        ieee8021PbbPipVipMap3
            OCTET STRING,
        ieee8021PbbPipVipMap4
            OCTET STRING,
        ieee8021PbbPipRowStatus
            RowStatus
    }

ieee8021PbbPipIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The number identifying the PIP."
    ::= { ieee8021PbbPipEntry 1 }

ieee8021PbbPipBMACAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The B-MAC used by this PIP for the B-SA."
    ::= { ieee8021PbbPipEntry 2 }

ieee8021PbbPipName OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(0..32))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A text string of local significance that identifies the
         PIP within a BEB."
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 3 }

ieee8021PbbPipIComponentId OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
```

```
        "Identifies the I-component associated with this PIP."
    ::= { ieee8021PbbPipEntry 4 }

ieee8021PbbPipVipMap OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..512))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object contains a bitmap indicating all the VIPs
         in the range 1 through 4094 that are associated with this
         PIP.  The bits correspond to Bridge Port numbers in the
         range 1 through 4094.  The high-order bit of the first
         octet corresponds to port number 1, and subsequent bits
         of the octet string correspond to subsequent port numbers.
         The following formula can be used to find the bit
         corresponding to a particular port number B:
            octet[(B-1)/8] & (1 >> ((B-1)%8))
         If the bit for a particular port number is 1, that VIP is
         associated with this PIP.

         The value of this object may be truncated to remove
         trailing octets of all zeros."
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 5 }

ieee8021PbbPipVipMap1 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..2048))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object contains a bitmap indicating all the VIPs
         in the range 4095 through 20478 that are associated with
         this PIP.  The bits correspond to Bridge Port numbers in
         the range 4095 through 20478.  The high-order bit of the first
         octet corresponds to port number 1, and subsequent bits
         of the octet string correspond to subsequent port numbers.
         The following formula can be used to find the bit
         corresponding to a particular port number B:
            octet[(B-4095)/8] & (1 >> ((B-4095)%8))
         If the bit for a particular port number is 1, that VIP is
         associated with this PIP.

         Note that ports numbers greater than 4094 cannot be used
         with xSTP.

         The value of this object may be truncated to remove
         trailing octets of all zeros."
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 6 }

ieee8021PbbPipVipMap2 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..2048))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object contains a bitmap indicating all the VIPs
         in the range 20479 through 36861 that are associated with
         this PIP.  The bits correspond to Bridge Port numbers in
         the range 20479 through 36861.  The high-order bit of the first
         octet corresponds to port number 1, and subsequent bits
         of the octet string correspond to subsequent port numbers.
         The following formula can be used to find the bit
         corresponding to a particular port number B:
            octet[(B-20479)/8] & (1 >> ((B-20479)%8))
         If the bit for a particular port number is 1, that VIP is
         associated with this PIP.

         Note that ports numbers greater than 4094 cannot be used
         with xSTP.

         The value of this object may be truncated to remove
         trailing octets of all zeros."
```

```
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 7 }

ieee8021PbbPipVipMap3 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..2048))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object contains a bitmap indicating all the VIPs
         in the range 36862 through 53245 that are associated with
         this PIP.  The bits correspond to Bridge Port numbers in
         the range 36862 through 53245.  The high-order bit of the first
         octet corresponds to port number 1, and subsequent bits
         of the octet string correspond to subsequent port numbers.
         The following formula can be used to find the bit
         corresponding to a particular port number B:
            octet[(B-36862)/8] & (1 >> ((B-36862)%8))
         If the bit for a particular port number is 1, that VIP is
         associated with this PIP.

         Note that ports numbers greater than 4094 cannot be used
         with xSTP.

         The value of this object may be truncated to remove
         trailing octets of all zeros."
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 8 }

ieee8021PbbPipVipMap4 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..1537))
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object contains a bitmap indicating all the VIPs
         in the range 53246 through 65535 that are associated with
         this PIP.  The bits correspond to Bridge Port numbers in
         the range 53246 through 65535.  The high-order bit of the first
         octet corresponds to port number 1, and subsequent bits
         of the octet string correspond to subsequent port numbers.
         The following formula can be used to find the bit
         corresponding to a particular port number B:
            octet[(B-53246)/8] & (1 >> ((B-53246)%8))
         If the bit for a particular port number is 1, that VIP is
         associated with this PIP.

         Note that ports numbers greater than 4094 cannot be used
         with xSTP.

         The value of this object may be truncated to remove
         trailing octets of all zeros."
    DEFVAL { ''H }
    ::= { ieee8021PbbPipEntry 9 }

ieee8021PbbPipRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the status of an entry in this table, and is used
        to create/delete entries.

        The object ieee8021PbbPipBMACAddress must be set before this
        object can be made active(1).

        The value of ieee8021PbbPipBMACAddress cannot be modified
        while this object is active(1)."
    ::= { ieee8021PbbPipEntry 10 }

-- ============================================================
-- 12.16.4.1    Provider Instance Port (PIP)
--              Priority Table
-- ============================================================
```

```
ieee8021PbbPipPriorityTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbPipPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about every PIP that
        is associated with this PBB."
    REFERENCE   "12.16.4.1"
    ::= { ieee8021PbbProviderBackboneBridge 5 }

ieee8021PbbPipPriorityEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbPipPriorityEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of Default User Priorities for each PIP of a
        PBB.  This is indexed by ieee8021PbbPipIfIndex."
    AUGMENTS { ieee8021PbbPipEntry }
    ::= { ieee8021PbbPipPriorityTable 1 }

Ieee8021PbbPipPriorityEntry ::=
    SEQUENCE {
        ieee8021PbbPipPriorityCodePointSelection
            IEEE8021PriorityCodePoint,
        ieee8021PbbPipUseDEI
            TruthValue,
        ieee8021PbbPipRequireDropEncoding
            TruthValue
    }

ieee8021PbbPipPriorityCodePointSelection OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        " This object identifies the rows in the PCP encoding and
          decoding tables that are used to remark frames on this
          PIP if this remarking is enabled."
    REFERENCE   "12.16.4.5, 12.16.4.6"
    ::= { ieee8021PbbPipPriorityEntry 1 }

ieee8021PbbPipUseDEI OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "If the Use_DEI is set to true(1) for the PIP then the
        drop_eligible parameter is encoded in the DEI of transmitted
        frames, and the drop_eligible parameter shall be true(1) for a
        received frame if the DEI is set in the VLAN tag or the Priority
        Code Point Decoding Table indicates drop_eligible True for
        the received PCP value. If the Use_DEI parameter is false(2),
        the DEI shall be transmitted as zero and ignored on receipt.
        The default value of the Use_DEI parameter is false(2)."
    REFERENCE   "12.16.4.11, 12.16.4.12"
    ::= { ieee8021PbbPipPriorityEntry 2 }

ieee8021PbbPipRequireDropEncoding OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "If a Bridge supports encoding or decoding of drop_eligible
        from the PCP field of a VLAN tag (6.9.3) on any of its PIPs,
        then it shall implement a Boolean parameter Require Drop
        Encoding on each of its PIPs with default value false(2). If
        Require Drop Encoding is True and the PIP cannot
        encode particular priorities with drop_eligible, then frames
        queued with those priorities and drop_eligible true(1) shall
        be discarded and not transmitted."
    REFERENCE   "12.16.4.13, 12.16.4.14"
```

```
    DEFVAL { false }
    ::= { ieee8021PbbPipPriorityEntry 3 }

-- ============================================================
-- 12.16.4.7/12.16.4.8 Provider Instance Port (PIP)
--              Priority Code Point (PCP) Decoding Table
-- ============================================================

ieee8021PbbPipDecodingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbPipDecodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about Priority Code
        Point Decoding Table for a PIP of a provider Bridge.
        Alternative values for each table are specified as rows
        in Table 6-3 (6.9.3), with each alternative labeled by
        the number of distinct priorities that can be communicated,
        and the number of these for which drop precedence can
        be communicated.  All writable objects in this table must
        be persistent over power up restart/reboot."
    REFERENCE   "12.16.4.7, 12.16.4.8"
    ::= { ieee8021PbbProviderBackboneBridge 6 }

ieee8021PbbPipDecodingEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbPipDecodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Priority Code Point Decoding
        information for a PIP of a provider Bridge."
    INDEX { ieee8021PbbPipIfIndex,
            ieee8021PbbPipDecodingPriorityCodePointRow,
            ieee8021PbbPipDecodingPriorityCodePoint }
    ::= { ieee8021PbbPipDecodingTable 1 }

Ieee8021PbbPipDecodingEntry ::= SEQUENCE {
      ieee8021PbbPipDecodingPriorityCodePointRow
          IEEE8021PriorityCodePoint,
      ieee8021PbbPipDecodingPriorityCodePoint
          Integer32,
      ieee8021PbbPipDecodingPriority
          IEEE8021PriorityValue,
      ieee8021PbbPipDecodingDropEligible
          TruthValue
}

ieee8021PbbPipDecodingPriorityCodePointRow OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-3 (6.9.3) indicating the PCP."
    ::= { ieee8021PbbPipDecodingEntry 1 }

ieee8021PbbPipDecodingPriorityCodePoint OBJECT-TYPE
    SYNTAX      Integer32 (0..7)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific PCP value in Table 6-3 (6.9.3)."
    ::= { ieee8021PbbPipDecodingEntry 2 }

ieee8021PbbPipDecodingPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The specific priority value in Table 6-3 (6.9.3)."
    REFERENCE   "12.6.2.8, 12.6.2.9"
    ::= { ieee8021PbbPipDecodingEntry 3 }
```

```
ieee8021PbbPipDecodingDropEligible OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The drop eligibility value in 12.6.2.8."
    REFERENCE   "12.6.2.8, 12.6.2.9"
    ::= { ieee8021PbbPipDecodingEntry 4 }

-- ============================================================
-- 12.16.4.9/10 Provider Instance Port (PIP)
--              Priority Code Point (PCP) Encoding Table
-- ============================================================

ieee8021PbbPipEncodingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbPipEncodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about Priority Code
        Point Decoding Table for a PIP of a provider Bridge.
        Alternative values for each table are specified as rows
        in Table 6-3 (6.9.3), with each alternative labeled by
        the number of distinct priorities that can be communicated,
        and the number of these for which drop precedence can be
        communicated.  All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "12.16.4.9, 12.16.4.10"
    ::= { ieee8021PbbProviderBackboneBridge 7 }

ieee8021PbbPipEncodingEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbPipEncodingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Priority Code Point Encoding
        information for a PIP of a provider Bridge."
    INDEX { ieee8021PbbPipIfIndex,
            ieee8021PbbPipEncodingPriorityCodePointRow,
            ieee8021PbbPipEncodingPriorityCodePoint,
            ieee8021PbbPipEncodingDropEligible }
    ::= { ieee8021PbbPipEncodingTable 1 }

Ieee8021PbbPipEncodingEntry ::= SEQUENCE {
      ieee8021PbbPipEncodingPriorityCodePointRow
          IEEE8021PriorityCodePoint,
      ieee8021PbbPipEncodingPriorityCodePoint
          Integer32,
      ieee8021PbbPipEncodingDropEligible
          TruthValue,
      ieee8021PbbPipEncodingPriority
          IEEE8021PriorityValue
}

ieee8021PbbPipEncodingPriorityCodePointRow OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-3 (6.9.3)indicating the PCP row.
         (i.e., 8P0D, 7P1D, 6P2D, 5P3D)"
    ::= { ieee8021PbbPipEncodingEntry 1 }

ieee8021PbbPipEncodingPriorityCodePoint OBJECT-TYPE
    SYNTAX      Integer32 (0..7)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-3 (6.9.3) indicating the PCP.
         (i.e., 0,1,2,3,4,5,6,7)."
    ::= { ieee8021PbbPipEncodingEntry 2 }
```

```
ieee8021PbbPipEncodingDropEligible OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The specific row in Table 6-3 (6.9.3) indicating the drop
         eligibility.  A value of true(1) means eligible for drop."
    ::= { ieee8021PbbPipEncodingEntry 3 }

ieee8021PbbPipEncodingPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The encoding priority in Table 6-3 (6.9.3)."
    REFERENCE   "12.6.2.10, 12.6.2.11"
    ::= { ieee8021PbbPipEncodingEntry 4 }

-- ============================================================
-- 12.16.4.3/12.16.4.4 Virtual Instance Port (VIP) to Provider
--             Instance Port (PIP) mapping table
-- ============================================================

ieee8021PbbVipToPipMappingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbVipToPipMappingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table lists VIPs and the PIP to which each is
         associated, and allows the PIP associated with each
         VIP to be configured.  Entries in this table must be
         persistent over power up restart/reboot."
    REFERENCE   "12.16.4.3, 12.16.4.4"
    ::= { ieee8021PbbProviderBackboneBridge 8 }

ieee8021PbbVipToPipMappingEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbVipToPipMappingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
         " The PIP is identified by the value of the
           ieee8021PbbVipToPipNumber. This value may be used to
           index the ieee8021PbbPipTable to set or retrieve the
           PIP's configuration information"
    INDEX       { ieee8021BridgeBasePortComponentId,
                  ieee8021BridgeBasePort }
    ::= { ieee8021PbbVipToPipMappingTable 1 }

Ieee8021PbbVipToPipMappingEntry ::=
    SEQUENCE {
        ieee8021PbbVipToPipMappingPipIfIndex
            InterfaceIndex,
        ieee8021PbbVipToPipMappingStorageType
            StorageType,
        ieee8021PbbVipToPipMappingRowStatus
            RowStatus
    }

ieee8021PbbVipToPipMappingPipIfIndex OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PIP's interface number."
    ::= { ieee8021PbbVipToPipMappingEntry 1 }

ieee8021PbbVipToPipMappingStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the storage type of this entry.  An entry whose
```

```
        storage type is permanent(4) need not allow write access to
        other columns in that entry."
    ::= { ieee8021PbbVipToPipMappingEntry 2 }

ieee8021PbbVipToPipMappingRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the status of an entry in this table, and is used
        to create/delete entries.

        The corresponding instance of ieee8021PbbVipToPipMappingPipIfIndex
        must be set before this object can be made active(1).

        The corresponding instance of ieee8021PbbVipToPipMappingPipIfIndex
        may not be changed while this object is active(1)."
    ::= { ieee8021PbbVipToPipMappingEntry 3 }

-- ============================================================
-- 12.16.5.1/12.16.5.2 Service Mapping configuration table
-- ============================================================

ieee8021PbbCBPServiceMappingTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbCBPServiceMappingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The CBP table of I-SID values (6.11).  The contents of this
         table are not persistent over power up restart/reboot."
    REFERENCE   "12.16.5.1, 12.16.5.2"
    ::= { ieee8021PbbProviderBackboneBridge 9 }

ieee8021PbbCBPServiceMappingEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbCBPServiceMappingEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Each entry includes the B-VID to carry and optionally an
         I-SID for mapping I-SIDs normally used at a Peer E-NNI
         (6.11, 26.6.2).  The table is indexed by the component ID
         of the relevant B-Component of the PBB, the Bridge port
         number of the CBP on that Bcomponent, and the I-SID for
         the service. "
    INDEX       { ieee8021BridgeBasePortComponentId,
                  ieee8021BridgeBasePort,
                  ieee8021PbbCBPServiceMappingBackboneSid }
    ::= { ieee8021PbbCBPServiceMappingTable 1 }

Ieee8021PbbCBPServiceMappingEntry ::=
    SEQUENCE {
        ieee8021PbbCBPServiceMappingBackboneSid
            IEEE8021PbbServiceIdentifier,
        ieee8021PbbCBPServiceMappingBVid
            VlanId,
        ieee8021PbbCBPServiceMappingDefaultBackboneDest
            MacAddress,
        ieee8021PbbCBPServiceMappingType
            IEEE8021PbbIngressEgress,
        ieee8021PbbCBPServiceMappingLocalSid
            IEEE8021PbbServiceIdentifierOrUnassigned,
        ieee8021PbbCBPServiceMappingRowStatus
            RowStatus
    }

ieee8021PbbCBPServiceMappingBackboneSid OBJECT-TYPE
    SYNTAX      IEEE8021PbbServiceIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The I-SID that will be transmitted over the PBBN."
    ::= { ieee8021PbbCBPServiceMappingEntry 1 }
```

```
ieee8021PbbCBPServiceMappingBVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The B-VID that will carry this service instance."
    ::= { ieee8021PbbCBPServiceMappingEntry 2 }

ieee8021PbbCBPServiceMappingDefaultBackboneDest OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A default destination B-MAC for the CBP to use."
    ::= { ieee8021PbbCBPServiceMappingEntry 3 }

ieee8021PbbCBPServiceMappingType OBJECT-TYPE
    SYNTAX      IEEE8021PbbIngressEgress
    MAX-ACCESS  read-create
    STATUS      deprecated
    DESCRIPTION
        "Used for Pt-MPt service where ingress or egress limiting
         is desired."
    ::= { ieee8021PbbCBPServiceMappingEntry 4 }

ieee8021PbbCBPServiceMappingLocalSid OBJECT-TYPE
    SYNTAX      IEEE8021PbbServiceIdentifierOrUnassigned
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The I-SID value used in frames transmitted and received through
         this CustomerBackbonePort."
    DEFVAL { 1 }
    ::= { ieee8021PbbCBPServiceMappingEntry 5 }

ieee8021PbbCBPServiceMappingRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the status of an entry in this table, and is used
        to create/delete entries.

        The corresponding instances of the following objects
        must be set before this object can be made active(1):
            ieee8021PbbCBPServiceMappingBVid
            ieee8021PbbCBPServiceMappingDefaultBackboneDest
            ieee8021PbbCBPServiceMappingType

        The corresponding instances of the following objects
        may not be changed while this object is active(1):
            ieee8021PbbCBPServiceMappingBVid
            ieee8021PbbCBPServiceMappingDefaultBackboneDest
            ieee8021PbbCBPServiceMappingType
            ieee8021PbbCBPServiceMappingLocalSid"
    ::= { ieee8021PbbCBPServiceMappingEntry 6 }

-- ============================================================
-- CBP port creation/deletion table
-- ============================================================

ieee8021PbbCbpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbCbpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "This table is used to dynamically create/delete Customer
        Backbone Ports in a PBB.

        Entries in this table must be persistent across reinitializations
        of the management system."
```

```
    REFERENCE   "17.5.3.4"
    ::= { ieee8021PbbProviderBackboneBridge 10 }

ieee8021PbbCbpEntry OBJECT-TYPE
    SYNTAX      Ieee8021PbbCbpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An entry representing a dynamically created CBP in a PBB."
    INDEX       { ieee8021BridgeBasePortComponentId,
                  ieee8021BridgeBasePort }
    ::= { ieee8021PbbCbpTable 1 }

Ieee8021PbbCbpEntry ::=
    SEQUENCE {
        ieee8021PbbCbpRowStatus
            RowStatus
    }

ieee8021PbbCbpRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This object is used for creation/deletion of entries in
        this table."
    ::= { ieee8021PbbCbpEntry 1 }

-- ================================================================
-- Conformance Information
-- ================================================================

ieee8021PbbGroups
    OBJECT IDENTIFIER ::= { ieee8021PbbConformance 1 }
ieee8021PbbCompliances
    OBJECT IDENTIFIER ::= { ieee8021PbbConformance 2 }

-- ================================================================
-- Units of conformance
-- ================================================================

ieee8021PbbBackboneEdgeBridgeGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbBackboneEdgeBridgeAddress,
        ieee8021PbbBackboneEdgeBridgeName,
        ieee8021PbbNumberOfIComponents,
        ieee8021PbbNumberOfBComponents,
        ieee8021PbbNumberOfBebPorts
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent a Backbone
         Edge Bridge."
    ::= { ieee8021PbbGroups 1 }

ieee8021PbbVipGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbVipPipIfIndex,
        ieee8021PbbVipISid,
        ieee8021PbbVipDefaultDstBMAC,
        ieee8021PbbVipType,
        ieee8021PbbVipRowStatus,
        ieee8021PbbISidToVipComponentId,
        ieee8021PbbISidToVipPort
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent a Virtual
         Instance Port (VIP)."
    ::= { ieee8021PbbGroups 2 }

ieee8021PbbPipGroup OBJECT-GROUP
```

```
    OBJECTS {
        ieee8021PbbNextAvailablePipIfIndex,
        ieee8021PbbPipBMACAddress,
        ieee8021PbbPipName,
        ieee8021PbbPipIComponentId,
        ieee8021PbbPipVipMap,
        ieee8021PbbPipVipMap1,
        ieee8021PbbPipVipMap2,
        ieee8021PbbPipVipMap3,
        ieee8021PbbPipVipMap4,
        ieee8021PbbPipRowStatus
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent a Provider
         Instance Port (PIP)."
    ::= { ieee8021PbbGroups 3 }

ieee8021PbbDefaultPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbPipPriorityCodePointSelection,
        ieee8021PbbPipUseDEI,
        ieee8021PbbPipRequireDropEncoding
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects defining the priority
        applicable to each port for media that do not support
        native priority."
    ::= { ieee8021PbbGroups 4 }

ieee8021PbbPipDecodingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbPipDecodingPriority,
        ieee8021PbbPipDecodingDropEligible
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing statistics counters for
        decoding priority and drop eligibility for Bridge Ports."
    ::= { ieee8021PbbGroups 5 }

ieee8021PbbPipEncodingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbPipEncodingPriority
    }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing statistics counters for
        encoding priority and drop eligibility for Bridge Ports."
    ::= { ieee8021PbbGroups 6 }

ieee8021PbbVipToPipMappingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbVipToPipMappingPipIfIndex,
        ieee8021PbbVipToPipMappingStorageType,
        ieee8021PbbVipToPipMappingRowStatus
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent the mapping
         of a VIP to a PIP."
    ::= { ieee8021PbbGroups 7 }

ieee8021PbbCBPServiceMappingGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbCBPServiceMappingBVid,
        ieee8021PbbCBPServiceMappingDefaultBackboneDest,
        ieee8021PbbCBPServiceMappingType,
        ieee8021PbbCBPServiceMappingLocalSid,
        ieee8021PbbCBPServiceMappingRowStatus
    }
```

```
    STATUS      current
    DESCRIPTION
        "The collection of objects used to represent a service instance."
    ::= { ieee8021PbbGroups 8 }

ieee8021PbbDynamicCbpGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbCbpRowStatus
    }
    STATUS      current
    DESCRIPTION
        "The collection of objects used to dynamically create/delete
        CBPs in a PBB."
    ::= { ieee8021PbbGroups 9 }

ieee8021PbbVipPbbTeGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbVipEnableConnectionId
    }
    STATUS     current
    DESCRIPTION
        "The collection of objects specific to PBB Bridges operating
         in a PBB-TE-aware manner."
    ::= { ieee8021PbbGroups 10 }

-- ============================================================
-- Compliance statements
-- ============================================================

ieee8021PbbCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting Provider
         Backbone Bridging as defined in IEEE Std 802.1ah."
    MODULE
        MANDATORY-GROUPS {
            ieee8021PbbBackboneEdgeBridgeGroup,
            ieee8021PbbVipGroup,
            ieee8021PbbPipGroup,
            ieee8021PbbVipToPipMappingGroup,
            ieee8021PbbCBPServiceMappingGroup,
            ieee8021PbbDynamicCbpGroup
        }

    GROUP       ieee8021PbbDefaultPriorityGroup
    DESCRIPTION
        "This group is mandatory only for devices supporting
        the priority forwarding operations defined by the
        extended Bridge services with media types, such as
        Ethernet, that do not support native priority."

    GROUP       ieee8021PbbPipDecodingGroup
    DESCRIPTION
        "This group is optional and supports Priority Code Point
        Decoding Table for a PIP of a provider Bridge."

    GROUP       ieee8021PbbPipEncodingGroup
    DESCRIPTION
        "This group is optional and supports Priority Code Point
        Encoding Table for a PIP of a provider Bridge."

    OBJECT ieee8021PbbPipName
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbPipVipMap
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbVipToPipMappingPipIfIndex
```

```
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbCBPServiceMappingBVid
    MIN-ACCESS not-accessible
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    OBJECT ieee8021PbbCBPServiceMappingDefaultBackboneDest
    MIN-ACCESS not-accessible
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    OBJECT ieee8021PbbCBPServiceMappingLocalSid
    MIN-ACCESS not-accessible
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    ::= { ieee8021PbbCompliances 1 }

ieee8021PbbWithPbbTeCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting Provider
         Backbone Bridging with traffic engineering as defined in IEEE Std 802.1ah
        and IEEE Std 802.1Qay."
    MODULE
        MANDATORY-GROUPS {
            ieee8021PbbBackboneEdgeBridgeGroup,
            ieee8021PbbVipGroup,
            ieee8021PbbPipGroup,
            ieee8021PbbVipToPipMappingGroup,
            ieee8021PbbCBPServiceMappingGroup,
            ieee8021PbbDynamicCbpGroup,
        ieee8021PbbVipPbbTeGroup
        }

    GROUP       ieee8021PbbDefaultPriorityGroup
    DESCRIPTION
        "This group is mandatory only for devices supporting
        the priority forwarding operations defined by the
        extended Bridge services with media types, such as
        Ethernet, that do not support native priority."

    GROUP       ieee8021PbbPipDecodingGroup
    DESCRIPTION
        "This group is optional and supports Priority Code Point
        Decoding Table for a PIP of a provider Bridge."

    GROUP       ieee8021PbbPipEncodingGroup
    DESCRIPTION
        "This group is optional and supports Priority Code Point
        Encoding Table for a PIP of a provider Bridge."

    OBJECT ieee8021PbbPipName
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbPipVipMap
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbVipToPipMappingPipIfIndex
    MIN-ACCESS read-only
    DESCRIPTION
        "Read-write access for this object is not required."

    OBJECT ieee8021PbbCBPServiceMappingBVid
    MIN-ACCESS not-accessible
```

```
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    OBJECT ieee8021PbbCBPServiceMappingDefaultBackboneDest
    MIN-ACCESS not-accessible
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    OBJECT ieee8021PbbCBPServiceMappingLocalSid
    MIN-ACCESS not-accessible
    DESCRIPTION
        "Read-only and read-write access for this object are optional."

    ::= { ieee8021PbbCompliances 2 }

END
```

17.7.9 Definitions for the IEEE8021-DDCFM-MIB module

```
IEEE8021-DDCFM-MIB DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE802.1Q DDCFM MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,OBJECT-TYPE, Integer32, Unsigned32
        FROM SNMPv2-SMI -- [RFC2578]
    TruthValue, RowStatus, MacAddress
        FROM SNMPv2-TC -- [RFC2579]
    ieee802dot1mibs
        FROM IEEE8021-TC-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF -- [RFC2580]
    InterfaceIndex
        FROM IF-MIB -- [RFC2863]
    VlanIdOrNone
        FROM Q-BRIDGE-MIB  -- [RFC4363]
    Dot1agCfmMDLevel, Dot1agCfmMpDirection
        FROM IEEE8021-CFM-MIB;

ieee8021DdcfmMIB MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
          "WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org

          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway
                   NJ 08854
                   USA
          E-mail: STDS-802-1-L@IEEE.ORG"
    DESCRIPTION
        "module for managing Data Dependent and Data Driven
         Connectivity Fault Management.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."
```

```
    REVISION "200904060000Z" -- 04/06/2009 00:00GMT
    DESCRIPTION
        "Included in IEEE P802.1Qaw D5.0
         Copyright (c) IEEE"
    ::= {ieee802dot1mibs 11}

ieee8021MIBObjects OBJECT IDENTIFIER ::= { ieee8021DdcfmMIB 1 }
ieee8021DdcfmConformance OBJECT IDENTIFIER ::= { ieee8021DdcfmMIB 2 }

-- ****************************************************************
-- Groups in the DDCFM MIB Module
-- ****************************************************************

ieee8021DdcfmStack OBJECT IDENTIFIER ::={ieee8021MIBObjects 1}
ieee8021DdcfmRr OBJECT IDENTIFIER ::={ieee8021MIBObjects 2}
ieee8021DdcfmRFMReceiver OBJECT IDENTIFIER ::={ieee8021MIBObjects 3}
ieee8021DdcfmDr OBJECT IDENTIFIER ::={ieee8021MIBObjects 4}
ieee8021DdcfmSFMOriginator OBJECT IDENTIFIER ::={ieee8021MIBObjects 5}

-- ****************************************************************
-- The DDCFM Stack Table
-- ****************************************************************
ieee8021DdcfmStackTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021DdcfmStackEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM Stack MIB object table. This table is for operator to
        retrieve all the DDCFM entities defined on a specified interface.
        This table is created by default."
    REFERENCE
        "12.17.1"
    ::= { ieee8021DdcfmStack 1 }

ieee8021DdcfmStackEntry OBJECT-TYPE
    SYNTAX Ieee8021DdcfmStackEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM Stack Table. "
    INDEX { ieee8021DdcfmStackIfIndex}
    ::= { ieee8021DdcfmStackTable 1 }

Ieee8021DdcfmStackEntry ::= SEQUENCE {
    ieee8021DdcfmStackIfIndex InterfaceIndex,
    ieee8021DdcfmStackRrMdLevel Dot1agCfmMDLevel,
    ieee8021DdcfmStackRrDirection Dot1agCfmMpDirection,
    ieee8021DdcfmStackRFMreceiverMdLevel Dot1agCfmMDLevel,
    ieee8021DdcfmStackDrMdLevel Dot1agCfmMDLevel,
    ieee8021DdcfmStackDrVlanIdOrNone VlanIdOrNone,
    ieee8021DdcfmStackSFMOriginatorMdLevel Dot1agCfmMDLevel,
    ieee8021DdcfmStackSFMOriginatorVlanIdOrNone VlanIdOrNone,
    ieee8021DdcfmStackSFMOriginatorDirection Dot1agCfmMpDirection
    }

ieee8021DdcfmStackIfIndex OBJECT-TYPE
    SYNTAX InterfaceIndex
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This object is the interface index of the interface either a
         Bridge Port, or an aggregated port within a Bridge
         Port. When the ifIndex value corresponds to the ifIndex of a
         Bridge Port, the value in this column must match the value in the
         ieee8021BridgeBasePortIfIndex column for the Bridge Port."
    REFERENCE
        "12.17.1.1.2 a.1"
    ::= { ieee8021DdcfmStackEntry 1 }

ieee8021DdcfmStackRrMdLevel OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS read-only
```

```
    STATUS current
    DESCRIPTION
        "MD level of the Reflection Responder managed object."
    REFERENCE
        "12.17.1.1.3 b.1"
    ::= { ieee8021DdcfmStackEntry 2 }

ieee8021DdcfmStackRrDirection OBJECT-TYPE
    SYNTAX Dot1agCfmMpDirection
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The direction in which the RR faces."
    REFERENCE
        "12.17.1.1.3 b1"
    ::= { ieee8021DdcfmStackEntry 3 }

ieee8021DdcfmStackRFMreceiverMdLevel OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "MD level of the RFM Receiver MO configured on the interface."
    REFERENCE
        "12.17.1.1.3 b.2"
    ::= { ieee8021DdcfmStackEntry 4 }

ieee8021DdcfmStackDrMdLevel OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "MD level of the Deflection Responder managed object."
    REFERENCE
        "12.17.1.1.3 b.3"
    ::= { ieee8021DdcfmStackEntry 5 }

ieee8021DdcfmStackDrVlanIdOrNone OBJECT-TYPE
    SYNTAX VlanIdOrNone
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The MA of the DR configured on the interface."
    REFERENCE
        "12.17.1.1.3 b.3"
    ::= { ieee8021DdcfmStackEntry 6 }

ieee8021DdcfmStackSFMOriginatorMdLevel OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "MD level of the SFM Originator MO configured on the interface."
    REFERENCE
        "12.17.1.1.3 b.4"
    ::= { ieee8021DdcfmStackEntry 7 }

ieee8021DdcfmStackSFMOriginatorVlanIdOrNone OBJECT-TYPE
    SYNTAX VlanIdOrNone
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The MA of the SFM Originator configured on the interface."
    REFERENCE
        "12.17.1.1.3 b.4"
    ::= { ieee8021DdcfmStackEntry 8 }

ieee8021DdcfmStackSFMOriginatorDirection OBJECT-TYPE
    SYNTAX Dot1agCfmMpDirection
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
```

```
        "The direction of which the SFM Originator is facing."
    REFERENCE
        "12.17.1.1.3 b.4"
    ::= { ieee8021DdcfmStackEntry 9 }

-- ****************************************************************
-- The Reflection Responder Table
-- ****************************************************************
ieee8021DdcfmRrTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021DdcfmRrEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The Reflection Responder MIB object table. Each row
        in the table represents a different Reflection Responder.
        All rows in this table persist across a system restart,
        however after such a restart, the value of the
        ActivationStatus column will be false."
    REFERENCE
        "12.17.2"
    ::= { ieee8021DdcfmRr 1 }

ieee8021DdcfmRrEntry OBJECT-TYPE
    SYNTAX Ieee8021DdcfmRrEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The Reflection Responder. Each entry associated with a Reflection
         Responder."
    INDEX { ieee8021DdcfmRrIfIndex,
            ieee8021DdcfmRrMdIndex,
            ieee8021DdcfmRrDirection
            }
    ::= { ieee8021DdcfmRrTable 1 }

Ieee8021DdcfmRrEntry ::= SEQUENCE {
    ieee8021DdcfmRrIfIndex InterfaceIndex,
    ieee8021DdcfmRrMdIndex Dot1agCfmMDLevel,
    ieee8021DdcfmRrDirection Dot1agCfmMpDirection,
    ieee8021DdcfmRrPrimaryVlanIdOrNone VlanIdOrNone,
    ieee8021DdcfmRrFilter OCTET STRING,
    ieee8021DdcfmRrSamplingInterval Unsigned32,
    ieee8021DdcfmRrTargetAddress MacAddress,
    ieee8021DdcfmRrContinueFlag TruthValue,
    ieee8021DdcfmRrDuration Unsigned32,
    ieee8021DdcfmRrDurationInTimeFlag TruthValue,
    ieee8021DdcfmRrVlanPriority Integer32,
    ieee8021DdcfmRrVlanDropEligible TruthValue,
    ieee8021DdcfmRrFloodingFlag TruthValue,
    ieee8021DdcfmRrTruncationFlag TruthValue,
    ieee8021DdcfmRrActivationStatus TruthValue,
    ieee8021DdcfmRrRemainDuration Unsigned32,
    ieee8021DdcfmRrNextRfmTransID Unsigned32,
    ieee8021DdcfmRrRowStatus RowStatus
    }

ieee8021DdcfmRrIfIndex OBJECT-TYPE
    SYNTAX InterfaceIndex
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This object is the interface index of the interface either a
         Bridge Port, or an aggregated port within a Bridge
         Port, on which Reflection Responder is defined.
         When the ifIndex value corresponds to the ifIndex of a
         Bridge Port, the value in this column must match the value in the
         ieee8021BridgeBasePortIfIndex column for the Bridge Port."
    REFERENCE
        "12.17.2.1.2 a.1"
    ::= { ieee8021DdcfmRrEntry 1 }

ieee8021DdcfmRrMdIndex   OBJECT-TYPE
```

```
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "MD level of the Reflection Responder managed object."
    REFERENCE
        "12.17.2.1.2 a.2"
    ::= { ieee8021DdcfmRrEntry 2 }

ieee8021DdcfmRrDirection   OBJECT-TYPE
    SYNTAX Dot1agCfmMpDirection
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The direction in which the RR faces."
    REFERENCE
        "12.17.2.1.2 a.3"
    ::= { ieee8021DdcfmRrEntry 3 }

ieee8021DdcfmRrPrimaryVlanIdOrNone   OBJECT-TYPE
    SYNTAX VlanIdOrNone
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The VID to be used on RFM frames."
    REFERENCE
        "12.17.2.2.2 b.1"
    DEFVAL { 0 }
    ::= { ieee8021DdcfmRrEntry 4 }

ieee8021DdcfmRrFilter OBJECT-TYPE
    SYNTAX OCTET STRING (SIZE(0..1500))
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "A pattern string specifies what data frames are selected to be
        reflected. Below are the primary Reflection Filters all
        Implementers should support. Multiple primary filters can be
        combined together by
         && (and), || (or), or !(negation).
         1) All;
         2) VID= vid;
         3) I-SID = x;
         4) DA = xx.xx.xx.xx.xx.xx;
         5) SA = xx.xx.xx.xx.xx.xx;
         6) EtherType =xx.
        For the reason that this management object allows a max size of
        1500, messages carrying this object may be fragmented on some
        segments."
    REFERENCE
        "12.17.2.2.2 b.2"
    ::= { ieee8021DdcfmRrEntry 5 }

ieee8021DdcfmRrSamplingInterval OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "miliseconds"
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "Indicates a time interval in which only the first frame matching
        the filter conditions is refected."
    REFERENCE
        "12.17.2.2.2 b.3"
    ::= { ieee8021DdcfmRrEntry 6 }

ieee8021DdcfmRrTargetAddress OBJECT-TYPE
    SYNTAX MacAddress
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The Reflection Target Address, which is a MAC address to which the
        reflected frames are targeted. Only individual address is allowed
```

```
        for the Reflection Target Address.
        If not specified, the source_address of the selected data frame is
        used for Reflection Target Address."
    REFERENCE
        "12.17.2.2.2 b.4"
    ::= { ieee8021DdcfmRrEntry 7 }

ieee8021DdcfmRrContinueFlag OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that the selected data frames are to be continued
         towards the DA specified in the frame header.
         False indicates that the selected data frames are terminated."
    REFERENCE
        "12.17.2.2.2 b.5"
    DEFVAL { true }
    ::= { ieee8021DdcfmRrEntry 8 }

ieee8021DdcfmRrDuration OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "Duration of time in the unit of seconds or the number
         of frames to be reflected, for Reflection Responder to
         remain active after activation; Minimum 2 octets (65536
         seconds) are needed for the duration of time;"
    REFERENCE
        "12.17.2.2.2 b.7"
    ::= { ieee8021DdcfmRrEntry 9 }

ieee8021DdcfmRrDurationInTimeFlag OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that duration is in seconds;
         False indicates that duration is by the total number of frames reflected."
    REFERENCE
        "12.17.2.2.2 b.6"
    DEFVAL { true }
    ::= { ieee8021DdcfmRrEntry 10 }

ieee8021DdcfmRrVlanPriority OBJECT-TYPE
    SYNTAX Integer32(0..7)
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "Priority, 3 bit value to be used in the VLAN tag, to be used in the
         transmitted encapsulated frames. The default value is the highest
         priority."
    REFERENCE
        "12.17.2.2.2 b.9"
    DEFVAL { 7 }
    ::= { ieee8021DdcfmRrEntry 11 }

ieee8021DdcfmRrVlanDropEligible OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "It indicates that the drop_eligible bit value to be used in
        the VLAN tag to be used in the transmitted encapsulated
        frames is set as True or False accordingly."
    REFERENCE
        "12.17.2.2.2 b.9"
    DEFVAL { false }
    ::= { ieee8021DdcfmRrEntry 12 }

ieee8021DdcfmRrFloodingFlag OBJECT-TYPE
```

```
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that flooding is allowed if Egress port cannot be
         identified for RFM by the Filtering Database, False otherwise."
    REFERENCE
        "12.17.2.2.2 b.10"
    DEFVAL { true }
    ::= { ieee8021DdcfmRrEntry 13 }


ieee8021DdcfmRrTruncationFlag OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that the received data frame will be truncated to
        keep the constructed RFM size not exceeding the egress port's
        Maximum Service Data Unit Size, False otherwise."
    REFERENCE
        "12.17.2.2.2 b.11"
    DEFVAL { true }
    ::= { ieee8021DdcfmRrEntry 14 }

ieee8021DdcfmRrActivationStatus OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "True When receiving a request to activate a Reflection Responder,
        False When receiving a request to stop Reflection Responder or
        its timer expires."
    REFERENCE
        "12.17.2.2.2 b.12"
    DEFVAL { false }
    ::= { ieee8021DdcfmRrEntry 15 }

ieee8021DdcfmRrRemainDuration OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The value indicates the time, in the unit of seconds, or count
        left for Reflection Responder to be active."
    REFERENCE
        "12.17.2.2.2 b.13"
    ::= { ieee8021DdcfmRrEntry 16 }

ieee8021DdcfmRrNextRfmTransID OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "It indicates the value of RFM Transaction Identifier field of the
        next RFM transmitted. It is incremented by 1 with each
        transmission of RFM."
    REFERENCE
        "12.17.2.2.2 b.14"
    ::= { ieee8021DdcfmRrEntry 17 }

ieee8021DdcfmRrRowStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status of the row.
        The writable columns in a row cannot be changed if the row is
        active."
    ::= { ieee8021DdcfmRrEntry 18 }
```

```
-- ********************************************************************
-- The RFM Receiver Table
-- ********************************************************************

ieee8021DdcfmRFMReceiverTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021DdcfmRFMReceiverEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The RFM Receiver MIB object table. Each row in the table
        represents a different RFM Receiver.
        All rows associated with this table persist across system restart."
    REFERENCE
        "12.17.3"
    ::= { ieee8021DdcfmRFMReceiver 1 }

ieee8021DdcfmRFMReceiverEntry OBJECT-TYPE
    SYNTAX Ieee8021DdcfmRFMReceiverEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM RFM Receiver. Each entry associated with a DDCFM RFM
        Receiver that reference to a MP."
    INDEX { ieee8021DdcfmRfmReceiverIfIndex,
    ieee8021DdcfmRfmReceiverMdIndex}
    ::= { ieee8021DdcfmRFMReceiverTable 1 }

Ieee8021DdcfmRFMReceiverEntry ::= SEQUENCE {
    ieee8021DdcfmRfmReceiverIfIndex InterfaceIndex,
    ieee8021DdcfmRfmReceiverMdIndex Dot1agCfmMDLevel,
        ieee8021DdcfmRFMRowStatus RowStatus
    }

ieee8021DdcfmRfmReceiverIfIndex OBJECT-TYPE
    SYNTAX InterfaceIndex
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The interface index of the interface either a
         Bridge Port, or an aggregated port within a Bridge
         Port, on which the RFM Receiver is created.
         When the ifIndex value corresponds to the ifIndex of a
         Bridge Port, the value in this column must match the value in the
         ieee8021BridgeBasePortIfIndex column for the Bridge Port."
    REFERENCE
        "12.17.3.1.2 a.2 "
    ::= { ieee8021DdcfmRFMReceiverEntry 1 }

ieee8021DdcfmRfmReceiverMdIndex   OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "MD level of the RFM Receiver managed object."
    REFERENCE
        "12.17.3.1.2 a.2"
    ::= { ieee8021DdcfmRFMReceiverEntry 2 }

ieee8021DdcfmRFMRowStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status of the row.
        The writable columns in a row cannot be changed if the row is
        active."
    ::= { ieee8021DdcfmRFMReceiverEntry 3 }

-- ********************************************************************
-- The Decapsulator Responder Table
-- ********************************************************************
ieee8021DdcfmDrTable OBJECT-TYPE
```

```
    SYNTAX SEQUENCE OF Ieee8021DdcfmDrEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM Decapsulator Responder MIB object table. Each row in the
        table represents a different DDCFM Decapsulator Responder. All rows
        in this table persist across a system restart; however after such
        a restart, the value of the ActivationStatus column will be false."
    REFERENCE
        "12.17.4"
    ::= { ieee8021DdcfmDr 1 }

ieee8021DdcfmDrEntry OBJECT-TYPE
    SYNTAX Ieee8021DdcfmDrEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM Decapsulator Responder. Each entry associated with a
        DDCFM RFM Receiver which reference to a MP."
    INDEX { ieee8021DdcfmDrIfIndex,
            ieee8021DdcfmDrMdIndex,
            ieee8021DdcfmDrVlanIdOrNone }
    ::= { ieee8021DdcfmDrTable 1 }

Ieee8021DdcfmDrEntry ::= SEQUENCE {
    ieee8021DdcfmDrIfIndex InterfaceIndex,
    ieee8021DdcfmDrMdIndex Dot1agCfmMDLevel,
    ieee8021DdcfmDrVlanIdOrNone VlanIdOrNone,
    ieee8021DdcfmDrSfmOriginator MacAddress,
    ieee8021DdcfmDrSourceAddressStayFlag TruthValue,
    ieee8021DdcfmDrFloodingFlag TruthValue,
    ieee8021DdcfmDrDuration Unsigned32,
    ieee8021DdcfmDrActivationStatus TruthValue,
    ieee8021DdcfmDrRemainDuration Unsigned32,
    ieee8021DdcfmDrSFMsequenceErrors Unsigned32,
    ieee8021DdcfmDrRowStatus RowStatus
    }

ieee8021DdcfmDrIfIndex OBJECT-TYPE
    SYNTAX InterfaceIndex
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The interface index of the interface either a Bridge
         Port, or an aggregated port within a Bridge
         Port, on which the Decapsulator Responder is created.
         When the ifIndex value corresponds to the ifIndex of a
         Bridge Port, the value in this column must match the value in the
         ieee8021BridgeBasePortIfIndex column for the Bridge Port."
    REFERENCE
        "12.17.4.1.2 a.2 "
    ::= { ieee8021DdcfmDrEntry 1 }

ieee8021DdcfmDrMdIndex   OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "MD level of the Decapsulator Responder managed object."
    REFERENCE
        "12.17.4.1.2 a.2"
    ::= { ieee8021DdcfmDrEntry 2 }

ieee8021DdcfmDrVlanIdOrNone   OBJECT-TYPE
    SYNTAX VlanIdOrNone
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An integer indicating the VID expected from the Send Frame Message
        frames."
    REFERENCE
        "12.17.4.1.2 a.2"
```

```
    ::= { ieee8021DdcfmDrEntry 3 }

ieee8021DdcfmDrSfmOriginator OBJECT-TYPE
    SYNTAX MacAddress
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "MAC address reference to the corresponding Send Frame Message
        Originator."
    REFERENCE
        "12.17.4.2.3 b.2"
    ::= { ieee8021DdcfmDrEntry 4 }

ieee8021DdcfmDrSourceAddressStayFlag OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that Decapsulator Responder does not replace the
        source_address field of the decapsulated frame with the
        Decapsulator Responder's own MAC address, False otherwise."
    REFERENCE
        "12.17.4.2.3 b.3"
    DEFVAL { true }
    ::= { ieee8021DdcfmDrEntry 5 }

ieee8021DdcfmDrFloodingFlag OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "True indicates that broadcast is allowed if Egress port cannot be
         identified by the Filtering Database, False otherwise."
    REFERENCE
        "12.17.4.3.2 b.3"
    DEFVAL { true }
    ::= { ieee8021DdcfmDrEntry 6 }

ieee8021DdcfmDrDuration OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "seconds"
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The time that the Decapsulator Responder can stay active after
        its activation in the unit of seconds."
    REFERENCE
        "12.17.4.3.2 b.4"
    ::= { ieee8021DdcfmDrEntry 7 }

ieee8021DdcfmDrActivationStatus OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "True When receiving a request to activate a Decapsulator
        Responder, false When receiving a request to stop the Decapsulator
        Responder or its timer expires."
    REFERENCE
        "12.17.4.2.3 b.6"
    DEFVAL { false }
    ::= { ieee8021DdcfmDrEntry 8 }

ieee8021DdcfmDrRemainDuration OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The value indicates the time left for Decapsulator Responder keep
         active. Its granularity is in seconds."
    REFERENCE
```

```
        "12.17.4.2.3 b.7"
    ::= { ieee8021DdcfmDrEntry 9 }

ieee8021DdcfmDrSFMsequenceErrors OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "integer"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The value indicates the total number of out-of-sequence SFMs."
    REFERENCE
        "12.17.4.2.3 b.8"
    ::= { ieee8021DdcfmDrEntry 10 }

ieee8021DdcfmDrRowStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status of the row.
        The writable columns in a row cannot be changed if the row is
        active."
    ::= { ieee8021DdcfmDrEntry 11 }

-- ****************************************************************
-- The SFM Originator Table
-- ****************************************************************
ieee8021DdcfmSoTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021DdcfmSoEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The DDCFM Send Frame Message Originator MIB object table. Each row
        in the table represents a different DDCFM Send Frame Message
        Originator. All rows in this table persist across a system restart;
        however after such a restart, the value of the ActivationStatus
        column will be false."
    REFERENCE
        "12.17.5"
    ::= { ieee8021DdcfmSFMOriginator 1 }

ieee8021DdcfmSoEntry OBJECT-TYPE
    SYNTAX Ieee8021DdcfmSoEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Each entry associated with a Send Frame Message Originator."
    INDEX { ieee8021DdcfmSfmIfIndex,
            ieee8021DdcfmSoMdIndex,
            ieee8021DdcfmSoVlanIdOrNone,
            ieee8021DdcfmSoDirection}
    ::= { ieee8021DdcfmSoTable 1 }

Ieee8021DdcfmSoEntry ::= SEQUENCE {
    ieee8021DdcfmSfmIfIndex InterfaceIndex,
    ieee8021DdcfmSoMdIndex Dot1agCfmMDLevel,
    ieee8021DdcfmSoVlanIdOrNone VlanIdOrNone,
    ieee8021DdcfmSoDirection Dot1agCfmMpDirection,
    ieee8021DdcfmSoDrMacAddress MacAddress,
    ieee8021DdcfmSoDuration Unsigned32,
    ieee8021DdcfmSoActivationStatus TruthValue,
    ieee8021DdcfmSoRemainDuration Unsigned32,
    ieee8021DdcfmSoRowStatus RowStatus
    }

ieee8021DdcfmSfmIfIndex OBJECT-TYPE
    SYNTAX InterfaceIndex
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The interface index of the interface either a Bridge
         port, or an aggregated port within a Bridge
```

```
          port, on which Send Frame Message Originator is created.
          When the ifIndex value corresponds to the ifIndex of a
          Bridge Port, the value in this column must match the value in the
          ieee8021BridgeBasePortIfIndex column for the Bridge Port."
    REFERENCE
        "12.17.5.1.2 a.2"
    ::= { ieee8021DdcfmSoEntry 1 }

ieee8021DdcfmSoMdIndex   OBJECT-TYPE
    SYNTAX Dot1agCfmMDLevel
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "MD level of the Send Frame Message Originator managed object."
    REFERENCE
        "12.17.5.1.2 a.2"
    ::= { ieee8021DdcfmSoEntry 2 }

ieee8021DdcfmSoVlanIdOrNone   OBJECT-TYPE
    SYNTAX VlanIdOrNone
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "An integer indicating the VID to be used on Send Frame Message
        frames."
    REFERENCE
        "12.17.5.1.2 a.2"
    ::= { ieee8021DdcfmSoEntry 3 }

ieee8021DdcfmSoDirection   OBJECT-TYPE
    SYNTAX Dot1agCfmMpDirection
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The direction in which the SFM Originator faces."
    REFERENCE
        "12.17.5.1.2 a.2"
    ::= { ieee8021DdcfmSoEntry 4 }

ieee8021DdcfmSoDrMacAddress OBJECT-TYPE
    SYNTAX MacAddress
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "MAC Address of the corresponding Decapsulator Responder."
    REFERENCE
        "12.17.5.4.2 b"
    ::= { ieee8021DdcfmSoEntry 5 }

ieee8021DdcfmSoDuration OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "seconds"
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "Duration, in the unit of seconds, of Send Frame Message Originator
         staying active once activated."
    REFERENCE
        "12.17.5.4.2 c"
    ::= { ieee8021DdcfmSoEntry 6 }

ieee8021DdcfmSoActivationStatus OBJECT-TYPE
    SYNTAX TruthValue
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "True When receiving a request to activate a Send Frame Message
        Originator, false When receiving a request to stop the Send Frame
        Message Originator or its timer expires."
    REFERENCE
        "12.17.5.2.3 b.4"
    DEFVAL { false }
```

```
    ::= { ieee8021DdcfmSoEntry 7 }

ieee8021DdcfmSoRemainDuration OBJECT-TYPE
    SYNTAX Unsigned32
    UNITS "seconds"
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The value indicates the time left for Send Frame Message
        Originator keep active. Its granularity is in seconds."
    REFERENCE
        "12.17.5.2.3 b.5"
    ::= { ieee8021DdcfmSoEntry 8 }

ieee8021DdcfmSoRowStatus OBJECT-TYPE
    SYNTAX RowStatus
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "The status of the row.
        The writable columns in a row cannot be changed if the row is
        active."
    ::= { ieee8021DdcfmSoEntry 9 }


-- ****************************************************************
-- IEEE802.1Qaw MIB Module - Conformance Information
-- ****************************************************************
ieee8021DdcfmCompliances OBJECT IDENTIFIER ::= { ieee8021DdcfmConformance 1 }
ieee8021DdcfmGroups OBJECT IDENTIFIER ::= { ieee8021DdcfmConformance 2 }

-- ****************************************************************
-- Units of conformance
-- ****************************************************************
ieee8021DdcfmStackGroup OBJECT-GROUP
    OBJECTS {
        ieee8021DdcfmStackRrMdLevel,
        ieee8021DdcfmStackRrDirection,
        ieee8021DdcfmStackRFMreceiverMdLevel,
        ieee8021DdcfmStackDrMdLevel,
        ieee8021DdcfmStackDrVlanIdOrNone,
        ieee8021DdcfmStackSFMOriginatorMdLevel,
        ieee8021DdcfmStackSFMOriginatorVlanIdOrNone,
        ieee8021DdcfmStackSFMOriginatorDirection
        }
    STATUS current
    DESCRIPTION
        "Objects for the DDCFM Stack group."
    ::= { ieee8021DdcfmGroups 1 }

ieee8021DdcfmRrGroup OBJECT-GROUP
    OBJECTS {
        ieee8021DdcfmRrPrimaryVlanIdOrNone,
        ieee8021DdcfmRrFilter,
        ieee8021DdcfmRrSamplingInterval,
        ieee8021DdcfmRrTargetAddress,
        ieee8021DdcfmRrContinueFlag,
        ieee8021DdcfmRrDuration,
        ieee8021DdcfmRrDurationInTimeFlag,
        ieee8021DdcfmRrVlanPriority,
        ieee8021DdcfmRrVlanDropEligible,
        ieee8021DdcfmRrFloodingFlag,
        ieee8021DdcfmRrTruncationFlag,
        ieee8021DdcfmRrActivationStatus,
        ieee8021DdcfmRrRemainDuration,
        ieee8021DdcfmRrNextRfmTransID,
        ieee8021DdcfmRrRowStatus
        }
    STATUS current
    DESCRIPTION
        "Objects for the Reflection Responder group."
    ::= { ieee8021DdcfmGroups 2 }
```

```
ieee8021DdcfmRFMReceiverGroup OBJECT-GROUP
    OBJECTS {
        ieee8021DdcfmRFMRowStatus
        }
    STATUS current
    DESCRIPTION
        "Objects for the RFM Receiver group."
    ::= { ieee8021DdcfmGroups 3 }

ieee8021DdcfmDrGroup OBJECT-GROUP
    OBJECTS {
        ieee8021DdcfmDrSourceAddressStayFlag,
        ieee8021DdcfmDrSfmOriginator,
        ieee8021DdcfmDrFloodingFlag,
        ieee8021DdcfmDrDuration,
        ieee8021DdcfmDrActivationStatus,
        ieee8021DdcfmDrRemainDuration,
        ieee8021DdcfmDrSFMsequenceErrors,
        ieee8021DdcfmDrRowStatus
        }
    STATUS current
    DESCRIPTION
        "Objects for the Decapsulator Responder group."
    ::= { ieee8021DdcfmGroups 4 }

ieee8021DdcfmSoGroup OBJECT-GROUP
    OBJECTS {
        ieee8021DdcfmSoDrMacAddress,
        ieee8021DdcfmSoDuration,
        ieee8021DdcfmSoActivationStatus,
        ieee8021DdcfmSoRemainDuration,
        ieee8021DdcfmSoRowStatus
        }
    STATUS current
    DESCRIPTION
        "Objects for the Send Frame Message Originator group."
    ::= { ieee8021DdcfmGroups 5 }


--*****************************************************************
-- MIB Module Compliance statements
--*****************************************************************
ieee8021DdcfmCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "The compliance statement for support of the DDCFM MIB module."
    MODULE
    MANDATORY-GROUPS {
        ieee8021DdcfmStackGroup,
        ieee8021DdcfmRrGroup,
        ieee8021DdcfmRFMReceiverGroup,
        ieee8021DdcfmDrGroup,
        ieee8021DdcfmSoGroup
        }

    OBJECT ieee8021DdcfmRrRowStatus
    SYNTAX RowStatus { active(1), notInService(2) }
    WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
        destroy(6) }
    DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021DdcfmRFMRowStatus
    SYNTAX RowStatus { active(1), notInService(2) }
    WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
        destroy(6) }
    DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021DdcfmDrRowStatus
    SYNTAX RowStatus { active(1), notInService(2) }
    WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
        destroy(6) }
```

```
    DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021DdcfmSoRowStatus
    SYNTAX RowStatus { active(1), notInService(2) }
    WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
        destroy(6) }
    DESCRIPTION "Support for createAndWait is not required."
    ::= { ieee8021DdcfmCompliances 1 }

END
```

17.7.10 Definitions for the IEEE8021-PBBTE-MIB module

```
IEEE8021-PBBTE-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q PBB-TE Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    NOTIFICATION-TYPE,
    OBJECT-TYPE,
    Unsigned32
        FROM SNMPv2-SMI
    RowStatus,
    StorageType,
    TruthValue
        FROM SNMPv2-TC
    ieee802dot1mibs,
    IEEE8021BridgePortNumber,
    IEEE8021PbbComponentIdentifier,
    IEEE8021PbbServiceIdentifier,
    IEEE8021PbbTeEsp,
    IEEE8021PbbTeProtectionGroupActiveRequests,
    IEEE8021PbbTeProtectionGroupId,
    IEEE8021PbbTeProtectionGroupConfigAdmin,
    IEEE8021PbbTeTSidId,
    IEEE8021VlanIndexOrWildcard
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId
        FROM IEEE8021-BRIDGE-MIB
    PortList
        FROM Q-BRIDGE-MIB
    ieee8021QBridgeVlanCurrentComponentId
        FROM IEEE8021-Q-BRIDGE-MIB
    MODULE-COMPLIANCE,
    NOTIFICATION-GROUP,
    OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021PbbTeMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"

    DESCRIPTION
       "Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
```

```
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

    REVISION "200811180000Z" -- November 18, 2008
    DESCRIPTION
        "Initial version of the PBB-TE MIB module based upon draft 3.2
         of the MIB modules defined in IEEE Std 802.1ap and IEEE Std 802.1Qay"

    ::= { ieee802dot1mibs 10 }

ieee8021PbbTeNotifications OBJECT IDENTIFIER ::= { ieee8021PbbTeMib 0 }
ieee8021PbbTeObjects       OBJECT IDENTIFIER ::= { ieee8021PbbTeMib 1 }
ieee8021PbbTeConformance   OBJECT IDENTIFIER ::= { ieee8021PbbTeMib 2 }

--
-- 802.1Qay MIB Objects
--

ieee8021PbbTeProtectionGroupListTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PbbTeProtectionGroupListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The PBB-TE Protection group list table.  Each entry in this table
         corresponds to a configured PBB-TE Protection Group configured on
         the B-Component of an IB-BEB."
    REFERENCE
        "12.18.1"
    ::= { ieee8021PbbTeObjects 1 }

ieee8021PbbTeProtectionGroupListEntry OBJECT-TYPE
    SYNTAX Ieee8021PbbTeProtectionGroupListEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The PBB-TE protection group list table entry.
        Note that the component ID must refer to an B component"
    INDEX { ieee8021BridgeBaseComponentId,
            ieee8021PbbTeProtectionGroupListGroupId }
    ::= { ieee8021PbbTeProtectionGroupListTable 1 }

Ieee8021PbbTeProtectionGroupListEntry ::=
    SEQUENCE {
        ieee8021PbbTeProtectionGroupListGroupId       IEEE8021PbbTeProtectionGroupId,
        ieee8021PbbTeProtectionGroupListMD            Unsigned32,
        ieee8021PbbTeProtectionGroupListWorkingMA     Unsigned32,
        ieee8021PbbTeProtectionGroupListProtectionMA  Unsigned32,
        ieee8021PbbTeProtectionGroupListStorageType   StorageType,
        ieee8021PbbTeProtectionGroupListRowStatus     RowStatus
    }

ieee8021PbbTeProtectionGroupListGroupId OBJECT-TYPE
    SYNTAX      IEEE8021PbbTeProtectionGroupId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
         "The unique identifier for the protection group."
    REFERENCE
        "12.18.2"
    ::= { ieee8021PbbTeProtectionGroupListEntry 1 }

ieee8021PbbTeProtectionGroupListMD OBJECT-TYPE
    SYNTAX      Unsigned32
```

```
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
         "This refers to the Maintenance Domain that qualifies the
          WorkingMA and ProtectionMA columns of this table.  The MD
      index in this column must hold a value that matches the
      in the dot1agCfmStackMdIndex in the dot1agCfmStackTable
      for the corresponding WorkingMA and ProtectionMA columns
      of this table.  This correspondence must hold for the RowStatus
      of this row to be set to Active.  Furthermore, this column may
      not be modified while the RowStatus for this row is Active"
      REFERENCE
          "12.18.1.1.3 b)"
::= { ieee8021PbbTeProtectionGroupListEntry 2 }


ieee8021PbbTeProtectionGroupListWorkingMA OBJECT-TYPE
    SYNTAX     Unsigned32
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This refers to the Maintenance Association that refers
        to the PBB-TE MA that corresponds to the group's working
        entity.  The MA index in this column must hold a value
        that is the value of dot1agCfmStackMaIndex column for
        some entry in the dot1agCfmStackTable before the RowStatus
        for this row can be set to Active.  Furthermore, this column
        may not be modified when the RowStatus for this row is Active."
    REFERENCE
        "12.18.1.1.3 b)"
::= { ieee8021PbbTeProtectionGroupListEntry 3 }

ieee8021PbbTeProtectionGroupListProtectionMA OBJECT-TYPE
    SYNTAX     Unsigned32
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This refers to the Maintenance Association that refers
        to the PBB-TE MA that corresponds to the group's protection
        entity.  The MA index in this column must hold a value
        that is the value of dot1agCfmStackMaIndex column for
        some entry in the dot1agCfmStackTable before the RowStatus
        for this row can be set to Active.  Furthermore, this column
        may not be modified when the RowStatus for this row is Active."
    REFERENCE
        "12.18.1.1.3 c)"
::= { ieee8021PbbTeProtectionGroupListEntry 4 }

ieee8021PbbTeProtectionGroupListStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this entry. All read-create
       columns must be writable if this column is set to permanent."
    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeProtectionGroupListEntry 5 }

ieee8021PbbTeProtectionGroupListRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "The status of this row.

        The writable columns in a row cannot be changed if the row is
        active.  The  PbbTeProtectionGroupListWorkingMA, and
        PbbTeProtectionGroupListProtectionMA columns must be specified
        before the row can be activated."
    REFERENCE
        "12.18.1.2"
    ::= { ieee8021PbbTeProtectionGroupListEntry 6 }
```

```
ieee8021PbbTeMASharedGroupTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021PbbTeMASharedGroupEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This table contains references to all protection groups that
         share a working or protection entity with a given protection
         group."
    REFERENCE
        "12.18.1.1.3 d)"
    ::= { ieee8021PbbTeObjects 2 }

ieee8021PbbTeMASharedGroupEntry OBJECT-TYPE
    SYNTAX     Ieee8021PbbTeMASharedGroupEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The ieee801PbbTeMASharedGroupEntry table.  The table is
        indexed by protection group and by a simple integer.  The
        table lists all protection groups that load share with that
        group."
    INDEX { ieee8021BridgeBaseComponentId,
            ieee8021PbbTeProtectionGroupListGroupId,
            ieee8021PbbTeMASharedGroupSubIndex }
    ::= { ieee8021PbbTeMASharedGroupTable 1 }

Ieee8021PbbTeMASharedGroupEntry ::=
    SEQUENCE {
            ieee8021PbbTeMASharedGroupSubIndex Unsigned32,
            ieee8021PbbTeMASharedGroupId       IEEE8021PbbTeProtectionGroupId
    }

ieee8021PbbTeMASharedGroupSubIndex OBJECT-TYPE
    SYNTAX  Unsigned32(1..4294967295)
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
       "A simple integer to distinguish the members of the set
        of MAs that comprise the set of load sharing MAs for the
        specified protection group."
     ::= { ieee8021PbbTeMASharedGroupEntry 1 }

ieee8021PbbTeMASharedGroupId OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeProtectionGroupId
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
       "This column holds the group id of a protection group that shares
        a working or protection group with the group whose index is the
        first index of this row."
    ::=  { ieee8021PbbTeMASharedGroupEntry 2 }


ieee8021PbbTeTesiTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021PbbTeTesiEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The PBB-TE TESI table contains information for each
         TE Service Instance known to a system."
    REFERENCE
        "12.16.5.3.1"
    ::= { ieee8021PbbTeObjects 3 }

ieee8021PbbTeTesiEntry  OBJECT-TYPE
    SYNTAX     Ieee8021PbbTeTesiEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
    "The PBB-TE TESI entry.  Each entry maps a TESI to
     a component and CBP."
```

```
    INDEX { ieee8021PbbTeTesiId }
    ::= { ieee8021PbbTeTesiTable 1 }

Ieee8021PbbTeTesiEntry ::=
    SEQUENCE {
        ieee8021PbbTeTesiId          IEEE8021PbbTeTSidId,
        ieee8021PbbTeTesiComponent   IEEE8021PbbComponentIdentifier,
    ieee8021PbbTeTesiBridgePort  IEEE8021BridgePortNumber,
        ieee8021PbbTeTesiStorageType StorageType,
    ieee8021PbbTeTesiRowStatus   RowStatus
    }

ieee8021PbbTeTesiId OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeTSidId
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This is the unique identifier for a PBB-TE TE-SID."
    REFERENCE
        "3.276"
    ::= { ieee8021PbbTeTesiEntry 1 }

ieee8021PbbTeTesiComponent OBJECT-TYPE
    SYNTAX     IEEE8021PbbComponentIdentifier
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
    "This is the component upon which the Bridge Port of the
     TESI is located."
    REFERENCE
        "12.16.5.3.2 a)"
    ::= { ieee8021PbbTeTesiEntry 2 }

ieee8021PbbTeTesiBridgePort OBJECT-TYPE
    SYNTAX     IEEE8021BridgePortNumber
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
    "This is the Bridge Port of the TESI."
    REFERENCE
        "12.16.5.3.2 b)"
    ::= { ieee8021PbbTeTesiEntry 3 }

ieee8021PbbTeTesiStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this entry. All read-crate
       columns must be writable for rows whose StorageType is permanaent."
    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeTesiEntry 4 }

ieee8021PbbTeTesiRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.

         When the status is active, no columns of this table may be
         modified.  All columns must have a valid value before the row
         can be activated."
    ::= { ieee8021PbbTeTesiEntry 5 }

ieee8021PbbTeTeSiEspTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021PbbTeTeSiEspEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The PBB-TE TE-SID table contains information for each TE
         service instance known to a system."
```

```
    REFERENCE
        "12.16.5.3.2 c)"
    ::= { ieee8021PbbTeObjects 4 }

ieee8021PbbTeTeSiEspEntry OBJECT-TYPE
    SYNTAX     Ieee8021PbbTeTeSiEspEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The PBB-TE TE-SID entry.  Each entry refers to a
         TE Service Instance by identifier and contains information about
         one of the ESPs that comprise this TE Service Instance."
    INDEX { ieee8021PbbTeTesiId,
            ieee8021PbbTeTeSiEspEspIndex }
    ::= { ieee8021PbbTeTeSiEspTable 1 }

Ieee8021PbbTeTeSiEspEntry ::=
    SEQUENCE {
        ieee8021PbbTeTeSiEspEspIndex    Unsigned32,
        ieee8021PbbTeTeSiEspEsp         IEEE8021PbbTeEsp,
        ieee8021PbbTeTeSiEspStorageType StorageType,
        ieee8021PbbTeTeSiEspRowStatus   RowStatus
    }

ieee8021PbbTeTeSiEspEspIndex OBJECT-TYPE
    SYNTAX     Unsigned32 (1..4294967295)
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This is an identifier, of local significance to a particular
         PBB-TE TE-SID that is used to index all of the ESPs associated
         with the TE-SID."
    REFERENCE
        "12.16.5.3.2 c)"
    ::= { ieee8021PbbTeTeSiEspEntry 1 }

ieee8021PbbTeTeSiEspEsp OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeEsp
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the ESP identifier for one of the Ethernet
         Switched Paths that define the TE service instance."
    REFERENCE
        "12.16.5.3.2 c)"
    ::= { ieee8021PbbTeTeSiEspEntry 2 }

ieee8021PbbTeTeSiEspStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this entry. All read-create
        columns must be writable for permanent rows."
    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeTeSiEspEntry 3 }

ieee8021PbbTeTeSiEspRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.

         When the status is active, no columns of this table may be
         modified.  All columns must have a valid value before the row
         can be activated."
    ::= { ieee8021PbbTeTeSiEspEntry 4 }

ieee8021PbbTeProtectionGroupConfigTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021PbbTeProtectionGroupConfigEntry
    MAX-ACCESS not-accessible
```

```
    STATUS     current
    DESCRIPTION

        "The PBB-TE Protection group config table contains
         configuration and status information for each configuration
         group configured in the system.  Entries in this table are
         created implicitly by the creation of entries in the
         ieee8021PbbTeProtectionGroupListTable table."
     REFERENCE
         "12.18.2"
     ::= { ieee8021PbbTeObjects 5 }

ieee8021PbbTeProtectionGroupConfigEntry OBJECT-TYPE
    SYNTAX     Ieee8021PbbTeProtectionGroupConfigEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The protection group configuration table entry.  Rows are
        created in this table implicitly when a row is added to the
        ieee8021PbbTeProtectionGroupListTable."
    INDEX { ieee8021BridgeBaseComponentId,
            ieee8021PbbTeProtectionGroupListGroupId }
    ::= { ieee8021PbbTeProtectionGroupConfigTable 1 }

Ieee8021PbbTeProtectionGroupConfigEntry ::=
    SEQUENCE {
        ieee8021PbbTeProtectionGroupConfigState
         INTEGER,
        ieee8021PbbTeProtectionGroupConfigCommandStatus
             IEEE8021PbbTeProtectionGroupConfigAdmin,
        ieee8021PbbTeProtectionGroupConfigCommandLast
             IEEE8021PbbTeProtectionGroupConfigAdmin,
        ieee8021PbbTeProtectionGroupConfigCommandAdmin
             IEEE8021PbbTeProtectionGroupConfigAdmin,
        ieee8021PbbTeProtectionGroupConfigActiveRequests
             IEEE8021PbbTeProtectionGroupActiveRequests,
        ieee8021PbbTeProtectionGroupConfigWTR
         Unsigned32,
        ieee8021PbbTeProtectionGroupConfigHoldOff
             Unsigned32,
    ieee8021PbbTeProtectionGroupConfigNotifyEnable
             TruthValue,
        ieee8021PbbTeProtectionGroupConfigStorageType
             StorageType
    }

ieee8021PbbTeProtectionGroupConfigState OBJECT-TYPE
    SYNTAX   INTEGER {
               workingPath(1),
               protectionPat(2),
               waitToRestore(3),
               protAdmin(4)
             }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
    "This column indicates the current state of the protection
     switching state machine for a protection group."
    REFERENCE "26.10.3.5 12.18.2.1.3 c)"
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 1 }

ieee8021PbbTeProtectionGroupConfigCommandStatus OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeProtectionGroupConfigAdmin
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates the status of administrative commands
        within the protection group.  It reflects the current
        operational administrative command being acted upon by the
        protection group."
     REFERENCE "12.18.2.1.3 d)"
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 2 }
```

```
ieee8021PbbTeProtectionGroupConfigCommandLast OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeProtectionGroupConfigAdmin
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates the last attempted administrative
    command applied to the protection group.  It is changed
    whenever a write is made to the CommandAdmin column of
    this table and is a record of the last attempted
        administrative operation."
     REFERENCE "12.18.2.1.3 d)"
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 3 }

ieee8021PbbTeProtectionGroupConfigCommandAdmin OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeProtectionGroupConfigAdmin
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This column is used by the operator to request that the
       protection group state machine perform some administrative
       operation.  The operator requests a command by writing the
       command value to this column.  The state machine indicates the
       command that it is performing by setting the value of the
       CommandStatus column of this table.  This column always reads
       back as clear(1)."
     REFERENCE "12.18.2.3.2"
     DEFVAL { clear }
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 4 }

ieee8021PbbTeProtectionGroupConfigActiveRequests OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeProtectionGroupActiveRequests
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
    "This column shows the status of active requests within
    the TE protection group."
    REFERENCE "12.18.2.1.3 d)"
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 5 }

ieee8021PbbTeProtectionGroupConfigWTR OBJECT-TYPE
    SYNTAX     Unsigned32 ( 0 | 5..12 )
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column is used to configure the wait-to-restore timer
        for the protection group operation.  The timer may be
        configured in steps of 1 minute between 5 and 12 minutes, the
        default being 5.  Additionally, the value 0 is used to
        indicate that the protection group is to operate
        non-revertively."
    REFERENCE "26.10.3.3.8 12.18.2.1.3 e)"
    DEFVAL { 5 }
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 6 }

ieee8021PbbTeProtectionGroupConfigHoldOff OBJECT-TYPE
    SYNTAX     Unsigned32( 0..100 )
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This column is used to configure the hold off
        timer.  The purpose is to allow a service layer protection
        mechanism to have a chance to fix the problem before
        switching at the client layer, or to allow an upstream
        protected domain to switch before a downstream domain.  The
        hold off timer has a period of from 0 to 10 seconds, the
        default being 0, with a 100ms granularity."
    REFERENCE "12.18.2.1.3 f)"
    DEFVAL { 0 }
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 7 }

ieee8021PbbTeProtectionGroupConfigNotifyEnable OBJECT-TYPE
```

```
    SYNTAX     TruthValue
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column is used to enable or disable transmission
         of ieee8021PbbTeProtectionGroupAdminFailure
         notifications. These notifications are generated
         whenever an administrative command cannot be performed
         by the protection group."
    DEFVAL { false }
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 8 }

ieee8021PbbTeProtectionGroupConfigStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this entry.  For
       permanent objects the
       ieee8021PbbTeProtectionGroupConfigCommandAdmin column
       must be writable."

    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeProtectionGroupConfigEntry 9 }

ieee8021PbbTeProtectionGroupISidTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021PbbTeProtectionGroupISidEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This table contains entries for each I-SID that is
        transported over TE-SIDs that belong to protection groups.
        Each I-SID maps to a single protection group."
    REFERENCE "12.18.2.1.3 b)"
    ::= { ieee8021PbbTeObjects 6 }

ieee8021PbbTeProtectionGroupISidEntry OBJECT-TYPE
    SYNTAX     Ieee8021PbbTeProtectionGroupISidEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The ieee8021PbbTeProtectionGroupISidTable entry."
    INDEX { ieee8021PbbTeProtectionGroupISidIndex }
    ::= { ieee8021PbbTeProtectionGroupISidTable 1 }

Ieee8021PbbTeProtectionGroupISidEntry ::=
    SEQUENCE {
     ieee8021PbbTeProtectionGroupISidIndex       IEEE8021PbbServiceIdentifier,
     ieee8021PbbTeProtectionGroupISidComponentId IEEE8021PbbComponentIdentifier,
     ieee8021PbbTeProtectionGroupISidGroupId     IEEE8021PbbTeProtectionGroupId,
     ieee8021PbbTeProtectionGroupISidStorageType StorageType,
     ieee8021PbbTeProtectionGroupISidRowStatus   RowStatus
    }

 ieee8021PbbTeProtectionGroupISidIndex OBJECT-TYPE
     SYNTAX     IEEE8021PbbServiceIdentifier
     MAX-ACCESS not-accessible
     STATUS     current
     DESCRIPTION
         "This is the I-Sid that is to be mapped to a protection
          group."
     ::= { ieee8021PbbTeProtectionGroupISidEntry 1 }

ieee8021PbbTeProtectionGroupISidComponentId OBJECT-TYPE
     SYNTAX IEEE8021PbbComponentIdentifier
     MAX-ACCESS read-create
     STATUS     current
     DESCRIPTION
         "This column qualifies the GroupId column to a particular
          component."
     ::= { ieee8021PbbTeProtectionGroupISidEntry 2 }
```

```
ieee8021PbbTeProtectionGroupISidGroupId OBJECT-TYPE
     SYNTAX     IEEE8021PbbTeProtectionGroupId
     MAX-ACCESS read-create
     STATUS     current
     DESCRIPTION
         "This column contains the Id of the protection group used
          to transport the data belonging to the service identified
          by the I-SID value specified in the ISidIndex column of this
          table."
     ::= { ieee8021PbbTeProtectionGroupISidEntry 3 }

ieee8021PbbTeProtectionGroupISidStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this entry."
    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeProtectionGroupISidEntry 4 }

ieee8021PbbTeProtectionGroupISidRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column contains the status for this row.  Once active
         none of the columns in the row may be modified.  All columns
         must be specified when creating the row."
    ::= { ieee8021PbbTeProtectionGroupISidEntry 5 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "A table containing forwarding information for each vlan
         specifying the set of ports to which forwarding of unicast
         addressed frames for which no more specific forwarding information
         applies.  This is configured statically by management."
    REFERENCE "8.8.1"
    ::= { ieee8021PbbTeObjects 7 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry OBJECT-TYPE
    SYNTAX Ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Forwarding information for a VLAN, specifying the
         set of ports to which forwarding of unicast addressed
         frames for which no more specific forwarding information
         applies.

         The EgressPorts and ForbiddenPorts PortList objects, together,
         implement the PortMap control element listed in IEEE Std 802.1Q 8.8.1.c."
    INDEX { ieee8021QBridgeVlanCurrentComponentId,
            ieee8021PbbTeBridgeStaticForwardAnyUnicastVlanIndex }
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastTable 1 }


Ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry ::=
    SEQUENCE  {
          ieee8021PbbTeBridgeStaticForwardAnyUnicastVlanIndex
              IEEE8021VlanIndexOrWildcard,
          ieee8021PbbTeBridgeStaticForwardAnyUnicastEgressPorts
              PortList,
          ieee8021PbbTeBridgeStaticForwardAnyUnicastForbiddenPorts
              PortList,
          ieee8021PbbTeBridgeStaticForwardAnyUnicastStorageType
              StorageType,
          ieee8021PbbTeBridgeStaticForwardAnyUnicastRowStatus
              RowStatus
    }
```

```
ieee8021PbbTeBridgeStaticForwardAnyUnicastVlanIndex OBJECT-TYPE
    SYNTAX IEEE8021VlanIndexOrWildcard
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
       "The VLAN-ID or other identifier referring to the VLAN to
       which this static filtering entry applies."
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry 1 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastEgressPorts OBJECT-TYPE
    SYNTAX PortList
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
       "The complete set of ports to which a unicast addressed frame
        is to be forwarded.  This value is persistent and will be restored
        upon system reboot.  A port may not be added to this set if it
        is already a member of
        ieee8021PbbTeBridgeStaticForwardAnyUnicastForbiddenPorts.  The default
        value is a string of zeros of appropriate length.

        The value of this object MUST be retained across
        reinitialization of the management system."
    REFERENCE "8.8.1 c)"
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry 2 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastForbiddenPorts OBJECT-TYPE
    SYNTAX PortList
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
       "The complete set of ports to which a unicast addressed frame
        is to be filtered.  This value is persistent and will be restored
        upon system reboot.  A port may not be added to this set if it
        is already a member of
        ieee8021PbbTeBridgeStaticForwardAnyUnicastEgress.  The default
        value is a string of zeros of appropriate length.

        The value of this object MUST be retained across
        reinitialization of the management system."
    REFERENCE "8.8.1 c)"
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry 3 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "The storage type for this row.  All read-create columns must be
       writable for permanent entries."
    DEFVAL { nonVolatile }
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry 4 }

ieee8021PbbTeBridgeStaticForwardAnyUnicastRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This column contains the status for this row."
    ::= { ieee8021PbbTeBridgeStaticForwardAnyUnicastEntry 5 }

-- ****************************************************************
-- NOTIFICATIONS (TRAPS)
-- These notifications will be sent to the management entity
-- whenever a ProtectionGroup admin command cannot be performed
-- ****************************************************************

ieee8021PbbTeProtectionGroupAdminFailure NOTIFICATION-TYPE
    OBJECTS {
        ieee8021PbbTeProtectionGroupConfigState,
        ieee8021PbbTeProtectionGroupConfigCommandStatus,
```

```
        ieee8021PbbTeProtectionGroupConfigCommandLast
    }
    STATUS  current
    DESCRIPTION
        "A protection group generates this notification whenever
         an administrative command cannot be executed by the
         protection state machine.  For example, a requested
         manual switch cannot be performed because of a signal
         failure condition.

         The management entity receiving the notification can
         identify the system from the network source address of
         the notification and can identify the protection group
         by the indices of the OID
         of the ieee8021PbbTeProtectionGroupConfigState variable in the
     notification:

                ieee8021BridgeBaseComponentId - Identifies the
                  component on the Bridge where the protection group
                  is configured.

                ieee8021PbbTeProtectionGroupListGroupId - The id
                  of the protection group.
        "
    ::= { ieee8021PbbTeNotifications 1 }

--
-- MIB Module Compliance Statements
--

ieee8021PbbTeCompliances OBJECT IDENTIFIER ::= { ieee8021PbbTeConformance 1 }
ieee8021PbbTeGroups      OBJECT IDENTIFIER ::= { ieee8021PbbTeConformance 2 }

--
-- Units of Conformance

ieee8021PbbTeGroupListGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeProtectionGroupListMD,
        ieee8021PbbTeProtectionGroupListWorkingMA,
        ieee8021PbbTeProtectionGroupListProtectionMA,
    ieee8021PbbTeProtectionGroupListStorageType,
        ieee8021PbbTeProtectionGroupListRowStatus
    }
    STATUS  current
    DESCRIPTION
        "Objects for the GroupList group."
    ::= { ieee8021PbbTeGroups 1 }

ieee8021PbbTeMASharedGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeMASharedGroupId
    }
    STATUS current
    DESCRIPTION
         "Objects for the MA Load Sharing Table Group."
    ::= { ieee8021PbbTeGroups 2 }


ieee8021PbbTeTesiGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeTesiComponent,
    ieee8021PbbTeTesiBridgePort,
        ieee8021PbbTeTesiStorageType,
    ieee8021PbbTeTesiRowStatus
    }
    STATUS current
    DESCRIPTION
         "Objects for the TE SI group "
    ::= { ieee8021PbbTeGroups 3 }

ieee8021PbbTeSiEspGroup OBJECT-GROUP
```

```
    OBJECTS {
        ieee8021PbbTeTeSiEspEsp,
        ieee8021PbbTeTeSiEspStorageType,
        ieee8021PbbTeTeSiEspRowStatus
    }
    STATUS current
    DESCRIPTION
        "Objects for the TESI ESP group."
    ::= { ieee8021PbbTeGroups 4 }

ieee8021PbbTeProtectionConfigManGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeProtectionGroupConfigState,
        ieee8021PbbTeProtectionGroupConfigCommandStatus,
        ieee8021PbbTeProtectionGroupConfigCommandLast,
        ieee8021PbbTeProtectionGroupConfigCommandAdmin,
    ieee8021PbbTeProtectionGroupConfigActiveRequests,
        ieee8021PbbTeProtectionGroupConfigNotifyEnable,
        ieee8021PbbTeProtectionGroupConfigStorageType
    }
    STATUS current
    DESCRIPTION
        "Objects for the PbbTeConfiguration group."
    ::= { ieee8021PbbTeGroups 5 }

ieee8021PbbTeProtectionConfigOptGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeProtectionGroupConfigWTR,
        ieee8021PbbTeProtectionGroupConfigHoldOff
    }
    STATUS current
    DESCRIPTION
        "Objects for the PbbTeConfiguration group."
    ::= { ieee8021PbbTeGroups 6 }

ieee8021PbbTeProtectionGroupISidGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PbbTeProtectionGroupISidComponentId,
        ieee8021PbbTeProtectionGroupISidGroupId,
        ieee8021PbbTeProtectionGroupISidStorageType,
        ieee8021PbbTeProtectionGroupISidRowStatus
    }
    STATUS current
    DESCRIPTION
        "Objects for the ieee8021PbbTeProtectionGroupISidGroup group."
    ::= { ieee8021PbbTeGroups 7 }

ieee8021PbbTeFdbGroup OBJECT-GROUP
    OBJECTS {
       ieee8021PbbTeBridgeStaticForwardAnyUnicastEgressPorts,
       ieee8021PbbTeBridgeStaticForwardAnyUnicastForbiddenPorts,
       ieee8021PbbTeBridgeStaticForwardAnyUnicastStorageType,
       ieee8021PbbTeBridgeStaticForwardAnyUnicastRowStatus
    }
    STATUS current
    DESCRIPTION
        "Fdb extension objects group"
    ::= { ieee8021PbbTeGroups 8 }

ieee8021PbbTeNotificationsGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
       ieee8021PbbTeProtectionGroupAdminFailure
    }
    STATUS    current
    DESCRIPTION
        "Objects for the notifications group."
    ::= { ieee8021PbbTeGroups 9 }

ieee8021PbbTeCompliance MODULE-COMPLIANCE
    STATUS    current
    DESCRIPTION
        "The compliance statement for support of the PBB-TE MIB module."
```

```
    MODULE
        MANDATORY-GROUPS {
            ieee8021PbbTeGroupListGroup,
            ieee8021PbbTeMASharedGroup,
            ieee8021PbbTeTesiGroup,
            ieee8021PbbTeSiEspGroup,
            ieee8021PbbTeProtectionConfigManGroup,
            ieee8021PbbTeProtectionGroupISidGroup,
            ieee8021PbbTeFdbGroup,
            ieee8021PbbTeNotificationsGroup
        }
        GROUP ieee8021PbbTeProtectionConfigOptGroup
        DESCRIPTION
           "This group allows implementation to optionally change the
            WaitToRestore and HoldOff timers for protection groups."

    OBJECT ieee8021PbbTeProtectionGroupConfigWTR
    MIN-ACCESS not-accessible
    DESCRIPTION "This object is optional."

    OBJECT ieee8021PbbTeProtectionGroupConfigHoldOff
    MIN-ACCESS not-accessible
    DESCRIPTION"This object is optional."

    OBJECT ieee8021PbbTeProtectionGroupListRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021PbbTeTeSiEspRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021PbbTeProtectionGroupISidRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { ieee8021PbbTeCompliances 1 }

END
```

17.7.11 Definitions for the IEEE8021-TPMR-MIB module

```
IEEE8021-TPMR-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q TPMR Devices
-- ============================================================

IMPORTS
   MODULE-IDENTITY, OBJECT-TYPE, Counter32, Counter64,
   Unsigned32
      FROM SNMPv2-SMI
   TEXTUAL-CONVENTION, TruthValue, MacAddress, TimeInterval,
   StorageType
      FROM SNMPv2-TC
   MODULE-COMPLIANCE, OBJECT-GROUP
      FROM SNMPv2-CONF
   ifCounterDiscontinuityGroup
      FROM IF-MIB
   IEEE8021BridgePortNumber, ieee802dot1mibs
      FROM IEEE8021-TC-MIB
   ieee8021BridgeBasePortComponentId
      FROM IEEE8021-BRIDGE-MIB;

ieee8021TpmrMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
      "Two-Port MAC Relay (TPMR) MIB module.

       Unless otherwise indicated, the references in this MIB
       module are to IEEE Std 802.1Q-2022.

       Copyright (C) IEEE (2022).
       This version of this MIB module is part of IEEE Std 802.1Q;
       see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

   REVISION     "200909040000Z" -- September 4, 2009
   DESCRIPTION
      "Initial version as published in IEEE Std 802.1aj"
```

```
   ::= { ieee802dot1mibs 14 }

ieee8021TpmrNotifications OBJECT IDENTIFIER ::= { ieee8021TpmrMib 0 }
ieee8021TpmrObjects       OBJECT IDENTIFIER ::= { ieee8021TpmrMib 1 }
ieee8021TpmrConformance   OBJECT IDENTIFIER ::= { ieee8021TpmrMib 2 }

-- ------------------------------------------------------------
-- Textual conventions
-- ------------------------------------------------------------

IEEE8021TpmrFrameDiscardErrorReason  ::= TEXTUAL-CONVENTION
   STATUS current
   DESCRIPTION
      "A reason code for a frame discard error."
   REFERENCE
      "12.19.3.1.1.3:h"
   SYNTAX INTEGER {
      txSduSizeExceeded (1)  -- transmissible SDU size exceeded
   }

-- ------------------------------------------------------------
-- ieee8021TpmrPort objects
-- ------------------------------------------------------------

ieee8021TpmrPortTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Ieee8021TpmrPortEntry
   MAX-ACCESS         not-accessible
   STATUS             current
   DESCRIPTION
      "The TPMR port table.  Each row in the table represents a
       TPMR port.  By definition there are two ports per TPMR.

       Note that the indices of this table are equivalent to
       those of the ieee8021BridgeBasePortTable in the
       IEEE8021-BRIDGE-MIB, with ieee8021TpmrPortNumber having
       a more limited value range than ieee8021BridgeBasePort."
   REFERENCE
      "12.19.1.2.1, 12.19.1.2.2"
   ::= { ieee8021TpmrObjects 1 }

ieee8021TpmrPortEntry OBJECT-TYPE
   SYNTAX      Ieee8021TpmrPortEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
      "A TPMR port table entry."
   INDEX { ieee8021BridgeBasePortComponentId,
           ieee8021TpmrPortNumber }
   ::= { ieee8021TpmrPortTable 1 }

Ieee8021TpmrPortEntry ::= SEQUENCE {
   ieee8021TpmrPortNumber             IEEE8021BridgePortNumber,
   ieee8021TpmrPortMgmtAddr           TruthValue,
   ieee8021TpmrPortMgmtAddrForwarding TruthValue
   }

ieee8021TpmrPortNumber OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumber (1..2)
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
      "The number of this TPMR port."
   REFERENCE
      "12.19.1.1.1.3:b,1"
   ::= { ieee8021TpmrPortEntry 1 }

ieee8021TpmrPortMgmtAddr OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Is 'true' if the TPMR port MAC address is the management
```

```
        address of the TPMR, otherwise 'false'."
    REFERENCE
       "12.19.1.1.1.3:b,3"
    ::= { ieee8021TpmrPortEntry 2 }

ieee8021TpmrPortMgmtAddrForwarding OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Is 'true' if forwarding is enabled for frames destined to the
        management address of the TPMR, otherwise 'false'."
    REFERENCE
       "12.19.1.2.1.3:c"
    ::= { ieee8021TpmrPortEntry 3 }

-- ------------------------------------------------------------
-- ieee8021TpmrPortStats objects
-- ------------------------------------------------------------

ieee8021TpmrPortStatsTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021TpmrPortStatsEntry
    MAX-ACCESS         not-accessible
    STATUS             current
    DESCRIPTION
       "The TPMR port statistics table.  Each row in the table
        represents a TPMR port.  By definition there are two
        ports per TPMR.

        Discontinuities in the value of counters in this table
        can occur at re-initialization of the management system,
        and at other times as indicated by the value of IF-MIB
        ifCounterDiscontinuityTime."
    REFERENCE
       "12.19.3.1"
    ::= { ieee8021TpmrObjects 2 }

ieee8021TpmrPortStatsEntry OBJECT-TYPE
    SYNTAX      Ieee8021TpmrPortStatsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A TPMR port counters table entry."
    AUGMENTS { ieee8021TpmrPortEntry }
    ::= { ieee8021TpmrPortStatsTable 1 }

Ieee8021TpmrPortStatsEntry ::= SEQUENCE {
    ieee8021TpmrPortStatsRxFrames                Counter64,
    ieee8021TpmrPortStatsRxOctets                Counter64,
    ieee8021TpmrPortStatsFramesForwarded         Counter64,
    ieee8021TpmrPortStatsFramesDiscarded         Counter64,
    ieee8021TpmrPortStatsFramesDiscardedQueueFull Counter64,
    ieee8021TpmrPortStatsFramesDiscardedLifetime  Counter64,
    ieee8021TpmrPortStatsFramesDiscardedError     Counter64
    }

ieee8021TpmrPortStatsRxFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "Count of all valid frames received on this port (including
        BPDUs, frames addressed to the TPMR as an end station, and
        frames that were submitted to the Forwarding Process)."
    REFERENCE
       "12.19.3.1.1.3:a"
    ::= { ieee8021TpmrPortStatsEntry 1 }

ieee8021TpmrPortStatsRxOctets OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "octets"
```

```
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of the total number of octets in all valid frames
       received on this port (including BPDUs, frames addressed
       to the TPMR as an end station, and frames that were
       submitted to the Forwarding Process)."
   REFERENCE
      "12.19.3.1.1.3:b"
   ::= { ieee8021TpmrPortStatsEntry 2 }

ieee8021TpmrPortStatsFramesForwarded OBJECT-TYPE
   SYNTAX      Counter64
   UNITS       "frames"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of all frames that were received on this port and
      were forwarded to the transmission port."
   REFERENCE
      "12.19.3.1.1.3:d"
   ::= { ieee8021TpmrPortStatsEntry 3 }

ieee8021TpmrPortStatsFramesDiscarded OBJECT-TYPE
   SYNTAX      Counter64
   UNITS       "frames"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of all frames that were received on this port but
       were discarded by the Forwarding Process for any reason."
   REFERENCE
      "12.19.3.1.1.3:c"
   ::= { ieee8021TpmrPortStatsEntry 4 }

ieee8021TpmrPortStatsFramesDiscardedQueueFull OBJECT-TYPE
   SYNTAX      Counter64
   UNITS       "frames"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of all frames received on this port that were to
       be transmitted through the transmission port but were
       discarded due to lack of available queue space."
   REFERENCE
      "12.19.3.1.1.3:e"
   ::= { ieee8021TpmrPortStatsEntry 5 }

ieee8021TpmrPortStatsFramesDiscardedLifetime OBJECT-TYPE
   SYNTAX      Counter64
   UNITS       "frames"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of all frames received on this port that were to
       be transmitted through the transmission port but were
       discarded due to their frame lifetime having been
       exceeded."
   REFERENCE
      "12.19.3.1.1.3:f"
   ::= { ieee8021TpmrPortStatsEntry 6 }

ieee8021TpmrPortStatsFramesDiscardedError OBJECT-TYPE
   SYNTAX      Counter64
   UNITS       "frames"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "Count of all frames received on this port that were to
       be transmitted through the transmission port but could
       not be transmitted (e.g., frame too large)."
   REFERENCE
```

```
      "12.19.3.1.1.3:g"
   ::= { ieee8021TpmrPortStatsEntry 7 }

-- ----------------------------------------------------------
-- ieee8021TpmrPortDiscardDetails objects
-- ----------------------------------------------------------

ieee8021TpmrPortDiscardDetailsTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Ieee8021TpmrPortDiscardDetailsEntry
   MAX-ACCESS         not-accessible
   STATUS             current
   DESCRIPTION
      "The TPMR frames discard details table.  Each row in
       the table represents a discarded frame on a TPMR port.
       By definition there are two ports per TPMR.

       This table is maintained as a FIFO.  A new entry is
       inserted in the first row, and existing entries are
       shuffled down, with the last entry being discarded.

       Because of the FIFO behavior, the relationship between
       the index and contents will change when an entry is
       added to the table.  This may result in apparent
       duplication of row content during a table traversal."
   REFERENCE
      "12.19.3.1.1.3:h"
   ::= { ieee8021TpmrObjects 3 }

ieee8021TpmrPortDiscardDetailsEntry OBJECT-TYPE
   SYNTAX      Ieee8021TpmrPortDiscardDetailsEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
      "A TPMR frames discarded error details table entry."
   INDEX { ieee8021BridgeBasePortComponentId,
           ieee8021TpmrPortNumber,
           ieee8021TpmrPortDiscardDetailsIndex }
   ::= { ieee8021TpmrPortDiscardDetailsTable 1 }

Ieee8021TpmrPortDiscardDetailsEntry ::= SEQUENCE {
   ieee8021TpmrPortDiscardDetailsIndex  Unsigned32,
   ieee8021TpmrPortDiscardDetailsSource MacAddress,
   ieee8021TpmrPortDiscardDetailsReason IEEE8021TpmrFrameDiscardErrorReason
   }

ieee8021TpmrPortDiscardDetailsIndex OBJECT-TYPE
   SYNTAX      Unsigned32 (1..16)
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
      "The second index of a TPMR frames discard details
       table entry."
   ::= { ieee8021TpmrPortDiscardDetailsEntry 1 }

ieee8021TpmrPortDiscardDetailsSource OBJECT-TYPE
   SYNTAX      MacAddress
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The source MAC address of the discarded frame."
   REFERENCE
      "12.19.3.1.1.3:h"
   ::= { ieee8021TpmrPortDiscardDetailsEntry 2 }

ieee8021TpmrPortDiscardDetailsReason OBJECT-TYPE
   SYNTAX      IEEE8021TpmrFrameDiscardErrorReason
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The reason why the frame was discarded."
   REFERENCE
      "12.19.3.1.1.3:h"
```

```
   ::= { ieee8021TpmrPortDiscardDetailsEntry 3 }

-- ------------------------------------------------------------
-- ieee8021TpmrMsp objects
-- ------------------------------------------------------------

ieee8021TpmrMspTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Ieee8021TpmrMspEntry
   MAX-ACCESS         not-accessible
   STATUS             current
   DESCRIPTION
      "The TPMR MAC status propagation performance table.  Each
       row in the table represents a TPMR port.  By definition
       there are two ports per TPMR.

       The persistence of writable objects in a conceptual row
       of this table is determined by the value of the
       ieee8021TpmrMspStorageType object."
   REFERENCE
      "12.19.4.1.1, 12.19.4.1.2"
   ::= { ieee8021TpmrObjects 4 }

ieee8021TpmrMspEntry OBJECT-TYPE
   SYNTAX      Ieee8021TpmrMspEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
      "A TPMR MAC status propagation performance table entry."
   AUGMENTS { ieee8021TpmrPortEntry }
   ::= { ieee8021TpmrMspTable 1 }

Ieee8021TpmrMspEntry ::= SEQUENCE {
   ieee8021TpmrMspLinkNotify      TruthValue,
   ieee8021TpmrMspLinkNotifyWait  TimeInterval,
   ieee8021TpmrMspLinkNotifyRetry TimeInterval,
   ieee8021TpmrMspMacNotify       TruthValue,
   ieee8021TpmrMspMacNotifyTime   TimeInterval,
   ieee8021TpmrMspMacRecoverTime  TimeInterval,
   ieee8021TpmrMspStorageType     StorageType
   }

ieee8021TpmrMspLinkNotify OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of LinkNotify used by the MSP state machines."
   REFERENCE
      "12.19.4.1.1.3:a, 12.19.4.1.2.2:b"
   DEFVAL { true }
   ::= { ieee8021TpmrMspEntry 1 }

ieee8021TpmrMspLinkNotifyWait OBJECT-TYPE
   SYNTAX      TimeInterval (20..100)
   UNITS       "centiseconds"
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of LinkNotifyWait used by the MSP state machines."
   REFERENCE
      "12.19.4.1.1.3:b, 12.19.4.1.2.2:c"
   DEFVAL { 40 }
   ::= { ieee8021TpmrMspEntry 2 }

ieee8021TpmrMspLinkNotifyRetry OBJECT-TYPE
   SYNTAX      TimeInterval (10..100)
   UNITS       "centiseconds"
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of LinkNotifyRetry used by the MSP state machines."
   REFERENCE
```

```
      "12.19.4.1.1.3:c, 12.19.4.1.2.2:d"
   DEFVAL { 100 }
   ::= { ieee8021TpmrMspEntry 3 }

ieee8021TpmrMspMacNotify OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of MacNotify used by the MSP state machines."
   REFERENCE
      "12.19.4.1.1.3:d, 12.19.4.1.2.2:e"
   DEFVAL { true }
   ::= { ieee8021TpmrMspEntry 4 }

ieee8021TpmrMspMacNotifyTime OBJECT-TYPE
   SYNTAX      TimeInterval (1..50)
   UNITS       "centiseconds"
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of MacNotifyTime used by the MSP state machines."
   REFERENCE
      "12.19.4.1.1.3:e, 12.19.4.1.2.2:f"
   DEFVAL { 20 }
   ::= { ieee8021TpmrMspEntry 5 }

ieee8021TpmrMspMacRecoverTime OBJECT-TYPE
   SYNTAX      TimeInterval (2..50)
   UNITS       "centiseconds"
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION
      "The value of MacRecoverTime used by the MSP state machines."
   REFERENCE
      "12.19.4.1.1.3:f, 12.19.4.1.2.2:g"
   DEFVAL { 10 }
   ::= { ieee8021TpmrMspEntry 6 }

ieee8021TpmrMspStorageType OBJECT-TYPE
    SYNTAX      StorageType
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The storage type for all read-write objects within this
         row.  Conceptual rows having the value 'permanent' need
         not allow write access to any columnar objects in the row.

         If this object has the value 'volatile', modifications
         to read-write objects in this row are not persistent
         across reboots or restarts.  If this object has the value
         'nonVolatile', modifications to objects in this row
         are persistent."
    DEFVAL { nonVolatile }
    ::= { ieee8021TpmrMspEntry 7 }

-- ----------------------------------------------------------
-- ieee8021TpmrMspStats objects
-- ----------------------------------------------------------

ieee8021TpmrMspStatsTable OBJECT-TYPE
   SYNTAX SEQUENCE OF Ieee8021TpmrMspStatsEntry
   MAX-ACCESS         not-accessible
   STATUS             current
   DESCRIPTION
      "The TPMR MAC status propagation statistics table.  Each
       row in the table represents a TPMR port.  By definition
       there are two ports per TPMR.

       Discontinuities in the value of counters in this table
       can occur at re-initialization of the management system,
       and at other times as indicated by the value of IF-MIB
```

```
        ifCounterDiscontinuityTime."
    REFERENCE
       "12.19.4.1.3"
    ::= { ieee8021TpmrObjects 5 }

ieee8021TpmrMspStatsEntry OBJECT-TYPE
    SYNTAX      Ieee8021TpmrMspStatsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A TPMR MAC status propagation statistics table entry."
    AUGMENTS { ieee8021TpmrPortEntry }
    ::= { ieee8021TpmrMspStatsTable 1 }

Ieee8021TpmrMspStatsEntry ::= SEQUENCE {
    ieee8021TpmrMspStatsTxAcks                Counter32,
    ieee8021TpmrMspStatsTxAddNotifications    Counter32,
    ieee8021TpmrMspStatsTxAddConfirmations    Counter32,
    ieee8021TpmrMspStatsTxLossNotifications   Counter32,
    ieee8021TpmrMspStatsTxLossConfirmations   Counter32,
    ieee8021TpmrMspStatsRxAcks                Counter32,
    ieee8021TpmrMspStatsRxAddNotifications    Counter32,
    ieee8021TpmrMspStatsRxAddConfirmations    Counter32,
    ieee8021TpmrMspStatsRxLossNotifications   Counter32,
    ieee8021TpmrMspStatsRxLossConfirmations   Counter32,
    ieee8021TpmrMspStatsAddEvents             Counter32,
    ieee8021TpmrMspStatsLossEvents            Counter32,
    ieee8021TpmrMspStatsMacStatusNotifications Counter32
    }

ieee8021TpmrMspStatsTxAcks OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "MSPDUs"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of acks transmitted by the port's Transmit
       Process as a consequence of txAck being set."
    REFERENCE
       "12.19.4.1.3.3:a"
    ::= { ieee8021TpmrMspStatsEntry 1 }

ieee8021TpmrMspStatsTxAddNotifications OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "MSPDUs"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of adds transmitted by the port's Transmit
        Process as a consequence of txAdd being set."
    REFERENCE
       "12.19.4.1.3.3:b"
    ::= { ieee8021TpmrMspStatsEntry 2 }

ieee8021TpmrMspStatsTxAddConfirmations OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "MSPDUs"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of add confirms transmitted by the port's
        Transmit Process as a consequence of txAddConfirm
        being set."
    REFERENCE
       "12.19.4.1.3.3:c"
    ::= { ieee8021TpmrMspStatsEntry 3 }

ieee8021TpmrMspStatsTxLossNotifications OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "MSPDUs"
    MAX-ACCESS  read-only
    STATUS      current
```

```
   DESCRIPTION
      "The number of losses transmitted by the port's Transmit
       Process as a consequence of txLoss being set."
   REFERENCE
      "12.19.4.1.3.3:d"
   ::= { ieee8021TpmrMspStatsEntry 4 }

ieee8021TpmrMspStatsTxLossConfirmations OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of loss confirms transmitted by the port's
       Transmit Process as a consequence of txLossConfirm
       being set."
   REFERENCE
      "12.19.4.1.3.3:e"
   ::= { ieee8021TpmrMspStatsEntry 5 }

ieee8021TpmrMspStatsRxAcks OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of acks received by the port's Receive
      Process."
   REFERENCE
      "12.19.4.1.3.3:f"
   ::= { ieee8021TpmrMspStatsEntry 6 }

ieee8021TpmrMspStatsRxAddNotifications OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of adds received by the port's Receive
       Process."
   REFERENCE
      "12.19.4.1.3.3:g"
   ::= { ieee8021TpmrMspStatsEntry 7 }

ieee8021TpmrMspStatsRxAddConfirmations OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of add confirms received by the port's
       Receive Process."
   REFERENCE
      "12.19.4.1.3.3:h"
   ::= { ieee8021TpmrMspStatsEntry 8 }

ieee8021TpmrMspStatsRxLossNotifications OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of losses received by the port's Receive
       Process."
   REFERENCE
      "12.19.4.1.3.3:i"
   ::= { ieee8021TpmrMspStatsEntry 9 }

ieee8021TpmrMspStatsRxLossConfirmations OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSPDUs"
   MAX-ACCESS  read-only
```

```
   STATUS      current
   DESCRIPTION
      "The number of loss confirms received by the port's
       Receive Process."
   REFERENCE
      "12.19.4.1.3.3:j"
   ::= { ieee8021TpmrMspStatsEntry 10 }

ieee8021TpmrMspStatsAddEvents OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSP transitions"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of transitions to STM:ADD directly from
       STM:DOWN or STM:LOSS."
   REFERENCE
      "12.19.4.1.3.3:k"
   ::= { ieee8021TpmrMspStatsEntry 11 }

ieee8021TpmrMspStatsLossEvents OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSP transitions"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of transitions to STM:LOSS directly from
       STM:UP or STM:ADD."
   REFERENCE
      "12.19.4.1.3.3:l"
   ::= { ieee8021TpmrMspStatsEntry 12 }

ieee8021TpmrMspStatsMacStatusNotifications OBJECT-TYPE
   SYNTAX      Counter32
   UNITS       "MSP transitions"
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
      "The number of transitions to SNM:MAC_NOTIFICATION."
   REFERENCE
      "12.19.4.1.3.3:m"
   ::= { ieee8021TpmrMspStatsEntry 13 }

-- ----------------------------------------------------------
-- IEEE 802.1aj MIB - Conformance Information
-- ----------------------------------------------------------

ieee8021TpmrCompliances OBJECT IDENTIFIER ::= { ieee8021TpmrConformance 1 }
ieee8021TpmrGroups      OBJECT IDENTIFIER ::= { ieee8021TpmrConformance 2 }

-- ----------------------------------------------------------
-- Units of conformance
-- ----------------------------------------------------------

ieee8021TpmrPortGroup OBJECT-GROUP
   OBJECTS {
      ieee8021TpmrPortMgmtAddr,
      ieee8021TpmrPortMgmtAddrForwarding
      }
   STATUS current
   DESCRIPTION
      "TPMR port objects."
   ::= { ieee8021TpmrGroups 1 }

ieee8021TpmrPortStatsGroup OBJECT-GROUP
   OBJECTS {
      ieee8021TpmrPortStatsRxFrames,
      ieee8021TpmrPortStatsRxOctets,
      ieee8021TpmrPortStatsFramesForwarded,
      ieee8021TpmrPortStatsFramesDiscarded,
      ieee8021TpmrPortStatsFramesDiscardedQueueFull,
      ieee8021TpmrPortStatsFramesDiscardedLifetime,
```

```
      ieee8021TpmrPortStatsFramesDiscardedError
      }
   STATUS current
   DESCRIPTION
      "TPMR port statistics objects."
   ::= { ieee8021TpmrGroups 2 }

ieee8021TpmrPortDiscardDetailsGroup OBJECT-GROUP
   OBJECTS {
      ieee8021TpmrPortDiscardDetailsSource,
      ieee8021TpmrPortDiscardDetailsReason
      }
   STATUS current
   DESCRIPTION
      "TPMR port discard details objects."
   ::= { ieee8021TpmrGroups 3 }

ieee8021TpmrMspGroup OBJECT-GROUP
   OBJECTS {
      ieee8021TpmrMspLinkNotify,
      ieee8021TpmrMspLinkNotifyWait,
      ieee8021TpmrMspLinkNotifyRetry,
      ieee8021TpmrMspMacNotify,
      ieee8021TpmrMspMacNotifyTime,
      ieee8021TpmrMspMacRecoverTime,
      ieee8021TpmrMspStorageType
      }
   STATUS current
   DESCRIPTION
      "TPMR port MSP objects."
   ::= { ieee8021TpmrGroups 4 }

ieee8021TpmrMspStatsGroup OBJECT-GROUP
   OBJECTS {
      ieee8021TpmrMspStatsTxAcks,
      ieee8021TpmrMspStatsTxAddNotifications,
      ieee8021TpmrMspStatsTxAddConfirmations,
      ieee8021TpmrMspStatsTxLossNotifications,
      ieee8021TpmrMspStatsTxLossConfirmations,
      ieee8021TpmrMspStatsRxAcks,
      ieee8021TpmrMspStatsRxAddNotifications,
      ieee8021TpmrMspStatsRxAddConfirmations,
      ieee8021TpmrMspStatsRxLossNotifications,
      ieee8021TpmrMspStatsRxLossConfirmations,
      ieee8021TpmrMspStatsAddEvents,
      ieee8021TpmrMspStatsLossEvents,
      ieee8021TpmrMspStatsMacStatusNotifications
      }
   STATUS current
   DESCRIPTION
      "TPMR port MSP statistics objects."
   ::= { ieee8021TpmrGroups 5 }

-- ----------------------------------------------------------
-- Compliance statements
-- ----------------------------------------------------------

ieee8021TpmrCompliance MODULE-COMPLIANCE
   STATUS current
   DESCRIPTION
      "The compliance statement for device support of TPMR."
   MODULE IF-MIB
      MANDATORY-GROUPS {
         ifCounterDiscontinuityGroup
         }
   MODULE
      MANDATORY-GROUPS {
         ieee8021TpmrPortGroup,
         ieee8021TpmrPortStatsGroup,
         ieee8021TpmrPortDiscardDetailsGroup,
         ieee8021TpmrMspGroup,
         ieee8021TpmrMspStatsGroup
```

```
        }
    ::= { ieee8021TpmrCompliances 1 }

END
```

17.7.12 Definitions for the IEEE8021-FQTSS-MIB module

```
IEEE8021-FQTSS-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for support of the Forwarding & Queuing Enhancements
-- for Time-Sensitive Streams (FQTSS) in IEEE 802.1Q Bridges.
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32
        FROM SNMPv2-SMI
    TEXTUAL-CONVENTION,
    TruthValue,
    RowStatus
        FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee802dot1mibs,
    IEEE8021PriorityValue
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId,
    ieee8021BridgeBaseEntry,
    ieee8021BridgeBasePort,
    ieee8021BridgeBasePortEntry
        FROM IEEE8021-BRIDGE-MIB
    BridgeId
        FROM BRIDGE-MIB
    ;

ieee8021FqtssMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        the Forwarding and Queuing Enhancements
        for Time-Sensitive Streams.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201810040000Z" -- October 4, 2018
    DESCRIPTION
            "Published as part of IEEE 802.1Qcc-2018.
                      Added managed objects for Stream Reservation
                      Protocol (SRP) Enhancements and Performance
                      Improvements"

    REVISION "201806280000Z" -- June 28, 2018
```

```
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018.
            Cross references corrected and updated. "

    REVISION "201512020000Z" -- December 2, 2015
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 Cor-1.
            ETS code point added to the textual convention
            IEEE8021FqtssTxSelectionAlgorithmIDValue "

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of IEEE Std 802.1Q."

    REVISION     "200910010000Z" -- October 1, 2009
    DESCRIPTION
         "Initial revision, included in IEEE 802.1Qav."
    ::= { ieee802dot1mibs 16 }

-- ================================================================
-- Textual Conventions
-- ================================================================

IEEE8021FqtssTrafficClassValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "An 802.1 FQTSS traffic class value.
        This is the numerical value associated with a traffic
        class in a Bridge. Larger values are associated with
        higher priority traffic classes."
    REFERENCE   "12.20.1"
    SYNTAX      Unsigned32 (0..7)

IEEE8021FqtssDeltaBandwidthValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "An 802.1 FQTSS delta bandwidth percentage,
        represented as a fixed point number scaled by
        1 000 000."
    REFERENCE   "12.20.1, 34.4"
    SYNTAX      Unsigned32 (0..100000000)

IEEE8021FqtssTxSelectionAlgorithmIDValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "An 802.1 transmission selection algorithm identifier
         value. This is an integer, with the following
         interpretation placed on the value:

         0: Strict priority algorithm,
         1: Credit-based shaper algorithm,
         2: Enhanced Transmission Selection algorithm,
         3-255: Reserved for future standardization,
         256-4294967295: Vendor-specific transmission selection
                         algorithm identifiers, consisting of a
                         four-octet integer, where the most
                         significant 3 octets hold an OUI or CID value,
                         and the least significant octet holds
                         an integer value in the range 0-255
                         assigned by the owner of the OUI or CID."
    REFERENCE   "8.6.4, 12.20.2"
    SYNTAX  Unsigned32
```

```
-- ============================================================
-- subtrees in the FQTSS MIB
-- ============================================================

ieee8021FqtssNotifications
    OBJECT IDENTIFIER ::= { ieee8021FqtssMib 0 }

ieee8021FqtssObjects
    OBJECT IDENTIFIER ::= { ieee8021FqtssMib 1 }

ieee8021FqtssConformance
    OBJECT IDENTIFIER ::= { ieee8021FqtssMib 2 }

ieee8021FqtssBap
    OBJECT IDENTIFIER ::= { ieee8021FqtssObjects 1 }

ieee8021FqtssMappings
    OBJECT IDENTIFIER ::= { ieee8021FqtssObjects 2 }

ieee8021FqtssBapX
    OBJECT IDENTIFIER ::= { ieee8021FqtssObjects 3 }

-- ============================================================
-- The ieee8021FqtssBap subtree
-- This subtree defines the objects necessary for the management
-- of bandwidth allocation for queues that support FQTSS.
-- ============================================================

-- ============================================================
-- the ieee8021FqtssBapTable
-- ============================================================

ieee8021FqtssBapTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021FqtssBapEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of bandwidth availability
        parameters for each traffic class that supports the
        credit-based shaper algorithm.
        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "12.20.1"
    ::= { ieee8021FqtssBap 1 }

ieee8021FqtssBapEntry OBJECT-TYPE
    SYNTAX      Ieee8021FqtssBapEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing bandwidth allocation
        information for each traffic class that supports the
        credit-based shaper algorithm. Rows in the table are
        automatically created and deleted as a result of the
        operation of the algorithm described in 34.5. "
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021FqtssBAPTrafficClass  }
    ::= { ieee8021FqtssBapTable 1 }

Ieee8021FqtssBapEntry ::=
    SEQUENCE {
        ieee8021FqtssBAPTrafficClass
            IEEE8021FqtssTrafficClassValue,
        ieee8021FqtssDeltaBandwidth
            IEEE8021FqtssDeltaBandwidthValue,
        ieee8021FqtssOperIdleSlopeMs
            Unsigned32,
        ieee8021FqtssOperIdleSlopeLs
            Unsigned32,
        ieee8021FqtssAdminIdleSlopeMs
            Unsigned32,
```

```
        ieee8021FqtssAdminIdleSlopeLs
            Unsigned32,
        ieee8021FqtssBapRowStatus
            RowStatus
        }

ieee8021FqtssBAPTrafficClass OBJECT-TYPE
    SYNTAX      IEEE8021FqtssTrafficClassValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The traffic class number associated with the row of
        the table.

        A row in this table is created for each traffic class
        that supports the credit-based shaper algorithm. The
        recommended mappings of priorities to traffic classes
        for support of the credit-based shaper algorithm are
        described in 34.5."
    REFERENCE   "12.20.2, 34.3, 34.5"
    ::= { ieee8021FqtssBapEntry 1 }


ieee8021FqtssDeltaBandwidth OBJECT-TYPE
    SYNTAX      IEEE8021FqtssDeltaBandwidthValue
    UNITS       "percent"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value of the deltaBandwidth parameter
        for the traffic class.
        This value is represented as a fixed point number
        scaled by a factor of 1 000 000; i.e., 100 000 000
        (the maximum value) represents 100%.

        The default value of the deltaBandwidth parameter
        for the highest numbered traffic class that supports
        the credit-based shaper algorithm is 75%; for all
        lower numbered traffic classes that support the
        credit-based shaper algorithm the default value is 0%.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3"
    ::= { ieee8021FqtssBapEntry 2}

ieee8021FqtssOperIdleSlopeMs OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "bits per second"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The most significant 32 bits of the bandwidth,
        in bits per second, that is currently allocated to the
        traffic class (idleSlope(N)). This object MUST be read
        at the same time as ieee8021FqtssOperIdleSlopeLs,
        which represents the LS 32 bits of the value, in order
        for the read operation to succeed.

        If SRP is supported and in operation, then the reserved
        bandwidth is determined by the operation of SRP; otherwise,
        the value of ieee8021FqtssOperIdleSlopeMs is equal to
        the value of ieee8021FqtssAdminIdleSlopeMs.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3"
    ::= { ieee8021FqtssBapEntry 3 }

ieee8021FqtssOperIdleSlopeLs OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "bits per second"
```

```
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The least significant 32 bits of the bandwidth,
        in bits per second, that is currently allocated to the
        traffic class (idleSlope(N)). This object MUST be read
        at the same time as ieee8021FqtssOperIdleSlopeMs,
        which represents the LS 32 bits of the value, in order
        for the read operation to succeed.

        If SRP is supported and in operation, then the reserved
        bandwidth is determined by the operation of SRP; otherwise,
        the value of ieee8021FqtssOperIdleSlopeLs is equal to
        the value of ieee8021FqtssAdminIdleSlopeMs.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3"
    ::= { ieee8021FqtssBapEntry 4 }

ieee8021FqtssAdminIdleSlopeMs OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "bits per second"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The most significant 32 bits of the bandwidth,
        in bits per second, that the manager desires to allocate
        to the traffic class as  idleSlope(N). This object MUST be
        read or written at the same time as
        ieee8021FqtssAdminIdleSlopeLs,
        which represents the LS 32 bits of the value, in order
        for the read or write operation to succeed.

        If SRP is supported and in operation, then the reserved
        bandwidth is determined by the operation of SRP, and any
        changes to the value of this object have no effect on the
        operational value of idleSlope(N).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3"
    DEFVAL { 0 }
    ::= { ieee8021FqtssBapEntry 5 }

ieee8021FqtssAdminIdleSlopeLs OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "bits per second"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The least significant 32 bits of the bandwidth,
        in bits per second, that the manager desires to allocate
        to the traffic class as  idleSlope(N). This object MUST be
        read or written at the same time as
        ieee8021FqtssAdminIdleSlopeMs,
        which represents the LS 32 bits of the value, in order
        for the read or write operation to succeed.

        If SRP is supported and in operation, then the reserved
        bandwidth is determined by the operation of SRP, and any
        changes to the value of this object have no effect on the
        operational value of idleSlope(N).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3"
    DEFVAL { 0 }
    ::= { ieee8021FqtssBapEntry 6 }

ieee8021FqtssBapRowStatus OBJECT-TYPE
    SYNTAX RowStatus
```

```
    MAX-ACCESS read-create
    STATUS current
    DESCRIPTION
        "Indicates the status of an entry (row) in this table, and is
        used to create/delete entries.

        The corresponding instances of the following objects
        must be set before this object can be made active(1):
           ieee8021FqtssBAPTrafficClass
           ieee8021FqtssDeltaBandwidth
           ieee8021FqtssOperIdleSlopeMs
           ieee8021FqtssOperIdleSlopeLs
           ieee8021FqtssAdminIdleSlopeMs
           ieee8021FqtssAdminIdleSlopeLs

        The corresponding instances of the following objects
        may not be changed while this object is active(1):
           ieee8021FqtssBAPTrafficClass"
::= { ieee8021FqtssBapEntry 7 }

-- ============================================================
-- The ieee8021FqtssMappings subtree
-- This subtree defines the objects necessary for the assignment
-- of transmission selection algorithms to traffic classes,
-- and definition of regeneration table override values.
-- ============================================================

-- ============================================================
-- the ieee8021FqtssTxSelectionAlgorithmTable
-- ============================================================

ieee8021FqtssTxSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021FqtssTxSelectionAlgorithmEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing the assignment of transmission
        selection algorithms to traffic classes for the Port.
        This table provides management of the Transmission
        Selection Algorithm Table defined in 8.6.8.

        For a given Port, a row in the table exists for each
        traffic class that is supported by the Port.

        The default assignments of transmission selection
        algorithms to traffic classes in the table are made
        on instantiation of the table, in accordance
        with the defaults defined in 8.6.8 and 34.5.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.8, 12.20.2, 34.5"
    ::= { ieee8021FqtssMappings 1 }

ieee8021FqtssTxSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX      Ieee8021FqtssTxSelectionAlgorithmEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contain the mapping of a
        traffic class value to a transmission selection algorithm
        value."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021FqtssTrafficClass  }
    ::= { ieee8021FqtssTxSelectionAlgorithmTable 1 }

Ieee8021FqtssTxSelectionAlgorithmEntry ::=
    SEQUENCE {
        ieee8021FqtssTrafficClass
            IEEE8021FqtssTrafficClassValue,
        ieee8021FqtssTxSelectionAlgorithmID
```

```
            IEEE8021FqtssTxSelectionAlgorithmIDValue
        }

ieee8021FqtssTrafficClass OBJECT-TYPE
    SYNTAX      IEEE8021FqtssTrafficClassValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The traffic class to which the transmission selection
         algorithm is assigned.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8, 12.20.2, 34.5"
    ::= { ieee8021FqtssTxSelectionAlgorithmEntry 1 }

ieee8021FqtssTxSelectionAlgorithmID OBJECT-TYPE
    SYNTAX      IEEE8021FqtssTxSelectionAlgorithmIDValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The identifier of the transmission selection algorithm
        assigned to the traffic class.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8, 12.20.2, 34.5"
    ::= { ieee8021FqtssTxSelectionAlgorithmEntry 2 }

-- ============================================================
-- the ieee8021FqtssSrpRegenOverrideTable
-- ============================================================

ieee8021FqtssSrpRegenOverrideTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021FqtssSrpRegenOverrideEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing the set of priority regeneration
        table override values for the Port.

        The recommended default values of priorities
        associated with SR classes, and the corresponding
        override values, are defined in 6.9.4.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "35.1.4, 6.9.4, 12.20.3"
    ::= { ieee8021FqtssMappings 2 }

ieee8021FqtssSrpRegenOverrideEntry OBJECT-TYPE
    SYNTAX      Ieee8021FqtssSrpRegenOverrideEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contain the mapping of a
        priority value to a priority regeneration override
        value, and a boundary port indication.
        Rows in the table exist for all priorities that are
        associated with SR classes."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021FqtssSrClassPriority  }
    ::= { ieee8021FqtssSrpRegenOverrideTable 1 }

Ieee8021FqtssSrpRegenOverrideEntry ::=
    SEQUENCE {
        ieee8021FqtssSrClassPriority
            IEEE8021PriorityValue,
        ieee8021FqtssPriorityRegenOverride
            IEEE8021PriorityValue,
        ieee8021FqtssSrpBoundaryPort
```

```
            TruthValue
        }

ieee8021FqtssSrClassPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The priority value that is overridden at the
        SRP domain boundary. "
    REFERENCE   "35.1.4, 6.9.4, 12.20.3"
    ::= { ieee8021FqtssSrpRegenOverrideEntry 1 }

ieee8021FqtssPriorityRegenOverride OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The priority value that is used to override the
         priority regeneration table entry at the SRP
         domain boundary.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "35.1.4, 6.9.4, 12.20.3"
    ::= { ieee8021FqtssSrpRegenOverrideEntry 2 }

ieee8021FqtssSrpBoundaryPort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the SRPdomainBoundaryPort parameter
        (35.1.4) for the priority. "
    REFERENCE   "35.1.4, 6.9.4, 12.20.3"
    ::= { ieee8021FqtssSrpRegenOverrideEntry 3 }

    -- ============================================================
    -- the ieee8021FqtssSRClassToPriorityTable
    -- ============================================================

    ieee8021FqtssSRClassToPriorityTable OBJECT-TYPE
        SYNTAX      SEQUENCE OF Ieee8021FqtssSRClassToPriorityEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "A table containing the mapping of the SR Class to
            the associated priority.

            The default values for the entries of this table are
            specified in 34.5"
        REFERENCE   "12.20.4, 35.2.2.9.2, 6.9.3"
        ::= { ieee8021FqtssMappings 3 }

    ieee8021FqtssSRClassToPriorityEntry OBJECT-TYPE
        SYNTAX      Ieee8021FqtssSRClassToPriorityEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "This attribute holds the Data Frame Priority
            (35.2.2.8.5(a)) value that will be used for streams
            that belong to the associated SR class."
        INDEX  { ieee8021BridgeBaseComponentId,
                 ieee8021BridgeBasePort,
                 ieee8021FqtssSrClassPriority }
        ::= { ieee8021FqtssSRClassToPriorityTable 1 }

    Ieee8021FqtssSRClassToPriorityEntry ::=
        SEQUENCE {
            ieee8021FqtssSRClassToPrioritySrClassID
                IEEE8021FqtssTrafficClassValue,
            ieee8021FqtssSRClassToPriorityRowStatus
```

```
            RowStatus
        }

        ieee8021FqtssSRClassToPrioritySrClassID OBJECT-TYPE
            SYNTAX      IEEE8021FqtssTrafficClassValue
            MAX-ACCESS  read-create
            STATUS      current
            DESCRIPTION
                "The srClassId attribute provides the SR class ID
                from Table 35-6 of 35.2.2.9.2, so that management
                software can associate the traffic class to the
                corresponding SR class A or B used by protocols
                such as SRP.

                The default values for this attribute use the
                default values specified in 34.5 (i.e. Priority 3
                for SRclassID 6 and Priority 2 for SRclassID 5).

                If this managed object is not supported, the default
                values specified in 34.5 are used as the fixed
                configuration."
            REFERENCE   "12.20.4, 35.2.2.9.2"
            ::= { ieee8021FqtssSRClassToPriorityEntry 1 }

        ieee8021FqtssSRClassToPriorityRowStatus OBJECT-TYPE
            SYNTAX RowStatus
            MAX-ACCESS read-create
            STATUS current
            DESCRIPTION
                "Indicates the status of an entry (row) in this table, and is
                used to create/delete entries."
        ::= { ieee8021FqtssSRClassToPriorityEntry 2 }

ieee8021FqtssBapXTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021FqtssBapXEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of bandwidth availability
        parameters for each traffic class configured for use with time-sensitive streams.
        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "12.20.2"
    ::= { ieee8021FqtssBapX 1 }

ieee8021FqtssBapXEntry OBJECT-TYPE
    SYNTAX      Ieee8021FqtssBapXEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing bandwidth allocation
        information for each traffic class configured for use with time-sensitive streams.
Rows in the table are
        automatically created and deleted as a result of the
        operation of the algorithm described in 34.5."
    AUGMENTS   { ieee8021FqtssBapEntry }
    ::= { ieee8021FqtssBapXTable 1 }

Ieee8021FqtssBapXEntry ::=
    SEQUENCE {
         ieee8021FqtssBAPClassMeasurementInterval
            Unsigned32,
         ieee8021FqtssBAPLockClassBandwidth
         TruthValue
    }

ieee8021FqtssBAPClassMeasurementInterval OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value of the ClassMeasurementInterval
```

```
        parameter for the traffic class.
        This attribute uses units of nanoseconds,
        converted to/from units of seconds for use in
        34.3.

        If management of classMeasurementInterval is
        not supported, the default values (34.5) are
        used as the fixed Port configuration.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.20.1, 34.3, 34.4, 34.6"
    ::= { ieee8021FqtssBapXEntry 1 }

ieee8021FqtssBAPLockClassBandwidth OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This attribute determines the interpretation of
        deltaBandwidth. For the value false(2), deltaBandwidth
        is specified in 34.3.1. For true(1), deltaBandwidth is
        specified in 34.3.2"
    REFERENCE   "12.20.1, 34.3"
    DEFVAL { false }
    ::= { ieee8021FqtssBapXEntry 2 }

-- ================================================================
-- IEEE8021 FQTSS MIB - Conformance Information
-- ================================================================

ieee8021FqtssCompliances
    OBJECT IDENTIFIER ::= { ieee8021FqtssConformance 1 }
ieee8021FqtssGroups
    OBJECT IDENTIFIER ::= { ieee8021FqtssConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021FqtssBap group
-- ================================================================

ieee8021FqtssBapGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FqtssDeltaBandwidth,
        ieee8021FqtssOperIdleSlopeMs,
        ieee8021FqtssOperIdleSlopeLs,
        ieee8021FqtssAdminIdleSlopeMs,
        ieee8021FqtssAdminIdleSlopeLs,
        ieee8021FqtssBapRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Objects that define bandwidth allocation for FQTSS."
    ::= { ieee8021FqtssGroups 1 }

-- ================================================================
-- the ieee8021FqtssTxSelectionAlgorithm group
-- ================================================================

ieee8021FqtssTxSelectionAlgorithmGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FqtssTxSelectionAlgorithmID
    }
    STATUS      current
    DESCRIPTION
        "Objects that define transmission selection
        mappings for FQTSS."
    ::= { ieee8021FqtssGroups 2 }
```

```
-- ============================================================
-- the ieee8021FqtssBoundaryPort group
-- ============================================================

ieee8021FqtssBoundaryPortGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FqtssPriorityRegenOverride,
        ieee8021FqtssSrpBoundaryPort
    }
    STATUS      current
    DESCRIPTION
        "Objects that define boundary port priority override
        mappings for FQTSS."
    ::= { ieee8021FqtssGroups 3 }

-- ============================================================
-- the ieee8021FqtssBapMeasurement group
-- ============================================================

ieee8021FqtssBapMeasurementGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FqtssBAPClassMeasurementInterval,
        ieee8021FqtssBAPLockClassBandwidth
    }
    STATUS      current
    DESCRIPTION
        "Objects that define the SRP TSpec measurement interval
        and deltaBandwidth interpretation for FQTSS."
    ::= { ieee8021FqtssGroups 4 }

-- ============================================================
-- the ieee8021FqtssSRClassPriority group
-- ============================================================

ieee8021FqtssSRClassPriorityGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FqtssSRClassToPrioritySrClassID,
        ieee8021FqtssSRClassToPriorityRowStatus
    }
    STATUS      current
    DESCRIPTION
        "Objects that define mappings of the SR class ID to
        the associated priority for FQTSS."
    ::= { ieee8021FqtssGroups 5 }

-- ============================================================
-- compliance statements
-- ============================================================

ieee8021FqtssCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        forwarding and queuing for time sensitive streams.

        Support of the objects defined in the IEEE8021-FQTSS MIB
        also requires support of the IEEE8021-BRIDGE-MIB; the
        provisions of 17.3.2 apply to implementations claiming
        support of the IEEE8021-FQTSS MIB. "

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021FqtssBapGroup,
            ieee8021FqtssTxSelectionAlgorithmGroup,
            ieee8021FqtssBoundaryPortGroup
        }

    GROUP   ieee8021FqtssBapMeasurementGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow management of the TSpec measurement interval
        and deltaBandwidth interpretation."
```

```
    GROUP   ieee8021FqtssSRClassPriorityGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow management of the mapping of SR class IDs to the
        associated Priority."

    ::= { ieee8021FqtssCompliances 1 }

END
```

17.7.13 Definitions for the IEEE8021-CN-MIB module

```
IEEE8021-CN-MIB
 DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE Std 802.1Q(TM) Congestion Management MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Integer32
                FROM SNMPv2-SMI    -- [RFC2578]
    Counter32
                FROM SNMPv2-SMI    -- [RFC2578]
    Counter64
                FROM SNMPv2-SMI    -- [RFC2578]
    Unsigned32
                FROM SNMPv2-SMI    -- [RFC2578]
    TEXTUAL-CONVENTION,
    TimeInterval
                FROM SNMPv2-TC     -- [RFC2579]
    RowStatus
                FROM SNMPv2-TC     -- [RFC2579]
    TruthValue
                FROM SNMPv2-TC     -- [RFC2579]
    MacAddress
                FROM SNMPv2-TC     -- [RFC2579]
    MODULE-COMPLIANCE,
    OBJECT-GROUP             FROM SNMPv2-CONF   -- [RFC2580]
    InterfaceIndex
                             FROM IF-MIB        -- [RFC2863]
    ifGeneralInformationGroup
                             FROM IF-MIB        -- [RFC2863]
    ieee802dot1mibs
                             FROM IEEE8021-TC-MIB
    IEEE8021PriorityValue
                             FROM IEEE8021-TC-MIB
    IEEE8021PbbComponentIdentifier
                             FROM IEEE8021-TC-MIB -- [IEEE Std 802.1ap]
    LldpV2DestAddressTableIndex
                             FROM LLDP-V2-TC-MIB
    systemGroup
              FROM SNMPv2-MIB    -- [RFC3418]
   ;

ieee8021CnMib
 MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
     "Congestion notification module.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."
```

```
    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            Imports tidied up to remove orphaned commas."

   REVISION     "201102270000Z" -- February 27, 2011
   DESCRIPTION
     "Minor edits to contact information etc. as part of
    2011 revision of IEEE Std 802.1Q."

   REVISION       "200912180000Z"    -- 12/18/2009 00:00GMT
   DESCRIPTION
      "Included in IEEE 802.1Qau-2010

        Copyright (C) IEEE."
    ::= { ieee802dot1mibs 18 }

ieee8021CnMIBObjects
      OBJECT IDENTIFIER ::= { ieee8021CnMib 1 }
ieee8021CnConformance
     OBJECT IDENTIFIER ::= { ieee8021CnMib 2 }

-- ****************************************************************
-- Textual conventions
-- ****************************************************************

Ieee8021CnControlChoice
 ::= TEXTUAL-CONVENTION
    STATUS  current
    DESCRIPTION
       "This controls what other object selects the CND defense mode and
        the Congestion Notification Priority Value (CNPV) alternate
        priority for a CNPV in an end station or Bridge component, or
        for a CNPV on a particular Port in an end station or Bridge
        component.  It can take the following values:

        cpcAdmin(1) The CND defense mode and alternate priority are
                    controlled by the administrative variables in the
                    same table entry as this object.
        cpcAuto(2)  This Port or all Ports' CND defense modes are
                    controlled automatically, as indicated by
                    ieee8021CnPortPriAutoDefenseMode, and the
                    alternate priority by ieee8021CnComPriAutoAltPri.
        cpcComp(3)  This CND defense mode and alternate priority are
                    both controlled by ieee8021CnPortPriTable.
       "
    REFERENCE
       "32.3.1, 32.4.1, Table 32-2"
    SYNTAX  INTEGER {
        cpcAdmin(1),
        cpcAuto(2),
        cpcComp(3)
    }

Ieee8021CnDefenseMode
 ::= TEXTUAL-CONVENTION
    STATUS  current
    DESCRIPTION
       "For a given Congestion Notification Priority Value (CNPV), a
        port can operate in one of four CND defense modes.  The CND
```

```
        defense mode determines whether congestion notification is
        enabled or not, and if enabled, whether the port translates the
        CNPV to a non-CNPV value on input, and whether the port removes
        CN-TAGs on output.

        cptDisabled(1)       The congestion notification capability is
                             administratively disabled for this priority
                             value and port. This priority is not a CNPV.
                             The priority regeneration table controls the
                             remapping of input frames on this port for
                             this priority. CN-TAGs are neither added by
                             an end station nor stripped by a Bridge.
        cptInterior(2)       On this port and for this CNPV, the priority
                             parameters of input frames are not remapped,
                             regardless of the priority regeneration
                             table. CN-TAGs are not added by an end
                             station, and are removed from frames before
                             being output by a Bridge.
        cptInteriorReady(3)  On this port and for this CNPV, the priority
                             parameters of input frames are not remapped,
                             regardless of the priority regeneration
                             table. CN-TAGs can be added by an end
                             station, and are not removed from frames by
                             a Bridge.
        cptEdge(4)           On this port and for this CNPV, the priority
                             parameters of input frames are remapped to
                             an alternate (non-CNPV) value, regardless of
                             the priority regeneration table. CN-TAGs are
                             not added by an end station, and are removed
                             from frames before being output by a Bridge.
                             This mode is optional for an end station.
      "
    REFERENCE
      "32.1.1, 32.3.4, 32.4.2, 32.4.3, Table 32-2"
    SYNTAX  INTEGER {
        cptDisabled(1),
        cptInterior(2),
        cptInteriorReady(3),
        cptEdge(4)
    }

Ieee8021CnLldpChoice
 ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
      "Specifies how to determine what index value is to be used as
       the index to lldpDestAddressTable, the table of destination MAC
       addresses, for both the destination addresses on transmitted
       LLDPDUs and on received LLDPDUs, found in the LLDP-MIB, either:

           cnlNone(1)       No LLDP Congestion Notification TLV is to
                            carry Per-priority CNPV indicators or
                            Per-priority Ready indicators on this Port
                            for this priority (or all Ports and all
                            priorities, as appropriate to the managed
                            object).
           cnlAdmin(2)      The administrative LLDP instance selector
                            in the same table entry as this object
                            governs which LLDP instance will carry the
                            Per-priority CNPV indicators and
                            Per-priority Ready indicators for this
                            priority in its Congestion Notification TLV
                            on this Port (or all Ports and all
                            priorities, as appropriate to the managed
                            object).
           cnlComponent(3)  ieee8021CnComPriLldpInstanceSelector governs
                            LLDP instance selection for this Port and
                            priority.
      "
    REFERENCE
      "32.3.6, 32.4.4, Table 32-1"
    SYNTAX  INTEGER {
```

```
        cnlNone(1),
        cnlAdmin(2),
        cnlComponent(3)
    }


-- ********************************************************************
-- The Global Table. This group will contain the MIB objects that
-- apply to the whole Bridge component or end station.
-- ********************************************************************

ieee8021CnGlobalTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnGlobalEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A table containing the global variables for each component of
        a Bridge or for an end station.  A value of 1 is used in a
        Bridge or end station that does not have multiple components.

        The contents of this table SHALL be maintained across a restart
        of the system.
       "
    REFERENCE
       "12.21.1"
    ::= { ieee8021CnMIBObjects 1 }

ieee8021CnGlobalEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnGlobalEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A list of objects pertaining to a whole Bridge component or
        end station.
       "
    INDEX { ieee8021CnGlobalComponentId }
    ::= { ieee8021CnGlobalTable 1 }

Ieee8021CnGlobalEntry
 ::= SEQUENCE {
        ieee8021CnGlobalComponentId  IEEE8021PbbComponentIdentifier,
        ieee8021CnGlobalMasterEnable            TruthValue,
        ieee8021CnGlobalCnmTransmitPriority     IEEE8021PriorityValue,
        ieee8021CnGlobalDiscardedFrames         Counter64
    }

ieee8021CnGlobalComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnGlobalEntry applies.  If the system is not
        a Bridge, or if only one component is present in the Bridge,
        then this variable (index) MUST be equal to 1.
       "
    ::= { ieee8021CnGlobalEntry 1 }

ieee8021CnGlobalMasterEnable
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The state of the congestion notification feature on this Bridge
        component or system.  If true, Congestion notification is
        enabled, and if false, congestion notification is disabled.
       "
    REFERENCE
```

```
       "32.2.1"
    ::= { ieee8021CnGlobalEntry 2 }

ieee8021CnGlobalCnmTransmitPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The priority to use for all Congestion Notification Messages
        transmitted by this Bridge component or end station.
       "
    REFERENCE
       "32.2.2"
    ::= { ieee8021CnGlobalEntry 3 }

ieee8021CnGlobalDiscardedFrames
 OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of frames discarded from full CP queues, in spite
        of the efforts of congestion notification to avoid discards.

        This object is incremented whenever any of the
        ieee8021CnCpDiscardedFrames objects on any Port or priority in
        this same component are incremented.

        Discontinuities in the value of this counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any).
       "
    REFERENCE
       "32.2.3"
    ::= { ieee8021CnGlobalEntry 4 }



-- ********************************************************************
-- The CCF Errored Port Table.  One per Bridge component or end station.
-- Scanning this table reveals which Interfaces at which priorities
-- have an Alternate Priority value that is a
-- Congestion Notification Priority Value.
-- ********************************************************************

ieee8021CnErroredPortTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnErroredPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "There is one Errored Port Table per Bridge component or end
        station. It permits the retrieval of information about which
        interfaces have congestion notification configuration errors,
        namely, those specifying an alternate priority that is a CNPV.
       "
    REFERENCE
       "32.2.4"
    ::= { ieee8021CnMIBObjects 2 }

ieee8021CnErroredPortEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnErroredPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A list of interfaces whose ieee8021CnComPriAlternatePriority
        and/or ieee8021CnPortPriAlternatePriority specify a priority
```

```
        value that is a Congestion Notification Priority Value.
       "
    REFERENCE
       "32.2.4"
    INDEX { ieee8021CnEpComponentId,
            ieee8021CnEpPriority,
            ieee8021CnEpIfIndex}
    ::= { ieee8021CnErroredPortTable 1 }

Ieee8021CnErroredPortEntry
 ::= SEQUENCE {
        ieee8021CnEpComponentId     IEEE8021PbbComponentIdentifier,
        ieee8021CnEpPriority        IEEE8021PriorityValue,
        ieee8021CnEpIfIndex         InterfaceIndex
    }

ieee8021CnEpComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnErroredPortEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "32.2.4"
    ::= { ieee8021CnErroredPortEntry 1 }

ieee8021CnEpPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The priority value whose alternate priority is misconfigured.
       "
    REFERENCE
       "32.2.4"
    ::= { ieee8021CnErroredPortEntry 2 }

ieee8021CnEpIfIndex
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object represents the Bridge Port or aggregated port
        on which the congestion notification alternate priority is
        misconfigured.
        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this variable so that it references the row
        in the ifXTable with the same value of ifAlias that it
        referenced before the system restart.  If no such row exists,
        then the system SHALL delete this row in the
        ieee8021CnErroredPortTable.
       "
    REFERENCE
       "32.2.4"
    ::= { ieee8021CnErroredPortEntry 3 }


-- ****************************************************************
-- The CCF Per-component per-priority table.  One table per Bridge
-- component or end station, one entry per
-- Congestion Notification Priority Value
-- ****************************************************************

ieee8021CnCompntPriTable
 OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF Ieee8021CnCompntPriEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each row in this table supplies default values for one
        Congestion Notification Priority Value for a whole Bridge
        component or end station.

        Creating a row in this table makes the priority value of
        ieee8021CnComPriPriority a
        Congestion Notification Priority Value.
        Deleting a row in this table makes the value in the deleted
        ieee8021CnComPriPriority no longer a
        Congestion Notification Priority Value.

        A  system SHALL NOT allow eight rows in this table
        to be created with the same value of
        ieee8021CnComPriComponentId; see the description of
        ieee8021CnComPriRowStatus.

        The contents of this table SHALL be maintained across a restart
        of the system.
       "
    REFERENCE
       "12.21.2, 12.21.2.1, 12.21.2.2"
    ::= { ieee8021CnMIBObjects 3 }

ieee8021CnCompntPriEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnCompntPriEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "One entry per Congestion Notification Priority Value per
        Bridge component or end station.
       "
    REFERENCE
       "12.21.2, 12.21.2.1, 12.21.2.2"
    INDEX { ieee8021CnComPriComponentId,
            ieee8021CnComPriPriority }
    ::= { ieee8021CnCompntPriTable 1 }

Ieee8021CnCompntPriEntry
 ::= SEQUENCE {
    ieee8021CnComPriComponentId       IEEE8021PbbComponentIdentifier,
    ieee8021CnComPriPriority          IEEE8021PriorityValue,
    ieee8021CnComPriDefModeChoice     Ieee8021CnControlChoice,
    ieee8021CnComPriAlternatePriority IEEE8021PriorityValue,
    ieee8021CnComPriAutoAltPri        IEEE8021PriorityValue,
    ieee8021CnComPriAdminDefenseMode  Ieee8021CnDefenseMode,
    ieee8021CnComPriCreation          INTEGER,
    ieee8021CnComPriLldpInstanceChoice    Ieee8021CnLldpChoice,
    ieee8021CnComPriLldpInstanceSelector  LldpV2DestAddressTableIndex,
    ieee8021CnComPriRowStatus         RowStatus
    }

ieee8021CnComPriComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnCompntPriEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.21.2, 12.21.2.1, 12.21.2.2"
    ::= { ieee8021CnCompntPriEntry 1 }

ieee8021CnComPriPriority
```

```
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Congestion Notification Priority Value for which this
        row supplies default values.
       "
    REFERENCE
       "802.1Qau clauses 12.21.2"
    ::= { ieee8021CnCompntPriEntry 2 }

ieee8021CnComPriDefModeChoice
 OBJECT-TYPE
    SYNTAX      Ieee8021CnControlChoice {
                    cpcAdmin(1),
                    cpcAuto(2)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Specifies how the default CND defense mode and alternate
        priority for this Congestion Notification Priority Value on all
        ports on this Bridge component or end station are to be chosen,
        either:

            cpcAdmin(1) Default CND defense mode is chosen by
                        ieee8021CnComPriAdminDefenseMode, and alternate
                        priority by ieee8021CnComPriAlternatePriority.
            cpcAuto(2)  Default CND defense mode is chosen by
                        ieee8021CnPortPriAutoDefenseMode, and alternate
                        priority by ieee8021CnComPriAutoAltPri.

        This variable can be overridden by
        ieee8021CnPortPriDefModeChoice.
       "
    REFERENCE
       "32.1.3, 32.3.1"
    DEFVAL { cpcAuto }
    ::= { ieee8021CnCompntPriEntry 3 }

ieee8021CnComPriAlternatePriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The Congestion Notification Priority Value to which an
        incoming frame is to be mapped, in spite of what the
        Priority Regeneration Table says, if 1) Congestion
        Notification is enabled and 2) the CND defense mode of the
        port is cptEdge.

        Deleting a row in this table does not alter the value of any
        other row's ieee8021CnComPriAlternatePriority.
       "
    REFERENCE
       "802.1Qau clauses 32.3.2"
    DEFVAL { 0 }
    ::= { ieee8021CnCompntPriEntry 4 }

ieee8021CnComPriAutoAltPri
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Congestion Notification Priority Value to which an
        incoming frame can be mapped, in spite of what the
        Priority Regeneration Table says, if 1) Congestion
        Notification is enabled, 2) the CND defense mode of the
        port is cptEdge, and 3) ieee8021CnComPriDefModeChoice
```

```
        contains the value cpcAuto(2).

        The value of this object is the next lower priority value
        than this row's ieee8021CnComPriPriority that is not a CNPV,
        or the next higher non-CNPV, if all lower values are CNPVs.

        The value of this object, and any consequent priority
        regeneration, is automatically updated by the managed system
        whenever a row in the ieee8021CnCompntPriTable is created or
        deleted.  The value of this object is not dependent upon
        whether congestion notification is enabled or disabled for any
        priority or for the whole Bridge component or end station; it
        depends only upon whether the ieee8021CnCompntPriTable row
        exists.
       "
    REFERENCE
       "802.1Qau clauses 32.3.3"
    ::= { ieee8021CnCompntPriEntry 5 }

ieee8021CnComPriAdminDefenseMode
 OBJECT-TYPE
    SYNTAX      Ieee8021CnDefenseMode
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The default CND defense mode for this
        Congestion Notification Priority Value on all ports on this
        Bridge component or end station.

        This variable can be overridden by
        ieee8021CnPortPriAdminDefenseMode.
       "
    REFERENCE
       "32.1.3, 32.3.4"
    DEFVAL { cptInterior }
    ::= { ieee8021CnCompntPriEntry 6 }

ieee8021CnComPriCreation
 OBJECT-TYPE
    SYNTAX      INTEGER {
                    cncpAutoEnable(1),
                    cncpAutoDisable(2)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The default value for ieee8021CnComPriDefModeChoice for
        newly-created entries in the ieee8021CnPortPriTable:

            cncpAutoEnable (1)  Newly-created
                                ieee8021CnPortPriDefModeChoice
                                objects take the value cpcComp(3).
            cncpAutoDisable(2)  Newly-created
                                ieee8021CnPortPriDefModeChoice
                                objects take the value cpcAdmin (1).
       "
    REFERENCE
       "32.3.5"
    DEFVAL { cncpAutoEnable }
    ::= { ieee8021CnCompntPriEntry 7 }

ieee8021CnComPriLldpInstanceChoice
 OBJECT-TYPE
    SYNTAX      Ieee8021CnLldpChoice {
                      cnlNone  (1),
                      cnlAdmin (2)
                }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Specifies whether or not the default value for all Ports is to
        send and receive the Congestion Notification TLV in LLDPDUs,
```

```
        either:
            cnlNone(1)  Do not send Congestion Notification TLVs, and
                        ignore them on receipt.
            cnlAdmin(2) Use the LLDP instance selected by
                        ieee8021CnComPriLldpInstanceSelector to send and
                        receive the Congestion Notification TLV.

        This object can be overridden by
        ieee8021CnPortPriLldpInstanceChoice.
       "
    REFERENCE
       "32.1.3, 32.3.6"
    DEFVAL { cnlAdmin }
    ::= { ieee8021CnCompntPriEntry 8 }

ieee8021CnComPriLldpInstanceSelector
 OBJECT-TYPE
    SYNTAX      LldpV2DestAddressTableIndex
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Specifies a default value for which LLDP instance is to be
        used to provide the information for automatic configuration
        of ports' CND defense modes (ieee8021CnPortPriAutoDefenseMode).

        This object is ignored by the managed system if
        ieee8021CnComPriLldpInstanceChoice contains the value cnlNone
        (1).

        This object can be overridden by
        ieee8021CnPortPriLldpInstanceChoice and
        ieee8021CnPortPriLldpInstanceChoice.
       "
    REFERENCE
       "32.1.3, 32.3.7"
    DEFVAL { 1 }
    ::= { ieee8021CnCompntPriEntry 9 }

ieee8021CnComPriRowStatus
 OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "This object indicates the status of an entry, and is used
        to create/delete entries.

        A system SHALL NOT permit eight ieee8021CnComPriRowStatus
        objects, all with the same value of ieee8021CnComPriComponentId,
        to have the value active(1).  An attempt to create or activate
        a row when there are already seven active rows SHALL result in
        that eighth row's ieee8021CnComPriRowStatus having the value
        notReady(3), and the return of an inconsistentValue error.
       "
    REFERENCE
       "30.4"
    ::= { ieee8021CnCompntPriEntry 10 }


-- ****************************************************************
-- The CCF Per-component per-interface per-priority table.  One table
-- per end station or Bridge component.  One entry per interface per
-- priority value, but only for priority values that are
-- Congestion Notification Priority Values (CNPVs).  Controls
-- a CNPV on a specific port when the default values in
-- ieee8021CnCompntPriTable need to be overridden.
-- ****************************************************************

ieee8021CnPortPriTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnPortPriEntry
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
       "Each row in this table supplies values for one port's
        Congestion Notification Priority Value (CNPV).

        Creating an entry in ieee8021CnCompntPriTable creates this
        entry, with the default values, on all ports in the Bridge
        component or end station.  Deleting an entry in
        ieee8021CnCompntPriTable deletes this ieee8021CnCompntPriEntry
        on all ports in the Bridge component or end station.

        The contents of this table SHALL be maintained across a restart
        of the system, except as noted in the description of
        ieee8021CnPortPriIfIndex.
       "
    REFERENCE
       "12.21.3"
    ::= { ieee8021CnMIBObjects 4 }

ieee8021CnPortPriEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnPortPriEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "One entry per port per Congestion Notification Priority Value
        per Bridge component or end station.
       "
    REFERENCE
       "12.21.3"
    INDEX { ieee8021CnPortPriComponentId,
            ieee8021CnPortPriority,
            ieee8021CnPortPriIfIndex }
    ::= { ieee8021CnPortPriTable 1 }

Ieee8021CnPortPriEntry
 ::= SEQUENCE {
        ieee8021CnPortPriComponentId    IEEE8021PbbComponentIdentifier,
        ieee8021CnPortPriority               IEEE8021PriorityValue,
        ieee8021CnPortPriIfIndex             InterfaceIndex,
        ieee8021CnPortPriDefModeChoice       Ieee8021CnControlChoice,
        ieee8021CnPortPriAdminDefenseMode    Ieee8021CnDefenseMode,
        ieee8021CnPortPriAutoDefenseMode     Ieee8021CnDefenseMode,
        ieee8021CnPortPriLldpInstanceChoice  Ieee8021CnLldpChoice,
        ieee8021CnPortPriLldpInstanceSelector
                                  LldpV2DestAddressTableIndex,
        ieee8021CnPortPriAlternatePriority   IEEE8021PriorityValue
    }

ieee8021CnPortPriComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnPortPriEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.21.3"
    ::= { ieee8021CnPortPriEntry 1 }

ieee8021CnPortPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Congestion Notification Priority Value for which
        this row supplies default values.
```

```
       "
    REFERENCE
       "802.1Qau clauses 12.21.3"
    ::= { ieee8021CnPortPriEntry 2 }

ieee8021CnPortPriIfIndex
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object represents the port or aggregated port
        to which the entry applies.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this object, and rearrange the order of the
        ieee8021CnPortPriTable, so that the value in
        ieee8021CnPortPriIfIndex references the row in the ifXTable
        with the same value for ifAlias that it referenced before the
        system restart.  If no such entry exists in the ifXTable, then
        the system SHALL delete the row in the ieee8021CnPortPriTable.
       "
    REFERENCE
       "12.21.3"
    ::= { ieee8021CnPortPriEntry 3 }

ieee8021CnPortPriDefModeChoice
 OBJECT-TYPE
    SYNTAX  Ieee8021CnControlChoice
    MAX-ACCESS  read-write
    STATUS current
    DESCRIPTION
       "This object determines how the CND defense mode and alternate
        priority value of this port for this CNPV is to be selected,
        either:

            cpcAdmin(1) CND defense mode is controlled by
                        ieee8021CnPortPriAdminDefenseMode, and alternate
                        priority by ieee8021CnPortPriAlternatePriority.
            cpcAuto(2)  CND defense mode is controlled by
                        ieee8021CnPortPriAutoDefenseMode and alternate
                        priority by ieee8021CnComPriAlternatePriority.
            cpcComp(3)  CND defense mode and alternate priority are
                        controlled by
                        ieee8021CnComPriDefModeChoice.

        This variable can override ieee8021CnComPriDefModeChoice.
       "
    REFERENCE
       "IEEE 32.1.3, 32.4.1"
    DEFVAL { cpcComp }
    ::= { ieee8021CnPortPriEntry 4 }

ieee8021CnPortPriAdminDefenseMode
 OBJECT-TYPE
    SYNTAX  Ieee8021CnDefenseMode
    MAX-ACCESS  read-write
    STATUS current
    DESCRIPTION
       "This object indicates the operator's choice for the CND defense
        mode in which this port is to operate for this CNPV whenever
        ieee8021CnPortPriDefModeChoice has the value cpcAdmin(1).

        This variable can override ieee8021CnComPriDefModeChoice.
       "
    REFERENCE
       "IEEE 32.1.3, 32.4.1"
    DEFVAL { cptDisabled }
    ::= { ieee8021CnPortPriEntry 5 }

ieee8021CnPortPriAutoDefenseMode
 OBJECT-TYPE
```

```
    SYNTAX  Ieee8021CnDefenseMode {
                cptInterior      (2),
                cptInteriorReady (3),
                cptEdge          (4)
            }
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
       "This object indicates in which the CND defense mode this port
        would operate for this CNPV as determined by the LLDP
        Congestion Notification TLV.
       "
    REFERENCE
       "IEEE 32.4.3"
    ::= { ieee8021CnPortPriEntry 6 }


ieee8021CnPortPriLldpInstanceChoice
 OBJECT-TYPE
    SYNTAX      Ieee8021CnLldpChoice
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "Specifies how to determine the LLDP instance to be used for the
        Congestion Notification TLV, either:
            cnlNone(1)      No LLDP Congestion Notification TLV is to
                            carry Per-priority CNPV indicators or
                            Per-priority Ready indicators on this Port
                            for this priority.
            cnlAdmin(2)     ieee8021CnPortPriLldpInstanceSelector
                            governs which LLDP instance is to carry
                            Per-priority CNPV indicators and
                            Per-priority Ready indicators for this
                            priority in its Congestion Notification TLV
                            on this Port
            cnlComponent(3) ieee8021CnComPriLldpInstanceChoice
                            governs LLDP instance selection for this
                            Port and priority.

        This object can override ieee8021CnComPriLldpInstanceChoice.
       "
    REFERENCE
       "32.1.3, 32.4.4"
    DEFVAL { cnlComponent }
    ::= { ieee8021CnPortPriEntry 7 }

ieee8021CnPortPriLldpInstanceSelector
 OBJECT-TYPE
    SYNTAX      LldpV2DestAddressTableIndex
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object determines which LLDP instance selector, if any,
        is used for automatic determination of the CND defense mode for
        this port and CNPV.

        This object can override ieee8021CnComPriLldpInstanceSelector.
       "
    REFERENCE
       "32.1.3, 32.4.5"
    DEFVAL { 3 }
    ::= { ieee8021CnPortPriEntry 8 }

ieee8021CnPortPriAlternatePriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The Congestion Notification Priority Value to which an
        incoming frame is to be mapped, in spite of what the
        Priority Regeneration Table says, if 1) Congestion
```

```
        Notification is enabled and 2) the port is acting in the
        cptEdge (4) CND defense mode.

        This object is ignored unless ieee8021CnPortPriDefModeChoice
        contains the value cpcAdmin (1).
       "
    REFERENCE
       "32.4.6"
    DEFVAL { 0 }
    ::= { ieee8021CnPortPriEntry 9 }



-- ****************************************************************
-- The CCF per-CP table.  One table per end station or Bridge component.
-- One entry per Congestion Point.  An entry in this table controls one
-- Congestion Point (CP).
-- ****************************************************************

ieee8021CnCpTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnCpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each row in this table supplies values for one
        Congestion Point (CP).

        This table is indexed by component, port (interface), and
        an arbitrary CP index.  This arbitrary CP index is not
        necessarily the Congestion Point Identifier (CPID) carried in
        Congestion Notification Messages (CNMs).

        Creating an entry in ieee8021CnCompntPriTable can create an
        entry in this table, with the default values, on all ports in
        the Bridge component or end station.  Because more than one
        Congestion Notification Priority Value (CNPV) can flow
        through a single CP, the creation of an entry in
        ieee8021CnCompntPriTable does not necessarily create a new
        entry in this table.  An end station can have more than one
        CP for the same CNPV, so creating an entry in
        ieee8021CnCompntPriTable can create multiple entries in this
        table.

        Because each port in a Bridge component or end station can have
        a different relationship between CNPVs and CPs, the entries
        created or deleted on each port can be different.

        Deleting the last entry in ieee8021CnCompntPriTable for a
        CNPV passing through the CP controlled by this entry deletes
        the entry on some or all of the ports in the Bridge component
        or end station.

        Because each port in a Bridge component or end station can have
        a different relationship between CNPVs and CPs, the entries
        created or deleted on each port can be different.

        The relationship between ieee8021CnCpIndex
        values and CPs is an implementation dependent matter.

        The contents of this table SHALL be maintained across a restart
        of the system, except as noted in the description of
        ieee8021CnCpIfIndex.
       "
    REFERENCE
       "12.21.4"
    ::= { ieee8021CnMIBObjects 5 }

ieee8021CnCpEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnCpEntry
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
       "An entry in the Congestion Point table controls a single
        Congestion Point on a port in a Bridge component or end station.
       "
    REFERENCE
       "12.21.4"
    INDEX { ieee8021CnCpComponentId,
            ieee8021CnCpIfIndex,
            ieee8021CnCpIndex }
    ::= { ieee8021CnCpTable 1 }

Ieee8021CnCpEntry
 ::= SEQUENCE {
       ieee8021CnCpComponentId      IEEE8021PbbComponentIdentifier,
       ieee8021CnCpIfIndex              InterfaceIndex,
       ieee8021CnCpIndex                Unsigned32,
       ieee8021CnCpPriority             IEEE8021PriorityValue,
       ieee8021CnCpMacAddress           MacAddress,
       ieee8021CnCpIdentifier           OCTET STRING,
       ieee8021CnCpQueueSizeSetPoint    Unsigned32,
       ieee8021CnCpFeedbackWeight       Integer32,
       ieee8021CnCpMinSampleBase        Unsigned32,
       ieee8021CnCpDiscardedFrames      Counter64,
       ieee8021CnCpTransmittedFrames    Counter64,
       ieee8021CnCpTransmittedCnms      Counter64,
       ieee8021CnCpMinHeaderOctets      Unsigned32
    }

ieee8021CnCpComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnCpEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "12.21.4"
    ::= { ieee8021CnCpEntry 1 }

ieee8021CnCpIfIndex
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object represents the port or aggregated port
        to which the entry applies.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this object, and rearrange the order of the
        ieee8021CnCpTable, so that the value in ieee8021CnCpIfIndex
        references the row in the ifXTable with the same value for
        ifAlias that it referenced before the system restart.  If no
        such entry exists in the ifXTable, then the system SHALL delete
        the row in the ieee8021CnCpTable.
       "
    REFERENCE
       "12.21.4"
    ::= { ieee8021CnCpEntry 2 }

ieee8021CnCpIndex
 OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4096)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object is an arbitrary integer indexing the entries in
```

```
         this table among the entries for the same component and
         interface.  In a system that supports no more than one
         Congestion Point per priority per interface, ieee8021CnCpIndex
         SHALL be equal to the lowest numerical
         Congestion Notification Priority Value served by this
         Congestion Point.  Otherwise, it SHOULD be a small integer
         value.
        "
    REFERENCE
       "12.21.4"
    ::= { ieee8021CnCpEntry 3 }

ieee8021CnCpPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object indicates the lowest numerical
        Congestion Notification Priority Value that this entry's
        Congestion Point serves.
       "
    REFERENCE
       "12.21.4"
    ::= { ieee8021CnCpEntry 4 }

ieee8021CnCpMacAddress
 OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object indicates the MAC address used as the source
        address in Congestion Notification Message transmitted
        by this Congestion Point.
       "
    REFERENCE
       "32.8.1"
    ::= { ieee8021CnCpEntry 5 }

ieee8021CnCpIdentifier
 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(8))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object indicates the Congestion Point Identifier (CPID)
        transmitted in Congestion Notification Message by this
        Congestion Point.

        It is not specified whether the CPID reported in a CNM by a CP
        that serves multiple CNPVs does or does not have the same value
        for its different CNPVs.
       "
    REFERENCE
       "32.8.2"
    ::= { ieee8021CnCpEntry 6 }

ieee8021CnCpQueueSizeSetPoint
 OBJECT-TYPE
    SYNTAX      Unsigned32 (100..4294967295)
    UNITS       "octets"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object is the set point for the queue managed by this
        Congestion Point (CP).  Congestion Notification Messages are
        transmitted to the sources of frames queued in this CP's
        queue in order to keep the total number of octets stored in
        the queue at this set point.
       "
    REFERENCE
```

```
       "30.2, 32.8.3"
    DEFVAL { 26000 }
    ::= { ieee8021CnCpEntry 7 }

ieee8021CnCpFeedbackWeight
 OBJECT-TYPE
    SYNTAX      Integer32 (-10..10)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the weight (cpW) change in queue length
        in the calculation of cpFb when the Congestion Point is
        generating a Congestion Notification Message.

        The weight cpW is equal to two to the power of this object.
        Thus, if this object contains a -1, cpW = 1/2.
       "
    REFERENCE
       "32.8.6"
    DEFVAL { 1 }
    ::= { ieee8021CnCpEntry 8 }

ieee8021CnCpMinSampleBase
 OBJECT-TYPE
    SYNTAX      Unsigned32 (10000..4294967295)
    UNITS       "octets"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object determines the minimum number of octets to
        enqueue in the Congestion Point's queue between transmissions
        of Congestion Notification Messages.
       "
    REFERENCE
       "32.8.11"
    DEFVAL { 150000 }
    ::= { ieee8021CnCpEntry 9 }

ieee8021CnCpDiscardedFrames
 OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of data frames discarded by the queue controlled
        by this Congestion Point due to queue congestion.

        Discontinuities in the value of this counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any).
       "
    REFERENCE
       "32.8.12"
    ::= { ieee8021CnCpEntry 10 }

ieee8021CnCpTransmittedFrames
 OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of data frames passed on to the queue controlled by
        this Congestion Point that were not discarded due to queue
        congestion.

        Discontinuities in the value of this counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
```

```
        ifCounterDiscontinuityTime object of the associated
        interface (if any).
       "
    REFERENCE
       "32.8.13"
    ::= { ieee8021CnCpEntry 11 }

ieee8021CnCpTransmittedCnms
 OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The number of Congestion Notification Message transmitted
        by this Congestion Point.

        Discontinuities in the value of this counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any).
       "
    REFERENCE
       "32.8.14"
    ::= { ieee8021CnCpEntry 12 }

ieee8021CnCpMinHeaderOctets
 OBJECT-TYPE
    SYNTAX      Unsigned32 (0..64)
    UNITS       "octets"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "Specifies the minimum number of octets to be returned in a
        Congestion Notification Message from the mac_service_data_unit
        of the data frame that triggered transmission of the CNM.  If
        the mac_service_data_unit has fewer octets than the value of
        this object, then all of the mac_service_data_unit is returned
        in the CNM.
       "
    REFERENCE
       "32.8.15, 32.9.4 k)"
    DEFVAL { 0 }
    ::= { ieee8021CnCpEntry 13 }



-- ****************************************************************
-- The CPID to {Interface, CP index} table.  One table per system.
-- One entry per CPID.
-- ****************************************************************

ieee8021CnCpidToInterfaceTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnCpidToInterfaceEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This table allows the network manager to obtain the
        interface index and CP index needed to access an entry in
        the ieee8021CnCpTable, given a Congestion Point Identifier
        (CPID) received a Congestion Notification Messages (CNMs).

        Upon a restart of the system, the system SHALL, if necessary,
        update this table to be consistent with the ieee8021CnCpTable.
       "
    REFERENCE
       "17.2.13, 12.21.4, 32.8.2"
    ::= { ieee8021CnMIBObjects 6 }

ieee8021CnCpidToInterfaceEntry
```

```
 OBJECT-TYPE
    SYNTAX      Ieee8021CnCpidToInterfaceEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "An entry in the ieee8021CnCpidToInterfaceTable.  Translates
        a Congestion Point Identifier to a component identifier,
        interface index, and CP index
       "
    REFERENCE
       "17.2.13"
    INDEX { ieee8021CnCpidToIfCpid }
    ::= { ieee8021CnCpidToInterfaceTable 1 }

Ieee8021CnCpidToInterfaceEntry
 ::= SEQUENCE {
        ieee8021CnCpidToIfCpid           OCTET STRING,
        ieee8021CnCpidToIfComponentId    IEEE8021PbbComponentIdentifier,
        ieee8021CnCpidToIfIfIndex        InterfaceIndex,
        ieee8021CnCpidToIfCpIndex        Unsigned32
    }

ieee8021CnCpidToIfCpid
 OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(8))
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object is the Congestion Point Identifier (CPID)
        transmitted in Congestion Notification Message by a
        Congestion Point residing in this Bridge component or
        end station.
       "
    REFERENCE
       "17.2.13, 32.8.2"
    ::= { ieee8021CnCpidToInterfaceEntry 1 }

ieee8021CnCpidToIfComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnCpidToInterfaceEntry applies.  If the system
        is not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    REFERENCE
       "17.2.13"
    ::= { ieee8021CnCpidToInterfaceEntry 2 }

ieee8021CnCpidToIfIfIndex
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object indicates the interface on which the selected
        Congestion Point resides.  This value can be used, along
        with ieee8021CnCpidToIfCpIndex, to find the Congestion Point
        in the ieee8021CnCpTable.
       "
    REFERENCE
       "17.2.13"
    ::= { ieee8021CnCpidToInterfaceEntry 3 }

ieee8021CnCpidToIfCpIndex
 OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4096)
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
       "This object indicates the Congestion Point's index on the
        interface on which the selected Congestion Point resides.
        This value can be used, along with ieee8021CnCpidToIfIfIndex,
        to find the Congestion Point in the ieee8021CnCpTable.
       "
    REFERENCE
       "17.2.13"
    ::= { ieee8021CnCpidToInterfaceEntry 4 }



-- ********************************************************************
-- The Reaction Point Port table.  One table per end station.  One
-- entry per Port per CNPV.
-- ********************************************************************

ieee8021CnRpPortPriTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnRpPortPriEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each row in this table supplies values for all of the
        Reaction Points (RPs) on one Port and one priority of an end
        station or Bridge component.  This table is indexed by
        component, port (interface), and priority.

        Creating an entry in ieee8021CnCompntPriTable can create an
        entry in this table, with the default values, on all ports
        in the end station.

        Deleting the an entry in ieee8021CnCompntPriTable for a
        CNPV passing through the RP controlled by this entry deletes
        entries on some or all of the ports in the end station.

        The contents of this table SHALL be maintained across a restart
        of the system, except as noted in the description of
        ieee8021CnRpPortPriIfIndex.
       "
    REFERENCE
       "12.21.5"
    ::= { ieee8021CnMIBObjects 7 }

ieee8021CnRpPortPriEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnRpPortPriEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "An entry in the Reaction Point table controls all of the
        Reaction Points on a port in an end station that share the same
        priority value.
       "
    REFERENCE
       "12.21.5"
    INDEX { ieee8021CnRpPortPriComponentId, ieee8021CnRpPortPriPriority,
            ieee8021CnRpPortPriIfIndex
          }
    ::= { ieee8021CnRpPortPriTable 1 }

Ieee8021CnRpPortPriEntry
 ::= SEQUENCE {
        ieee8021CnRpPortPriComponentId   IEEE8021PbbComponentIdentifier,
        ieee8021CnRpPortPriPriority      IEEE8021PriorityValue,
        ieee8021CnRpPortPriIfIndex       InterfaceIndex,
        ieee8021CnRpPortPriMaxRps        Unsigned32,
        ieee8021CnRpPortPriCreatedRps    Counter32,
        ieee8021CnRpPortPriCentiseconds  Counter64
    }

ieee8021CnRpPortPriComponentId
```

```
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnRpGroupEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    ::= { ieee8021CnRpPortPriEntry 1 }

ieee8021CnRpPortPriPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object indicates the lowest numerical
        Congestion Notification Priority Value that this entry's
        Reaction Point serves.
       "
    REFERENCE
       "12.21.5"
    ::= { ieee8021CnRpPortPriEntry 2 }

ieee8021CnRpPortPriIfIndex
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object indicates the interface on which the selected
        Reaction Points reside.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this object, and rearrange the order of the
        ieee8021CnRpPortPriTable, so that the value in
        ieee8021CnRpPortPriIfIndex references the row in the ifXTable
        with the same value for ifAlias that it referenced before the
        system restart.  If no such entry exists in the ifXTable, then
        the system SHALL delete the row in the
        ieee8021CnRpPortPriTable.
       "
    REFERENCE
       "12.21.5"
    ::= { ieee8021CnRpPortPriEntry 3 }

ieee8021CnRpPortPriMaxRps
 OBJECT-TYPE
    SYNTAX      Unsigned32 (1..100)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "An integer controlling the maximum number of Reaction Points
        allowed for this CNPV on this Port. An end station SHALL
        not create more than this many Reaction Point on this Port,
        but it MAY create fewer.
       "
    REFERENCE
       "32.10.1"
    DEFVAL { 1 }
    ::= { ieee8021CnRpPortPriEntry 4 }

ieee8021CnRpPortPriCreatedRps
 OBJECT-TYPE
    SYNTAX      Counter32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object returns the number of times any of the
        Reaction Points (RPs) controlled by this entry has had
```

```
        its rpEnabled variable set TRUE by the reception of a
        Congestion Notification Message.

        Dividing the change in ieee8021CnRpPortPriCentiseconds by the
        change in this object over a time interval yields the average
        lifetime of an active RP during that interval.
       "
    REFERENCE
       "32.10.2, 32.10.3, 32.13.1"
    ::= { ieee8021CnRpPortPriEntry 5 }

ieee8021CnRpPortPriCentiseconds
 OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "centiseconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "This object returns the total number of centi-seconds that
        any of the Reaction Points (RPs) controlled by this entry
        has had its rpEnabled variable in the TRUE state.  That is,
        once each centi-second, this counter is incremented by the
        number of RPs this entry controls that are actively rate
        limiting output frames.

        Dividing the change in this object over a time interval by the
        length of the interval yields the average number of RPs active
        over that interval.  Dividing the change in this object by the
        change in ieee8021CnRpPortPriCreatedRps over that same time
        interval yields the average lifetime of an active RP during that
        interval.
       "
    REFERENCE
       "32.10.3, 32.13.1"
    ::= { ieee8021CnRpPortPriEntry 6 }



-- ********************************************************************
-- The Reaction Point Group table.  One table per end station.
-- One entry per Reaction Point.
-- ********************************************************************

ieee8021CnRpGroupTable
 OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021CnRpGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each row in this table supplies values for one or more
        Reaction Points (RPs).  This table is indexed by component,
        port (interface), and an arbitrary RP index.

        Creating an entry in ieee8021CnCompntPriTable can create an
        entry in this table, with the default values, on all ports
        in the end station.  An end station can have more than one
        RP for the same Congestion Notification Priority Value
        (CNPV), so creating an entry in ieee8021CnCompntPriTable can
        create multiple entries in this table.

        Because each port in a Bridge component or end station can have
        a different relationship between CNPVs and RPs, the entries
        created or deleted on each port can be different.

        Deleting the an entry in ieee8021CnCompntPriTable for a
        CNPV passing through the RP controlled by this entry deletes
        entries on some or all of the ports in the end station.

        Because each port in an end station can have a
        different relationship between CNPVs and RPs, the entries
        created or deleted on each port can be different.
```

```
        The relationship between ieee8021CnRpgIdentifier
        values and RPs is an implementation dependent matter.

        The contents of this table SHALL be maintained across a restart
        of the system, except as noted in the description of
        ieee8021CnRpgIfIndex.
       "
    REFERENCE
       "12.21.6"
    ::= { ieee8021CnMIBObjects 8 }

ieee8021CnRpGroupEntry
 OBJECT-TYPE
    SYNTAX      Ieee8021CnRpGroupEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "An entry in the Reaction Point table controls a group of
        Reaction Points, on a port in an end station.  All of the
        Reaction Point controlled by this entry serve the same
        Congestion Notification Priority Value.
       "
    INDEX { ieee8021CnRpgComponentId, ieee8021CnRpgPriority,
            ieee8021CnRpgIfIndex, ieee8021CnRpgIdentifier }
    ::= { ieee8021CnRpGroupTable 1 }

Ieee8021CnRpGroupEntry
 ::= SEQUENCE {
        ieee8021CnRpgComponentId    IEEE8021PbbComponentIdentifier,
        ieee8021CnRpgPriority       IEEE8021PriorityValue,
        ieee8021CnRpgIfIndex        InterfaceIndex,
        ieee8021CnRpgIdentifier     Unsigned32,
        ieee8021CnRpgEnable         TruthValue,
        ieee8021CnRpgTimeReset      TimeInterval,
        ieee8021CnRpgByteReset      Unsigned32,
        ieee8021CnRpgThreshold      Unsigned32,
        ieee8021CnRpgMaxRate        Unsigned32,
        ieee8021CnRpgAiRate         Unsigned32,
        ieee8021CnRpgHaiRate        Unsigned32,
        ieee8021CnRpgGd             Integer32,
        ieee8021CnRpgMinDecFac      Unsigned32,
        ieee8021CnRpgMinRate        Unsigned32
    }

ieee8021CnRpgComponentId
 OBJECT-TYPE
    SYNTAX      IEEE8021PbbComponentIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The Bridge component within the system to which the information
        in this ieee8021CnRpGroupEntry applies.  If the system is
        not a Bridge, or if only one component is present in the
        Bridge, then this variable (index) MUST be equal to 1.
       "
    ::= { ieee8021CnRpGroupEntry 1 }

ieee8021CnRpgPriority
 OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object indicates the lowest numerical
        Congestion Notification Priority Value that this entry's
        Reaction Point serves.
       "
    REFERENCE
       "12.21.5"
    ::= { ieee8021CnRpGroupEntry 2 }

ieee8021CnRpgIfIndex
```

```
 OBJECT-TYPE
    SYNTAX      InterfaceIndex
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object indicates the interface on which the group of
        Reaction Points reside.

        Upon a restart of the system, the system SHALL, if necessary,
        change the value of this object, and rearrange the order of the
        ieee8021CnRpGroupTable, so that the value in
        ieee8021CnRpgIfIndex references the row in the ifXTable with
        the same value for ifAlias that it referenced before the system
        restart.  If no such entry exists in the ifXTable, then the
        system SHALL delete the row in the ieee8021CnRpGroupTable.
       "
    REFERENCE
       "12.21.5"
    ::= { ieee8021CnRpGroupEntry 3 }

ieee8021CnRpgIdentifier
 OBJECT-TYPE
    SYNTAX      Unsigned32 (1..4096)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "This object is an arbitrary integer indexing the entries in
        this table among the entries for the same interface.  This
        index SHOULD, where possible, be equal to the
        Congestion Notification Priority Value served by this
        Reaction Point.
       "
    REFERENCE
       "12.21.6"
    ::= { ieee8021CnRpGroupEntry 4 }

ieee8021CnRpgEnable
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "Controls the rpEnabled variable of the Reaction Point state
        machines of the Reaction Points (RPs) controlled by this
        entry as follows:
            true(1)     The rpEnabled variable for the RPs controlled by
                        this object are not held in the FALSE state,
                        thus enabling them to pay attention to received
                        CNMs.
            false(2)    The rpEnabled variable for the RPs controlled by
                        this object are held in the FALSE state, thus
                        disabling them from paying attention to received
                        CNMs.
       "
    REFERENCE
       "32.11.1, 32.13.1"
    DEFVAL { true }
    ::= { ieee8021CnRpGroupEntry 5 }

ieee8021CnRpgTimeReset
 OBJECT-TYPE
    SYNTAX      TimeInterval
    UNITS       "milliseconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the value for all of the state machine
        variables, rpgTimeReset, used to reset the timers RpWhile.
       "
    REFERENCE
       "32.11.2"
    DEFVAL { 15 }
```

```
    ::= { ieee8021CnRpGroupEntry 6 }

ieee8021CnRpgByteReset
 OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "octets"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the value for all of the state machine
        variables, rpgByteReset, used to reset the counters
        rpByteCount.
       "
    REFERENCE
       "32.11.3"
    DEFVAL { 150000 }
    ::= { ieee8021CnRpGroupEntry 7 }

ieee8021CnRpgThreshold
 OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the number of times rpByteStage or
        rpTimeStage can count before the
        RP rate control state machine advances states.
       "
    REFERENCE
       "32.11.4"
    DEFVAL { 5 }
    ::= { ieee8021CnRpGroupEntry 8 }

ieee8021CnRpgMaxRate
 OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "Mb/s"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the maximum rate, in multiples of 1 Mb/s,
        at which an RP can transmit. Default value is the speed of the
        port. A system SHALL support a minimum  value for this object
        that is no larger than 5 Mbits/s (object value 5). This rate
        includes all bits consequent to transmitting the frame on the
        LAN, including preamble, inter-frame gap, etc.
       "
    REFERENCE
       "32.11.5"
    ::= { ieee8021CnRpGroupEntry 9 }

ieee8021CnRpgAiRate
 OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "Mb/s"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the transmission rate increment in the
        RPR_ACTIVE_INCREASE state (rpgAiRate) in multiples of 1 Mb/s.
        This rate includes all bits consequent to transmitting the
        frame on the LAN, including preamble, inter-frame gap, etc.
       "
    REFERENCE
       "32.11.6"
    DEFVAL { 5 }
    ::= { ieee8021CnRpGroupEntry 10 }

ieee8021CnRpgHaiRate
 OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "Mb/s"
```

```
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the transmission rate increment in the
        RPR_HYPER_INCREASE state (rpgHaiRate) in multiples of 1 Mb/s.
        This rate includes all bits consequent to transmitting the
        frame on the LAN, including preamble, inter-frame gap, etc.
       "
    REFERENCE
       "32.11.7"
    DEFVAL { 50 }
    ::= { ieee8021CnRpGroupEntry 11 }

ieee8021CnRpgGd
 OBJECT-TYPE
    SYNTAX      Integer32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the number of bits that the value of the
        Quantized Feedback field received in a CNM PDU is shifted to
        the right to decrease rpTargetRate. rpgGd is thus 2 to the
        negative power of this object, e.g., 7 means rpgGd = 1/128.
       "
    REFERENCE
       "32.11.8"
    DEFVAL { 7 }
    ::= { ieee8021CnRpGroupEntry 12 }

ieee8021CnRpgMinDecFac
 OBJECT-TYPE
    SYNTAX      Unsigned32 (1..100)
    UNITS       "percent"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the minimum factor by which the current
        RP transmit rate rpCurrentRate can be changed by reception
        of a Congestion Notification Message.  Its integer value
        represents a percentage, from 1% to 100%.
       "
    REFERENCE
       "32.11.9"
    DEFVAL { 50 }
    ::= { ieee8021CnRpGroupEntry 13 }

ieee8021CnRpgMinRate
 OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "Mb/s"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "This object controls the minimum transmission rate (rpgMinRate)
        in multiples of 1 Mb/s.  A system SHALL support a value for
        this object that is no larger than 5 Mb/s per second.
        This rate includes all bits consequent to transmitting the
        frame on the LAN, including preamble, inter-frame gap, etc.
       "
    REFERENCE
       "32.11.10"
    DEFVAL { 5 }
    ::= { ieee8021CnRpGroupEntry 14 }



-- ****************************************************************
-- IEEE 802.1Qau MIB Module - Conformance Information
-- ****************************************************************

ieee8021CnCompliances
 OBJECT IDENTIFIER ::= { ieee8021CnConformance 1 }
```

```
ieee8021CnGroups
      OBJECT IDENTIFIER ::= { ieee8021CnConformance 2 }

-- ****************************************************************
-- Units of conformance
-- ****************************************************************

ieee8021CnGlobalReqdGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnGlobalMasterEnable,
      ieee8021CnComPriLldpInstanceChoice,
      ieee8021CnComPriLldpInstanceSelector
    }
    STATUS      current
    DESCRIPTION
       "Objects in the global required group."
    ::= { ieee8021CnGroups 1 }

ieee8021CnCpGlobalGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnGlobalCnmTransmitPriority,
      ieee8021CnGlobalDiscardedFrames
    }
    STATUS      current
    DESCRIPTION
       "Objects in the Congestion Point global group."
    ::= { ieee8021CnGroups 2 }

ieee8021CnCpidTranslateGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnCpidToIfComponentId,
      ieee8021CnCpidToIfIfIndex,
      ieee8021CnCpidToIfCpIndex
    }
    STATUS      current
    DESCRIPTION
       "Objects in the CPID translate group."
    ::= { ieee8021CnGroups 3 }

ieee8021CnEplGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnEpIfIndex
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Errored Ports Table group."
    ::= { ieee8021CnGroups 4 }

ieee8021CnComPriGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnComPriDefModeChoice,
      ieee8021CnComPriAdminDefenseMode,
      ieee8021CnComPriCreation,
      ieee8021CnComPriRowStatus
    }
    STATUS      current
    DESCRIPTION
       "Objects for the global per-priority group."
    ::= { ieee8021CnGroups 5 }

ieee8021CnCpPriGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnComPriAlternatePriority,
      ieee8021CnComPriAutoAltPri
    }
    STATUS      current
```

```
    DESCRIPTION
       "Objects for the Congestion Point per-priority group."
    ::= { ieee8021CnGroups 6 }

ieee8021CnGlobalPriPortGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnPortPriDefModeChoice,
      ieee8021CnPortPriAdminDefenseMode,
      ieee8021CnPortPriAutoDefenseMode,
      ieee8021CnPortPriLldpInstanceChoice,
      ieee8021CnPortPriLldpInstanceSelector
    }
    STATUS      current
    DESCRIPTION
       "Objects for the global per-priority per-port group."
    ::= { ieee8021CnGroups 7 }

ieee8021CnCpPriPortGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnPortPriAlternatePriority
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Congestion Point per-priority per-port
        group.
       "
    ::= { ieee8021CnGroups 8 }

ieee8021CnCpGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnCpPriority,
      ieee8021CnCpMacAddress,
      ieee8021CnCpIdentifier,
      ieee8021CnCpQueueSizeSetPoint,
      ieee8021CnCpFeedbackWeight,
      ieee8021CnCpMinSampleBase,
      ieee8021CnCpDiscardedFrames,
      ieee8021CnCpTransmittedFrames,
      ieee8021CnCpTransmittedCnms,
      ieee8021CnCpMinHeaderOctets
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Congestion Point group."
    ::= { ieee8021CnGroups 9 }

ieee8021CnRpppGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnRpPortPriMaxRps,
      ieee8021CnRpPortPriCreatedRps,
      ieee8021CnRpPortPriCentiseconds
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Reaction Point per-Port per-priority group."
    ::= { ieee8021CnGroups 10 }

ieee8021CnRpGroup
 OBJECT-GROUP
    OBJECTS {
      ieee8021CnRpgEnable,
      ieee8021CnRpgTimeReset,
      ieee8021CnRpgByteReset,
      ieee8021CnRpgThreshold,
      ieee8021CnRpgMaxRate,
      ieee8021CnRpgAiRate,
      ieee8021CnRpgHaiRate,
      ieee8021CnRpgGd,
```

```
      ieee8021CnRpgMinDecFac,
      ieee8021CnRpgMinRate
    }
    STATUS      current
    DESCRIPTION
       "Objects for the Reaction Point group."
    ::= { ieee8021CnGroups 11 }


-- ****************************************************************
-- MIB Module Compliance statements
-- ****************************************************************

ieee8021CnBridgeCompliance
 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support by a Bridge of
        the IEEE8021-MIRP-MIB module."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE IF-MIB -- The interfaces MIB, RFC 2863
        MANDATORY-GROUPS {
            ifGeneralInformationGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021CnGlobalReqdGroup,
            ieee8021CnCpGlobalGroup,
            ieee8021CnCpidTranslateGroup,
            ieee8021CnEplGroup,
            ieee8021CnComPriGroup,
            ieee8021CnCpPriGroup,
            ieee8021CnGlobalPriPortGroup,
            ieee8021CnCpPriPortGroup,
            ieee8021CnCpGroup
         }

    OBJECT ieee8021CnComPriRowStatus
      SYNTAX       RowStatus { active(1), notInService(2),
                               notReady(3) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { ieee8021CnCompliances 1 }

ieee8021CnStationCompliance
 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support by an end station of
        the IEEE8021-MIRP-MIB module."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE IF-MIB -- The interfaces MIB, RFC 2863
        MANDATORY-GROUPS {
            ifGeneralInformationGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021CnGlobalReqdGroup,
```

```
            ieee8021CnComPriGroup,
            ieee8021CnGlobalPriPortGroup,
            ieee8021CnRpppGroup,
            ieee8021CnRpGroup
         }

    GROUP ieee8021CnCpGlobalGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    GROUP ieee8021CnCpidTranslateGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    GROUP ieee8021CnEplGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    GROUP ieee8021CnCpPriGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    GROUP ieee8021CnCpPriPortGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    GROUP ieee8021CnCpGroup
        DESCRIPTION
           "This group is optional and supports end stations that
            choose to implement Congestion Points."

    ::= { ieee8021CnCompliances 2 }
END
```

17.7.14 Definitions for the IEEE8021-SRP-MIB module

```
IEEE8021-SRP-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for support of IEEE 802.1Qat Stream Reservation Protocol
-- (SRP) in IEEE 802.1Q Bridges.
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Counter64,
    Unsigned32
        FROM SNMPv2-SMI
    MacAddress,
    TEXTUAL-CONVENTION,
    TruthValue
        FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee802dot1mibs,
    IEEE8021PriorityCodePoint,
    IEEE8021VlanIndex
        FROM IEEE8021-TC-MIB
    IEEE8021FqtssTrafficClassValue
        FROM IEEE8021-FQTSS-MIB
    ieee8021BridgeBaseComponentId,
    ieee8021BridgeBaseEntry,
    ieee8021BridgeBasePort,
    ieee8021BridgeBasePortEntry
        FROM IEEE8021-BRIDGE-MIB

    ;

ieee8021SrpMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        the IEEE Std 802.1Q Stream Reservation Protocol.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201810040000Z" -- October 4, 2018
    DESCRIPTION
            "Published as part of IEEE 802.1Qcc-2018.
                      Added managed objects for Stream Reservation
                      Protocol (SRP) Enhancements and Performance
                      Improvements"
```

```
    REVISION "201806280000Z" -- June 28, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018.
            Cross references updated. "

    REVISION "201512020000Z" -- December 2, 2015
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2014 Cor-1.
            ieee8021SrpReservationFailureBridgeId changed to
            ieee8021SrpReservationFailureSystemId."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION     "201102270000Z" -- February 27, 2011
    DESCRIPTION
         "Minor edits to contact information etc. as part of
          2011 revision of Std 802.1Q."

    REVISION     "201004190000Z" -- April 19, 2010
    DESCRIPTION
         "Initial revision, included in IEEE 802.1Qat"
    ::= { ieee802dot1mibs 19 }

-- ================================================================
-- Textual Conventions
-- ================================================================

IEEE8021SrpStreamRankValue ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "An 802.1 SRP Stream Rank value. This is an integer,
         with the following interpretation placed on the value:

         0: Emergency, high-rank stream,
         1: Non-emergency stream."
    REFERENCE    "35.2.2.8.5b"
    SYNTAX       INTEGER {
                     emergency(0),
                     nonEmergency(1)
                 }


IEEE8021SrpStreamIdValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "1x:1x:1x:1x:1x:1x.1x:1x"
    STATUS       current
    DESCRIPTION
            "Represents an SRP Stream ID, which is often defined
            as a MAC Address followed by a unique 16-bit ID."
    SYNTAX       OCTET STRING (SIZE (8))

IEEE8021SrpReservationDirectionValue ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "An 802.1 SRP Stream Reservation Direction value. This is
         an integer, with the following interpretation placed on
         the value:

         0: Talker registrations,
         1: Listener registrations."
    REFERENCE    "35.2.1.2"
    SYNTAX       INTEGER {
                     talkerRegistrations(0),
                     listenerRegistrations(1)
                 }


IEEE8021SrpReservationDeclarationTypeValue ::= TEXTUAL-CONVENTION
    STATUS       current
```

```
    DESCRIPTION
        "An 802.1 SRP Stream Reservation Declaration Type value.
         This is an integer, with the following interpretation
         placed on the value:

         0: Talker Advertise,
         1: Talker Failed,
         2: Listener Asking Failed,
         3: Listener Ready,
         4: Listener Ready Failed."
    REFERENCE    "35.2.1.3"
    SYNTAX       INTEGER {
                     talkerAdvertise(0),
                     talkerFailed(1),
                     listenerAskingFailed(2),
                     listenerReady(3),
                     listenerReadyFailed(4)
                 }


IEEE8021SrpReservationFailureCodeValue ::= TEXTUAL-CONVENTION
    STATUS       current
    DESCRIPTION
        "An 802.1 SRP Stream Reservation Failure Code value.
         This is an integer, with the following interpretation
         placed on the value:

         0: No failure,
         1: Insufficient bandwidth,
         2: Insufficient Bridge resources,
         3: Insufficient bandwidth for Traffic Class,
         4: StreamID in use by another Talker,
         5: Stream destination address already in use,
         6: Stream pre-empted by higher rank,
         7: Reported latency has changed,
         8: Egress port is not AVBCapable,
         9: Use a different destination_address,
         10: Out of MSRP resources,
         11: Out of MMRP resources,
         12: Cannot store destination_address,
         13: Requested priority is not an SR Class priority,
         14: MaxFrameSize is too large for media,
         15: maxFanInPorts limit has been reached,
         16: Changes in FirstValue for a registered StreamID,
         17: VLAN is blocked on this egress port (Registration Forbidden),
         18: VLAN tagging is disabled on this egress port (untagged set),
         19: SR class priority mismatch."
    REFERENCE    "35.2.2.8.7"
    SYNTAX       INTEGER {
                    noFailure(0),
                    insufficientBandwidth(1),
                    insufficientResources(2),
                    insufficientTrafficClassBandwidth(3),
                    streamIDInUse(4),
                    streamDestinationAddressInUse(5),
                    streamPreemptedByHigherRank(6),
                    latencyHasChanged(7),
                    egressPortNotAVBCapable(8),
                    useDifferentDestinationAddress(9),
                    outOfMSRPResources(10),
                    outOfMMRPResources(11),
                    cannotStoreDestinationAddress(12),
                    priorityIsNoAnSRCLass(13),
                    maxFrameSizeTooLarge(14),
                    maxFanInPortsLimitReached(15),
                    firstValueChangedForStreamID(16),
                    vlanBlockedOnEgress(17),
                    vlanTaggingDisabledOnEgress(18),
                    srClassPriorityMismatch(19)
                }
```

```
-- ============================================================
-- subtrees in the SRP MIB
-- ============================================================

ieee8021SrpNotifications
    OBJECT IDENTIFIER ::= { ieee8021SrpMib 0 }

ieee8021SrpObjects
    OBJECT IDENTIFIER ::= { ieee8021SrpMib 1 }

ieee8021SrpConformance
    OBJECT IDENTIFIER ::= { ieee8021SrpMib 2 }

ieee8021SrpConfiguration
    OBJECT IDENTIFIER ::= { ieee8021SrpObjects 1 }

ieee8021SrpLatency
    OBJECT IDENTIFIER ::= { ieee8021SrpObjects 2 }

ieee8021SrpStreams
    OBJECT IDENTIFIER ::= { ieee8021SrpObjects 3 }

ieee8021SrpReservations
    OBJECT IDENTIFIER ::= { ieee8021SrpObjects 4 }


-- ============================================================
-- The ieee8021SrpConfiguration subtree
-- This subtree defines the objects necessary for the
-- operational management of SRP.
-- ============================================================

ieee8021SrpBridgeBaseTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpBridgeBaseEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table for SRP main control and status information.
        All writable objects in this table must be persistent
        over power up restart/reboot.  These objects augment
        the ieee8021BridgeBasePortTable."
    ::= { ieee8021SrpConfiguration 1 }

ieee8021SrpBridgeBaseEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpBridgeBaseEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "SRP control and status information for a Bridge."
    AUGMENTS { ieee8021BridgeBaseEntry }
    ::= { ieee8021SrpBridgeBaseTable 1 }

Ieee8021SrpBridgeBaseEntry ::=
    SEQUENCE {
         ieee8021SrpBridgeBaseMsrpEnabledStatus
            TruthValue,
         ieee8021SrpBridgeBaseMsrpTalkerPruning
            TruthValue,
         ieee8021SrpBridgeBaseMsrpMaxFanInPorts
            Unsigned32,
         ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize
            Unsigned32,
         ieee8021SrpBridgeBaseMsrpTalkerVlanPruning
            TruthValue,
         ieee8021SrpBridgeBaseMsrpMaxSRClasses
            Unsigned32
    }

ieee8021SrpBridgeBaseMsrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
```

```
    DESCRIPTION
        "The administrative status requested by management for
        MSRP.  The value true(1) indicates that MSRP should
        be enabled on this device, in all VLANs, on all ports
        for which it has not been specifically disabled.  When
        false(2), MSRP is disabled, in all VLANs and on all
        ports, and all MSRP frames will be forwarded
        transparently.  This objects affects both Applicant and
        Registrar state machines.  A transition from false(2)
        to true(1) will cause a reset of all MSRP state
        machines on all ports.

        This object may be modified while the corresponding
        instance of ieee8021BridgeBaseRowStatus is active(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "35.2.1.4d"
    DEFVAL      { true }
    ::= { ieee8021SrpBridgeBaseEntry 1 }

ieee8021SrpBridgeBaseMsrpTalkerPruning OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value of the talkerPruning parameter, which
        controls the propagation of Talker declarations.
        The value true(1) indicates that Talker attributes
        are only declared on ports that have the Stream
        destination_address registered in the MMRP MAC
        Address Registration Entries.  When false(2),
        Talker attribute are declared on all egress ports
        in the active topology.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.22.1, 35.2.1.4b, 35.2.4.3.1"
    DEFVAL      { false }
    ::= { ieee8021SrpBridgeBaseEntry 2 }

ieee8021SrpBridgeBaseMsrpMaxFanInPorts OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value of the msrpMaxFanInPorts parameter, which
        limits the total number of ports on a Bridge that
        are allowed to establish reservations for inbound
        Streams.  A value of zero (0) indicates no fan-in
        limit is being specified and calculations involving
        fan-in will only be limited by the number of MSRP
        enabled ports.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.22.1, 35.2.1.4f"
    DEFVAL      { 0 }
    ::= { ieee8021SrpBridgeBaseEntry 3 }

ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value of msrpLatencyMaxFrameSize parameter
        which is used in the calculation of the maximum
        latency through a Bridge.  The maximum size is
        defined to be 2000 octets by default, but may be
        set to a smaller or larger value dependent on the
        particular Bridge configuration. This parameter
        does not imply any type of policing of frame size,
```

```
        it is only used in the latency calculations.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.22.1, 35.2.1.4g"
    DEFVAL      { 2000 }
    ::= { ieee8021SrpBridgeBaseEntry 4 }

ieee8021SrpBridgeBaseMsrpTalkerVlanPruning OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This parameter allows to limit the Talker declaration
        to ports, that have the Stream's VLAN identifier
        registered as a member in the VLAN Registration
        Entries. The value true(1) indicates that Talker
        declarations are only sent out on ports, that have the
        Stream's VLAN identifier registered as a member in the
        VLAN Registration Entries. When false(2), Talker
        declarations are propagated according to the VLAN
        spanning tree."
    REFERENCE   "12.22.1, 35.2.1.4l"
    DEFVAL      { false }
    ::= { ieee8021SrpBridgeBaseEntry 5 }

ieee8021SrpBridgeBaseMsrpMaxSRClasses OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the maximum number of SR classes
        supported by the Bridge."
    REFERENCE   "12.22.1, 35.2.1.4m"
    ::= { ieee8021SrpBridgeBaseEntry 6 }


ieee8021SrpBridgePortTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpBridgePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table for SRP control and status information about
        every Bridge Port.  Augments the ieee8021BridgeBasePortTable."
    ::= { ieee8021SrpConfiguration 2 }

ieee8021SrpBridgePortEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpBridgePortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "SRP control and status information for a Bridge Port."
    AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021SrpBridgePortTable 1 }

Ieee8021SrpBridgePortEntry ::=
    SEQUENCE {
        ieee8021SrpBridgePortMsrpEnabledStatus
            TruthValue,
        ieee8021SrpBridgePortMsrpFailedRegistrations
            Counter64,
        ieee8021SrpBridgePortMsrpLastPduOrigin
            MacAddress,
        ieee8021SrpBridgePortSrPvid
            IEEE8021VlanIndex,
        ieee8021SrpBridgePortMsrpTalkerPrunningPerPort
        TruthValue
    }

ieee8021SrpBridgePortMsrpEnabledStatus OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
```

```
    STATUS      current
    DESCRIPTION
        "The administrative state of MSRP operation on this port.  The
        value true(1) indicates that MSRP is enabled on this port
        in all VLANs as long as ieee8021BridgeMsrpEnabledStatus is
        also true(1).  A value of false(2) indicates that MSRP is
        disabled on this port in all VLANs: any MSRP frames received
        will be silently discarded, and no MSRP registrations will be
        propagated from other ports.  Setting this to a value of
        true(1) will be stored by the agent but will only take
        effect on the MSRP protocol operation if
        ieee8021BridgeMsrpEnabledStatus
        also indicates the value true(1).  This object affects
        all MSRP Applicant and Registrar state machines on this
        port.  A transition from false(2) to true(1) will
        cause a reset of all MSRP state machines on this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "35.2.1.4e"
    DEFVAL      { true }
    ::= { ieee8021SrpBridgePortEntry 1 }

ieee8021SrpBridgePortMsrpFailedRegistrations OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "failed MSRP registrations"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The total number of failed MSRP registrations, for any
        reason, in all VLANs, on this port.

        Discontinuities in the value of the counter can occur at
        re-initialization of the management system, and at other
        times as indicated by the value of ifCounterDiscontinuityTime
        object of the associated interface (if any)."
    REFERENCE   "10.7.12.1"
    ::= { ieee8021SrpBridgePortEntry 2 }

ieee8021SrpBridgePortMsrpLastPduOrigin OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Source MAC Address of the last MSRP message
        received on this port."
    REFERENCE   "10.7.12.2"
    ::= { ieee8021SrpBridgePortEntry 3 }

ieee8021SrpBridgePortSrPvid OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The default VLAN ID that Streams are assigned to.
        Talkers learn this VID from the SRP Domain attribute
        and tag Streams accordingly.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "35.2.2.8.3b"
    DEFVAL      { 2 }
    ::= { ieee8021SrpBridgePortEntry 4}

ieee8021SrpBridgePortMsrpTalkerPrunningPerPort OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "This parameter controls the forwarding behavior for
        Talker declarations on the port when the TalkerPruning
        parameter is disabled for the bridge. The value true(1)
```

```
        indicates, that Talker declarations are only forwarded
        on that port, if the destination_address of the Stream
        is found in the MAC Address Registration Entries for the
        port. When false(2), Talker declarations are forwarded
        on that port regardless of the destination address."
    REFERENCE   "12.22.2, 35.2.1.4k"
    DEFVAL      { false }
    ::= { ieee8021SrpBridgePortEntry 5 }

-- ============================================================
-- The ieee8021SrpLatency subtree
-- This subtree defines the objects necessary for retrieving
-- the latency of the various traffic classes on a port.
-- ============================================================

-- ============================================================
-- the ieee8021SrpLatencyTable
-- ============================================================
ieee8021SrpLatencyTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpLatencyEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of latency measurement
        parameters for each traffic class."
    REFERENCE   "35.2.2.8.6"
    ::= { ieee8021SrpLatency 1 }

ieee8021SrpLatencyEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpLatencyEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing latency information
        for each traffic class. Rows in the table are
        automatically created for ports that are not an
        SRP domain boundary port (i.e. SRPdomainBoundaryPort
        is FALSE). See 35.1.4, 8.8.2, 12.22.3."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021SrpTrafficClass  }
    ::= { ieee8021SrpLatencyTable 1 }

Ieee8021SrpLatencyEntry ::=
    SEQUENCE {
        ieee8021SrpTrafficClass
            IEEE8021FqtssTrafficClassValue,
        ieee8021SrpPortTcLatency
            Unsigned32
        }

ieee8021SrpTrafficClass OBJECT-TYPE
    SYNTAX      IEEE8021FqtssTrafficClassValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The traffic class number associated with the
        row of the table.

        Rows in the table are automatically created for
        ports that are not an SRP domain boundary port
        (i.e. SRPdomainBoundaryPort is FALSE)."
    REFERENCE   "35.1.4, 8.8.2, 12.22.3"
    ::= { ieee8021SrpLatencyEntry 1 }


ieee8021SrpPortTcLatency OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nano-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
```

```
        "The value of the portTcMaxLatency parameter for the
        traffic class.  This value is expressed in
        nano-seconds."
    REFERENCE   "35.2.1.4, 35.2.2.8.6"
    ::= { ieee8021SrpLatencyEntry 2 }


-- ============================================================
-- The ieee8021SrpStreams subtree
-- This subtree defines the objects necessary for retrieving
-- the characteristics of the various Streams currently registered.
-- ============================================================

-- ============================================================
-- the ieee8021SrpStreamTable
-- ============================================================
ieee8021SrpStreamTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpStreamEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of characteristics
        for each registered Stream."
    REFERENCE   "35.2.2.8"
    ::= { ieee8021SrpStreams 1 }

ieee8021SrpStreamEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpStreamEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing characteristics
        for each registered Stream. Rows in the table are
        automatically created for Streams registered on any
        port of a Bridge."
    INDEX  { ieee8021SrpStreamId }
    ::= { ieee8021SrpStreamTable 1 }

Ieee8021SrpStreamEntry ::=
    SEQUENCE {
        ieee8021SrpStreamId
            IEEE8021SrpStreamIdValue,
        ieee8021SrpStreamDestinationAddress
            MacAddress,
        ieee8021SrpStreamVlanId
            IEEE8021VlanIndex,
        ieee8021SrpStreamTspecMaxFrameSize
            Unsigned32,
        ieee8021SrpStreamTspecMaxIntervalFrames
            Unsigned32,
        ieee8021SrpStreamDataFramePriority
            IEEE8021PriorityCodePoint,
        ieee8021SrpStreamRank
            IEEE8021SrpStreamRankValue
        }

ieee8021SrpStreamId OBJECT-TYPE
    SYNTAX      IEEE8021SrpStreamIdValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Stream ID associated with the row of the table.

        Rows in the table are automatically created when
        Streams are registered via MSRP."
    REFERENCE   "35.2.2.8.2"
    ::= { ieee8021SrpStreamEntry 1 }

ieee8021SrpStreamDestinationAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
        "The MAC destination address for the Stream described
        by this reservation."
    REFERENCE   "35.2.2.8.3a"
    ::= { ieee8021SrpStreamEntry 2}

ieee8021SrpStreamVlanId OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The VLAN ID associated with the MSRP registration
        for this Stream."
    REFERENCE   "35.2.2.8.3b"
    ::= { ieee8021SrpStreamEntry 3}

ieee8021SrpStreamTspecMaxFrameSize OBJECT-TYPE
    SYNTAX      Unsigned32 (0..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum size frame that will be sent by
        a Talker for this Stream. This value is part
        of the Traffic Specification for the Stream."
    REFERENCE   "35.2.2.8.4a"
    ::= { ieee8021SrpStreamEntry 4}

ieee8021SrpStreamTspecMaxIntervalFrames OBJECT-TYPE
    SYNTAX      Unsigned32 (0..65535)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum number of frame that will be sent
        during a class measurement interval (L.2).  This
        value is part of the Traffic Specification for
        the Stream."
    REFERENCE   "35.2.2.8.4b, L.2"
    ::= { ieee8021SrpStreamEntry 5}

ieee8021SrpStreamDataFramePriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityCodePoint
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Priority Code Point (PCP) value that the
        referenced Stream will be tagged with. This value
        is used to distinguish Class A and Class B traffic."
    REFERENCE   "35.2.2.8.5a"
    ::= { ieee8021SrpStreamEntry 6}

ieee8021SrpStreamRank OBJECT-TYPE
    SYNTAX      IEEE8021SrpStreamRankValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "SRP supports emergency and non-emergency.
        Emergency traffic will interrupt non-emergency
        traffic if there is insufficient bandwidth or
        resources available for the emergency traffic."
    REFERENCE   "35.2.2.8.5b"
    ::= { ieee8021SrpStreamEntry 7}


    -- ============================================================
    -- the ieee8021SrpStreamPreloadTable
    -- ============================================================
    ieee8021SrpStreamPreloadTable OBJECT-TYPE
        SYNTAX      SEQUENCE OF Ieee8021SrpStreamPreloadEntry
        MAX-ACCESS  not-accessible
        STATUS      current
        DESCRIPTION
            "A table containing a set of parameters for each StreamID
```

```
        that is preloaded on the Bridge as it initializes."
    REFERENCE   "12.22.6"
    ::= { ieee8021SrpStreams 2 }

ieee8021SrpStreamPreloadEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpStreamPreloadEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing characteristics
        for each registered Stream. Rows in the table are
        automatically created for Streams registered on any
        port of a Bridge."
    INDEX  { ieee8021SrpStreamPreloadId }
    ::= { ieee8021SrpStreamPreloadTable 1 }

Ieee8021SrpStreamPreloadEntry ::=
    SEQUENCE {
        ieee8021SrpStreamPreloadId
            IEEE8021SrpStreamIdValue,
        ieee8021SrpStreamPreloadDestinationAddress
            MacAddress,
        ieee8021SrpStreamPreloadVlanId
            IEEE8021VlanIndex,
        ieee8021SrpStreamPreloadTspecMaxFrameSize
            Unsigned32,
        ieee8021SrpStreamPreloadTspecMaxIntervalFrames
            Unsigned32,
        ieee8021SrpStreamPreloadDataFramePriority
            IEEE8021PriorityCodePoint,
        ieee8021SrpStreamPreloadRank
            IEEE8021SrpStreamRankValue
        }

ieee8021SrpStreamPreloadId OBJECT-TYPE
    SYNTAX      IEEE8021SrpStreamIdValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The 64-bit StreamID is used to match Talker
        registrations with their corresponding Listener
        registrations(35.2.4)."
    REFERENCE   "12.22.6, 35.2.2.8.2"
    ::= { ieee8021SrpStreamPreloadEntry 1 }

ieee8021SrpStreamPreloadDestinationAddress OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The MAC destination address for the Stream described
        by this reservation."
    REFERENCE   "12.22.6, 35.2.2.8.3a"
    ::= { ieee8021SrpStreamPreloadEntry 2}

ieee8021SrpStreamPreloadVlanId OBJECT-TYPE
    SYNTAX      IEEE8021VlanIndex
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The VLAN ID associated with the MSRP registration
        for this Stream."
    REFERENCE   "12.22.6, 35.2.2.8.3b"
    ::= { ieee8021SrpStreamPreloadEntry 3}

ieee8021SrpStreamPreloadTspecMaxFrameSize OBJECT-TYPE
    SYNTAX      Unsigned32 (0..65535)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The maximum size frame that will be sent by
        a Talker for this Stream. This value is part
```

```
            of the Traffic Specification for the Stream."
        REFERENCE   "12.22.6, 35.2.2.8.4a"
        ::= { ieee8021SrpStreamPreloadEntry 4}

    ieee8021SrpStreamPreloadTspecMaxIntervalFrames OBJECT-TYPE
        SYNTAX      Unsigned32 (0..65535)
        MAX-ACCESS  read-write
        STATUS      current
        DESCRIPTION
            "The maximum number of frames that the Talker may
            transmit in one classMeasurementInterval (34.3).
            This value is part of the Traffic Specification
            for the Stream."
        REFERENCE   "12.22.6, 35.2.2.8.4b"
        ::= { ieee8021SrpStreamPreloadEntry 5}

    ieee8021SrpStreamPreloadDataFramePriority OBJECT-TYPE
        SYNTAX      IEEE8021PriorityCodePoint
        MAX-ACCESS  read-write
        STATUS      current
        DESCRIPTION
            "The Priority Code Point (PCP) value that the
            referenced Stream will be tagged with. This value
            is used to distinguish Class A and Class B traffic."
        REFERENCE   "12.22.6, 35.2.2.8.5a"
        ::= { ieee8021SrpStreamPreloadEntry 6}

    ieee8021SrpStreamPreloadRank OBJECT-TYPE
        SYNTAX      IEEE8021SrpStreamRankValue
        MAX-ACCESS  read-write
        STATUS      current
        DESCRIPTION
            "SRP supports emergency and non-emergency.
            Emergency traffic will interrupt non-emergency
            traffic if there is insufficient bandwidth or
            resources available for the emergency traffic."
        REFERENCE   "12.22.6, 35.2.2.8.5b"
        ::= { ieee8021SrpStreamPreloadEntry 7}


-- ================================================================
-- The ieee8021SrpReservations subtree
-- This subtree defines the objects necessary for retrieving
-- the Stream attribute registrations on each port of a Bridge.
-- ================================================================

-- ================================================================
-- the ieee8021SrpReservationsTable
-- ================================================================
ieee8021SrpReservationsTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpReservationsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing Stream attribute
        registrations per port."
    REFERENCE   "35.2.4"
    ::= { ieee8021SrpReservations 1 }

ieee8021SrpReservationsEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpReservationsEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Stream attribute
        registrations per port. Rows in the table are
        automatically created for Streams registered on any
        port of a Bridge."
    INDEX  { ieee8021SrpReservationStreamId,
             ieee8021SrpReservationDirection,
             ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort }
```

```
    ::= { ieee8021SrpReservationsTable 1 }

Ieee8021SrpReservationsEntry ::=
    SEQUENCE {
        ieee8021SrpReservationStreamId
            IEEE8021SrpStreamIdValue,
        ieee8021SrpReservationDirection
            IEEE8021SrpReservationDirectionValue,
        ieee8021SrpReservationDeclarationType
            IEEE8021SrpReservationDeclarationTypeValue,
        ieee8021SrpReservationAccumulatedLatency
            Unsigned32,
        ieee8021SrpReservationFailureSystemId
            OCTET STRING,
        ieee8021SrpReservationFailureCode
            IEEE8021SrpReservationFailureCodeValue,
        ieee8021SrpReservationDroppedStreamFrames
            Counter64,
        ieee8021SrpReservationStreamAge
            Unsigned32
        }

ieee8021SrpReservationStreamId OBJECT-TYPE
    SYNTAX      IEEE8021SrpStreamIdValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The Stream ID associated with the row of the table.

        Rows in the table are automatically created when
        Streams are registered via MSRP."
    REFERENCE   "35.2.2.8.2"
    ::= { ieee8021SrpReservationsEntry 1 }

ieee8021SrpReservationDirection OBJECT-TYPE
    SYNTAX      IEEE8021SrpReservationDirectionValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The source of this Stream registration, either
        Talker or Listener."
    REFERENCE   "35.2.1.2"
    ::= { ieee8021SrpReservationsEntry 2 }

ieee8021SrpReservationDeclarationType OBJECT-TYPE
    SYNTAX      IEEE8021SrpReservationDeclarationTypeValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The type of Talker or Listener registration."
    REFERENCE   "35.2.1.3"
    ::= { ieee8021SrpReservationsEntry 3 }

ieee8021SrpReservationAccumulatedLatency OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nano-seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The Accumulated Latency associated with the current
        registration.

        For Talker registrations this represents the accumulated
        latency from the Talker to the ingress port of this
        Bridge.

        For Listener registrations this represents the accumulated
        latency to the ingress port of the neighbor Bridge or
        end stations. This include the latency of the media
        attached to this egress port."
    REFERENCE   "35.2.2.8.6"
    ::= { ieee8021SrpReservationsEntry 4 }
```

```
ieee8021SrpReservationFailureSystemId OBJECT-TYPE
    SYNTAX      OCTET STRING(SIZE(8))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The first system that changes a Talker Advertise to a
        Talker Failed registration will report its System
        Identification in this field. That single System
        Identification is then propagated from system to system."
    REFERENCE   "35.2.2.8.7a"
    ::= { ieee8021SrpReservationsEntry 5 }

ieee8021SrpReservationFailureCode OBJECT-TYPE
    SYNTAX      IEEE8021SrpReservationFailureCodeValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The first Bridge that changes a Talker Advertise to a
        Talker Failed registration will report the Failure Code
        in this field. That single Failure Code is then propagated
        from Bridge to Bridge."
    REFERENCE   "35.2.2.8.7b"
    ::= { ieee8021SrpReservationsEntry 6 }

ieee8021SrpReservationDroppedStreamFrames OBJECT-TYPE
    SYNTAX      Counter64
    UNITS       "frames"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A count of the number of data stream frames that have
        been dropped for whatever reason.  These are not MSRP
        frames, but the stream data frames that are carried by
        the MSRP Reservation.

        Discontinuities in the value of the counter can occur at
        re-initialization of the management system, and at other
        times as indicated by the value of ifCounterDiscontinuityTime
        object of the associated interface (if any)."
     REFERENCE   "35.2.5.1"
    ::= { ieee8021SrpReservationsEntry 7 }

ieee8021SrpReservationStreamAge OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "seconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The number of seconds since the reservation was established
        on this port."
    REFERENCE   "35.2.1.4c"
    ::= { ieee8021SrpReservationsEntry 8 }


-- ============================================================
-- the ieee8021SrpReservationsPreloadTable
-- ============================================================
ieee8021SrpReservationsPreloadTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021SrpReservationsPreloadEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing Stream attribute
        registrations per port."
    REFERENCE   "12.22.7"
    ::= { ieee8021SrpReservations 2 }

ieee8021SrpReservationsPreloadEntry OBJECT-TYPE
    SYNTAX      Ieee8021SrpReservationsPreloadEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
        "A list of objects containing Stream attribute
        registrations per port. Rows in the table are
        automatically created for Streams registered on any
        port of a Bridge."
    INDEX  { ieee8021SrpReservationsPreloadStreamId,
             ieee8021SrpReservationPreloadDirection,
             ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort }
    ::= { ieee8021SrpReservationsPreloadTable 1 }

Ieee8021SrpReservationsPreloadEntry ::=
    SEQUENCE {
        ieee8021SrpReservationsPreloadStreamId
            IEEE8021SrpStreamIdValue,
        ieee8021SrpReservationPreloadDirection
            IEEE8021SrpReservationDirectionValue,
        ieee8021SrpReservationPreloadAccumulatedLatency
            Unsigned32
        }

ieee8021SrpReservationsPreloadStreamId OBJECT-TYPE
    SYNTAX      IEEE8021SrpStreamIdValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The 64-bit StreamID is used to match Talker
        registrations with their corresponding Listener
        registrations(35.2.4)."
    REFERENCE   "12.22.7, 35.2.2.8.2"
    ::= { ieee8021SrpReservationsPreloadEntry 1 }

ieee8021SrpReservationPreloadDirection OBJECT-TYPE
    SYNTAX      IEEE8021SrpReservationDirectionValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The source of this Stream registration, either
        Talker or Listener"
    REFERENCE   "12.22.7, 35.2.1.1"
    ::= { ieee8021SrpReservationsPreloadEntry 2 }

ieee8021SrpReservationPreloadAccumulatedLatency OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nano-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The Accumulated Latency associated with the current
        registration.

        For Talker registrations this represents the accumulated
        latency from the Talker to the ingress port of this
        Bridge.

        For Listener registrations this represents the accumulated
        latency to the ingress port of the neighbor Bridge or
        end stations. This include the latency of the media
        attached to this egress port."
    REFERENCE   "12.22.7, 35.2.2.8.6"
    ::= { ieee8021SrpReservationsPreloadEntry 3 }


-- ============================================================
-- IEEE8021 SRP MIB - Conformance Information
-- ============================================================

ieee8021SrpCompliances
    OBJECT IDENTIFIER ::= { ieee8021SrpConformance 1 }
ieee8021SrpGroups
    OBJECT IDENTIFIER ::= { ieee8021SrpConformance 2 }
```

```
-- ============================================================
-- units of conformance
-- ============================================================

-- ============================================================
-- the ieee8021SrpConfiguration group
-- ============================================================

ieee8021SrpConfigurationGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpBridgeBaseMsrpEnabledStatus,
        ieee8021SrpBridgeBaseMsrpTalkerPruning,
        ieee8021SrpBridgeBaseMsrpMaxFanInPorts,
        ieee8021SrpBridgeBaseMsrpLatencyMaxFrameSize,
        ieee8021SrpBridgeBaseMsrpTalkerVlanPruning,
        ieee8021SrpBridgeBaseMsrpMaxSRClasses,
        ieee8021SrpBridgePortMsrpEnabledStatus,
        ieee8021SrpBridgePortMsrpFailedRegistrations,
        ieee8021SrpBridgePortMsrpLastPduOrigin,
        ieee8021SrpBridgePortSrPvid,
        ieee8021SrpBridgePortMsrpTalkerPrunningPerPort
    }
    STATUS      current
    DESCRIPTION
        "Objects that define configuration of SRP."
    ::= { ieee8021SrpGroups 1 }

-- ============================================================
-- the ieee8021SrpLatency group
-- ============================================================

ieee8021SrpLatencyGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpPortTcLatency
    }
    STATUS      current
    DESCRIPTION
        "Objects that define latency for SRP."
    ::= { ieee8021SrpGroups 2 }

-- ============================================================
-- the ieee8021SrpStreams group
-- ============================================================

ieee8021SrpStreamsGroup OBJECT-GROUP
    OBJECTS {
        -- ieee8021SrpStreamId,
        ieee8021SrpStreamDestinationAddress,
        ieee8021SrpStreamVlanId,
        ieee8021SrpStreamTspecMaxFrameSize,
        ieee8021SrpStreamTspecMaxIntervalFrames,
        ieee8021SrpStreamDataFramePriority,
        ieee8021SrpStreamRank
    }
    STATUS      current
    DESCRIPTION
        "Objects that define Streams for SRP."
    ::= { ieee8021SrpGroups 3 }

-- ============================================================
-- the ieee8021SrpReservations group
-- ============================================================

ieee8021SrpReservationsGroup OBJECT-GROUP
    OBJECTS {
        -- ieee8021SrpReservationStreamId,
        -- ieee8021SrpReservationDirection,
        ieee8021SrpReservationDeclarationType,
        ieee8021SrpReservationAccumulatedLatency,
        ieee8021SrpReservationFailureSystemId,
        ieee8021SrpReservationFailureCode,
        ieee8021SrpReservationDroppedStreamFrames,
```

```
        ieee8021SrpReservationStreamAge
    }
    STATUS      current
    DESCRIPTION
        "Objects that define Stream Reservations for SRP."
    ::= { ieee8021SrpGroups 4 }

-- ============================================================
-- the ieee8021SrpConfigurationPruning group
-- ============================================================

ieee8021SrpConfigurationPruningGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpBridgeBaseMsrpTalkerVlanPruning,
        ieee8021SrpBridgePortMsrpTalkerPrunningPerPort
    }
    STATUS      current
    DESCRIPTION
        "Objects that allow configuration of pruning behavior
        for SRP."
    ::= { ieee8021SrpGroups 5 }

-- ============================================================
-- the ieee8021SrpMonitoringSRclasses group
-- ============================================================

ieee8021SrpMonitoringSRclassesGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpBridgeBaseMsrpMaxSRClasses
    }
    STATUS      current
    DESCRIPTION
        "Objects that provides information on the maximum number
        of SR classes supported on the Bridge."
    ::= { ieee8021SrpGroups 6 }

-- ============================================================
-- the ieee8021SrpStreamsPreload group
-- ============================================================

ieee8021SrpStreamsPreloadGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpStreamPreloadId,
        ieee8021SrpStreamPreloadDestinationAddress,
        ieee8021SrpStreamPreloadVlanId,
        ieee8021SrpStreamPreloadTspecMaxFrameSize,
        ieee8021SrpStreamPreloadTspecMaxIntervalFrames,
        ieee8021SrpStreamPreloadDataFramePriority,
        ieee8021SrpStreamPreloadRank
    }
    STATUS      current
    DESCRIPTION
        "Objects that allow to preload parameters for each
        StreamId on Bridge Ports as the Bridge initializes."
    ::= { ieee8021SrpGroups 7 }

-- ============================================================
-- the ieee8021SrpReservationsPreload group
-- ============================================================

ieee8021SrpReservationsPreloadGroup OBJECT-GROUP
    OBJECTS {
        ieee8021SrpReservationsPreloadStreamId,
        ieee8021SrpReservationPreloadDirection,
        ieee8021SrpReservationPreloadAccumulatedLatency
    }
    STATUS      current
    DESCRIPTION
        "Objects that allow to initialize Streams within each
        Bridge as it powers up, to preload the Stream
        registrations that will later be provided by operation
        of SRP."
```

```
    ::= { ieee8021SrpGroups 8 }

-- ============================================================
-- compliance statements
-- ============================================================

ieee8021SrpCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        Stream Reservation Protocol.

        Support of the objects defined in the IEEE8021-SRP MIB
        also requires support of the IEEE8021-BRIDGE-MIB; the
        provisions of 17.3.2 apply to implementations claiming
        support of the IEEE8021-SRP MIB."

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021SrpConfigurationGroup,
            ieee8021SrpLatencyGroup,
            ieee8021SrpStreamsGroup,
            ieee8021SrpReservationsGroup
        }

    GROUP   ieee8021SrpConfigurationPruningGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow configuration of pruning behavior for SRP."

    GROUP   ieee8021SrpMonitoringSRclassesGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow configuration of pruning behavior for SRP."

    GROUP   ieee8021SrpStreamsPreloadGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow to preload parameters for each StreamId on
        Bridge Ports as the Bridge initializes."

    GROUP   ieee8021SrpReservationsPreloadGroup
    DESCRIPTION
        "Implementation of this group is optional. Implementation
        will allow to initialize Streams within each Bridge as it
        powers up, to preload the Stream registrations that will
        later be provided by operation of SRP."

    ::= { ieee8021SrpCompliances 1 }

END
```

17.7.15 Definitions for the IEEE8021-MVRPX-MIB module

```
IEEE8021-MVRPX-MIB
 DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE P802.1Q(TM) Multiple VLAN Registration Protocol Extension MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE
          FROM SNMPv2-SMI    -- [RFC2578]
    TruthValue
           FROM SNMPv2-TC     -- [RFC2579]
    MODULE-COMPLIANCE,
    OBJECT-GROUP         FROM SNMPv2-CONF   -- [RFC2580]
    systemGroup
          FROM SNMPv2-MIB    -- [RFC3418]
    ieee8021BridgeBasePortEntry

                         FROM IEEE8021-BRIDGE-MIB -- IEEE Std 802.1Q
   ;

ieee8021MvrpxMib
 MODULE-IDENTITY
    LAST-UPDATED "202103050000Z" -- March 5, 2021
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
       "Multiple VLAN Registration Protocol extension module for
        managing MVRP extensions defined in IEEE Std 802.1Q

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202103050000Z" -- March 5, 2021
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

   REVISION       "201104050000Z"    -- (YYYYMMDDHHMM Zulu=GMT)
   DESCRIPTION
      "Included in IEEE Std 802.1Qbe-2011

       Copyright (C) IEEE (2011)."
    ::= { iso(1) org(3) ieee(111)
```

```
         standards-association-numbers-series-standards (2)
         lan-man-stds (802) ieee802dot1 (1) ieee802dot1mibs (1) 22 }

ieee8021MvrpxMIBObjects
   OBJECT IDENTIFIER ::= { ieee8021MvrpxMib 1 }
ieee8021MvrpxConformance
  OBJECT IDENTIFIER ::= { ieee8021MvrpxMib 2 }



-- ============================================================
-- MVRP extension augmentation of the Generic Bridge Port Table
-- ============================================================

ieee8021MvrpxPortTable
 OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021MvrpxPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A table that contains controls for the Multiple VLAN
        Registration Protocol (MVRP) state machines for all of the Ports
        of a Bridge."
    REFERENCE   "12.9.2"
    ::= { ieee8021MvrpxMIBObjects 1 }

ieee8021MvrpxPortEntry
 OBJECT-TYPE
    SYNTAX Ieee8021MvrpxPortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each entry contains the MVRP Registrar controls for one Port."
AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021MvrpxPortTable 1 }

Ieee8021MvrpxPortEntry
 ::= SEQUENCE {
        ieee8021MvrpxPortNewOnly             TruthValue,
        ieee8021MvrpxPortMvrpNewPropagated   TruthValue,
        ieee8021MvrpxPortXmitZero            TruthValue
    }

ieee8021MvrpxPortNewOnly
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The mode of operation of the MVRP state machines on
        this port, if enabled.  The value of this object and the value
        of the individual Port+Attribute type enable object
        ieee8021QBridgePortMvrpEnabledStatus combine to control the
        state machines as follows:

        ieee8021MvrpxPortNewOnly
                             ieee8021QBridgePortMvrpEnabledStatus
                                                  MVRP state machines

        not implemented      true(1)             Full participant
        false(2)             true(1)             Full participant
        true(1)              true(1)             New-only participant
        not implemented      false(2)            MVRP disabled
        false(2)             false(2)            MVRP disabled
        true(1)              false(2)            MVRP disabled

        This object affects all MVRP Applicant and Registrar state
        machines on this port. A change to the value of this object
        will cause a reset of all MVRP state machines for this attribute
        type on this port.

        The value of this object MUST be retained across
```

```
        reinitializations of the management system."
    REFERENCE   "12.9.2.1.3, 12.9.2.2.2"
    DEFVAL      { false }
    ::= { ieee8021MvrpxPortEntry 1 }

ieee8021MvrpxPortMvrpNewPropagated
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The mode of operation of the MVRP on this port, if enabled.
        If this object contains the value true(1), then all Static VLAN
        Registration Entries that are Registration Fixed are treated as
        Registration Fixed (New propagated), and if false(2), as
        Registration Fixed (New ignored)

        This object affects only the MVRP Applicant and Registrar state
        machines on this port. A change to the value of this object
        will cause a reset of all MVRP state machines on this port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.7.7.1.2:d, 12.7.7.3.3:d"
    DEFVAL      { false }
    ::= { ieee8021MvrpxPortEntry 2 }

ieee8021MvrpxPortXmitZero
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "Selects whether MVRP is enabled to transmit 0 as the attribute
        value for the one VLAN ID for which this Port is in the untagged
        set, true(1) to enable transmit 0, and false(2) to transmit the
        VLAN ID.  The value 0 is not transmitted unless
        ieee8021MvrpxPortNewOnly is true(1).

        This feature is optional.  If not supported, the system SHALL
        NOT allow this object to be set to the value true(1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.9.2.1.3:c, 12.9.2.2.2:e, 11.2.3.1.7"
    DEFVAL      { false }
    ::= { ieee8021MvrpxPortEntry 3 }



-- ****************************************************************
-- IEEE 802.1Qbe MVRP extension Module - Conformance Information
-- ****************************************************************

ieee8021MvrpxCompliances
     OBJECT IDENTIFIER
    ::= { ieee8021MvrpxConformance 1 }
ieee8021MvrpxGroups
          OBJECT IDENTIFIER
    ::= { ieee8021MvrpxConformance 2 }



-- ****************************************************************
-- Units of conformance
-- ****************************************************************

ieee8021MvrpxReqdGroup
 OBJECT-GROUP
    OBJECTS {
        ieee8021MvrpxPortNewOnly,
        ieee8021MvrpxPortMvrpNewPropagated,
```

```
        ieee8021MvrpxPortXmitZero
    }
    STATUS current
    DESCRIPTION
       "Objects in the MVRP extension augmentation table required
        group."
    ::= { ieee8021MvrpxGroups 1 }



-- ****************************************************************
-- MIB Module Compliance statements
-- ****************************************************************

ieee8021MvrpxCompliance
 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support by a Bridge of
        the IEEE8021-MVRPX-MIB module."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021MvrpxReqdGroup
        }

    ::= { ieee8021MvrpxCompliances 1 }

END
```

17.7.16 Definitions for the IEEE8021-MIRP-MIB module

```
IEEE8021-MIRP-MIB
 DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE P802.1Q(TM) Multiple I-SID Registration Protocol MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE
              FROM SNMPv2-SMI    -- [RFC2578]
    TruthValue
               FROM SNMPv2-TC     -- [RFC2579]
    MODULE-COMPLIANCE,
    OBJECT-GROUP             FROM SNMPv2-CONF   -- [RFC2580]
    systemGroup
              FROM SNMPv2-MIB    -- [RFC3418]
    VlanIdOrNone
             FROM Q-BRIDGE-MIB  -- [RFC4363]
    IEEE8021BridgePortNumberOrZero

                              FROM IEEE8021-TC-MIB  -- IEEE Std 802.1ap
    ieee8021PbbBackboneEdgeBridgeObjects

                              FROM IEEE8021-PBB-MIB -- IEEE Std 802.1ap
    ieee8021BridgeBasePortEntry

                         FROM IEEE8021-BRIDGE-MIB -- IEEE Std 802.1ap
   ;

ieee8021MirpMib
 MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
       "The Bridge MIB module for managing devices that support the
        Multiple I-SID Registration Protocol module for IEEE 802.1Q Bridges

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Description, cross references, and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
```

```
            Objects renamed and attached to the proper MIB arc.
            NOTE THAT the original MIB version incorrectly
            attached new objects to the CN MIB arc. The old objects
            and object names SHOULD NOT be used. The old names/objects
            concerned are:
            ieee8021MirpMIBObjects
            ieee8021MirpConformance
            ieee8021MirpPortTable
            ieee8021MirpCompliances
            ieee8021MirpGroups"

   REVISION       "2011040500002"    -- (YYYYMMDDHHMM Zulu=GMT)
   DESCRIPTION
      "Included in IEEE Std 802.1Qbe-2011

         Copyright (C) IEEE Std 802.1."
    ::= { iso(1) org(3) ieee(111)
         standards-association-numbers-series-standards (2)
         lan-man-stds (802) ieee802dot1 (1) ieee802dot1mibs (1) 23 }

ieee8021MirpV2MIBObjects
    OBJECT IDENTIFIER ::= { ieee8021MirpMib 1 }
ieee8021MirpV2Conformance
   OBJECT IDENTIFIER ::= { ieee8021MirpMib 2 }


-- ================================================================
-- MIRP augmentation of the Generic Bridge Port Table
-- ================================================================

ieee8021MirpV2PortTable
 OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021MirpV2PortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A table that contains controls for the Multiple I-SID
        Registration Protocol (MIRP) state machines for all of the Ports
        of a Bridge."
    REFERENCE   "12.9.2"
    ::= { ieee8021MirpV2MIBObjects 1 }

ieee8021MirpV2PortEntry
 OBJECT-TYPE
    SYNTAX Ieee8021MirpV2PortEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each entry contains the MIRP Participant controls for one Port."
AUGMENTS { ieee8021BridgeBasePortEntry }
    ::= { ieee8021MirpV2PortTable 1 }

Ieee8021MirpV2PortEntry
 ::= SEQUENCE {
        ieee8021MirpV2PortEnabledStatus           TruthValue
    }

ieee8021MirpV2PortEnabledStatus
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The state of MIRP operation on this port. The value
        true(1) indicates that MIRP is enabled on this port,
        as long as ieee8021PbbMirpEnableStatus is also enabled
        for this component. When false(2) but
        ieee8021PbbMirpEnableStatus is still
        enabled for the device, MIRP is disabled on this port.

        If MIRP is enabled on a VIP, then the MIRP Participant is
        enabled on that VIP's PIP.  If MIRP is enabled on none of the
```

```
        VIPs on a PIP, then the MIRP Participant on the PIP is
        disabled; any MIRP packets received will be silently discarded,
        and no MIRP registrations will be propagated from the PIP. A
        transition from all VIPs on a PIP false(2) to at least one VIP
        on the PIP true(1) will cause a reset of all MIRP state
        machines on this PIP.

        If MIRP is enabled on any port not a VIP, then the MIRP
        Participant is enabled on that port.  If MIRP is
        disabled on a non-VIP port, then MIRP packets received will be
        silently discarded, and no MIRP registrations will be
        propagated from the port.  A transition from false(2) to
        true(1) will cause a reset of all  MIRP state machines on a
        non-VIP port.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.7.7.1, 12.7.7.2, 39.2.1.11"
    DEFVAL      { true }
    ::= { ieee8021MirpV2PortEntry 1 }



-- ============================================================
-- MIRP augmentation of BEB subtree
-- ============================================================


ieee8021PbbMirpEnableStatus
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The administrative status requested by management for
        MIRP. The value true(1) indicates that MIRP should be enabled
        on this component, on all ports for which it has not been
        specifically disabled. When false(2), MIRP is disabled on all
        ports. This object affects all MIRP Applicant and Registrar
        state machines. A transition from false(2) to true(1) will
        cause a reset of all MIRP state machines on all ports.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "12.16.1.1.3:i, 12.16.1.2.2:b"
    DEFVAL      { false }
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 7 }

ieee8021PbbMirpBvid
 OBJECT-TYPE
    SYNTAX      VlanIdOrNone
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "The B-VID to which received MIRPDUs are to be assigned, or 0,
        if they are to be sent on the CBP PVID."
    REFERENCE   "12.14.7.7.2 j),12.14.7.7.2 c)"
    DEFVAL      { 0 }
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 8 }

ieee8021PbbMirpDestSelector
 OBJECT-TYPE
    SYNTAX      INTEGER {
                    cbpMirpGroup (1),
                    cbpMirpVlan  (2),
                    cbpMirpTable (3)
                }
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "An enumerated value specifying what destination_address and
        vlan_identifier are to be used when the MIRP Participant
```

```
        transmits an MIRPDU towards the MAC relay entity:

            cbpMirpGroup (1) Use the Nearest Customer Bridge group
                             address from Table 8-1 with the MIRP B-VID.
            cbpMirpVlan  (2) Use the Nearest Customer Bridge group
                             address from Table 8-1 with the Backbone
                             VLAN Identifier field from the Backbone
                             Service Instance table.
            cbpMirpTable (3) Use the Default Backbone Destination and
                             Backbone VLAN Identifier fields from the
                             Backbone Service Instance table.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "Table 8-1, 12.14.7.7.2 k), 12.14.7.7.2 d)"
    DEFVAL      { cbpMirpGroup }
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 9 }

ieee8021PbbMirpPnpEnable
 OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
       "A Boolean value specifying the administrative status requested
        by management for attaching a MIRP Participant to a PNP if
        and only if this system is a Backbone Edge Bridge (BEB):

        true(1)  The BEB is to attach a MIRP Participant to exactly one
                 Port, either a management Port with no LAN connection
                 external to the BEB, or a PNP.
        false(2) No MIRP Participant is to be present on any PNP (or
                 on the MAC Relay-facing side of a CBP).

        The value of this object MUST be retained across
        reinitializations of the management system.
       "
    REFERENCE   "12.14.7.7.2 j),12.14.7.7.2 c)"
    DEFVAL      { true }
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 10 }

ieee8021PbbMirpPnpPortNumber
 OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumberOrZero
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
       "The Bridge Port Number of the Provider Network Port (PNP) that
        has an associated MIRP Participant, or 0, if no Bridge Port has
        an associated MIRP Participant. This object indexes an entry in
        the Bridge Port Table.  The system SHALL ensure that either
        ieee8021PbbMirpPnpPortNumber contains 0, or that the indexed
        ieee8021BridgeBasePortType object contains the value
        providerNetworkPort(3)."
    REFERENCE   "12.14.7.7.2 j), 12.14.7.7.2 c)"
    DEFVAL      { 0 }
    ::= { ieee8021PbbBackboneEdgeBridgeObjects 11 }




-- ****************************************************************
-- IEEE 802.1Qbe MIB Module - Conformance Information
-- ****************************************************************

ieee8021MirpV2Compliances
     OBJECT IDENTIFIER
    ::= { ieee8021MirpV2Conformance 1 }
ieee8021MirpV2Groups
          OBJECT IDENTIFIER
    ::= { ieee8021MirpV2Conformance 2 }
```

```
-- ********************************************************************
-- Units of conformance
-- ********************************************************************

ieee8021MirpV2ReqdGroup
 OBJECT-GROUP
    OBJECTS {
        ieee8021MirpV2PortEnabledStatus,
        ieee8021PbbMirpEnableStatus,
        ieee8021PbbMirpBvid,
        ieee8021PbbMirpDestSelector,
        ieee8021PbbMirpPnpEnable,
        ieee8021PbbMirpPnpPortNumber
    }
    STATUS current
    DESCRIPTION
       "Objects in the MIRP augmentation required group."
    ::= { ieee8021MirpV2Groups 1 }

-- ********************************************************************
-- MIB Module Compliance statements
-- ********************************************************************

ieee8021MirpV2BridgeCompliance
 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support by a Bridge of
        the IEEE8021-MIRP-MIB module."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021MirpV2ReqdGroup
        }

    ::= { ieee8021MirpV2Compliances 1 }

END
```

17.7.17 Definitions for the IEEE8021-PFC-MIB module

```
IEEE8021-PFC-MIB DEFINITIONS ::= BEGIN

-- ****************************************************************
-- IEEE P802.1Q(TM) Priority-based Flow Control MIB
-- ****************************************************************

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Counter32,
    Unsigned32               FROM SNMPv2-SMI    -- [RFC2578]
    ieee802dot1mibs          FROM IEEE8021-TC-MIB
    MODULE-COMPLIANCE,
    OBJECT-GROUP             FROM SNMPv2-CONF   -- [RFC2580]
    ifEntry,
    ifGeneralInformationGroup
                             FROM IF-MIB        -- [RFC2863]
    systemGroup              FROM SNMPv2-MIB    -- [RFC3418]
   ;

ieee8021PFCMib MODULE-IDENTITY
    LAST-UPDATED "202103050000Z" -- March 5, 2021
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
   DESCRIPTION
     "Priority-based Flow Control module for IEEE Std 802.1Q.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202103050000Z" -- March 5, 2021
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

   REVISION       "201002080000Z"    -- 02/08/2010 00:00GMT
   DESCRIPTION
      "Included in IEEE P802.1Qbb

        Copyright (C) IEEE."
    ::= { ieee802dot1mibs 21 }


ieee8021PfcMIBObjects      OBJECT IDENTIFIER ::= { ieee8021PFCMib 1 }
ieee8021PfcConformance     OBJECT IDENTIFIER ::= { ieee8021PFCMib 2 }
```

```
ieee8021PfcIfTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PfcIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "A table of PFC information for all interfaces of a system."
    REFERENCE
       "12.22.6"
    ::= { ieee8021PfcMIBObjects 1 }

ieee8021PfcIfEntry OBJECT-TYPE
    SYNTAX      Ieee8021PfcIfEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "Each entry contains information about
        the PFC function on a single interface."
    REFERENCE
       "12.22.6"
    AUGMENTS { ifEntry }
    ::= { ieee8021PfcIfTable 1 }

Ieee8021PfcIfEntry ::= SEQUENCE {
        ieee8021PfcLinkDelayAllowance       Unsigned32,
        ieee8021PfcRequests                 Counter32,
        ieee8021PfcIndications              Counter32
    }

ieee8021PfcLinkDelayAllowance    OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The allowance made for round-trip propagation delay
        of the link in bits.

        The value of this object MUST be retained across
        reinitializations of the management system."
    ::= { ieee8021PfcIfEntry 1 }

ieee8021PfcRequests    OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "Requests"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A count of the invoked PFC M_CONTROL.request primitives.

         Discontinuities in the value of this counter can occur at
         re-initialization of the management system, and at other
         times as indicated by the value of
         ifCounterDiscontinuityTime."
    ::= { ieee8021PfcIfEntry 2 }

ieee8021PfcIndications    OBJECT-TYPE
    SYNTAX      Counter32
    UNITS       "Indications"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A count of the received PFC M_CONTROL.indication primitives.

         Discontinuities in the value of this counter can occur at
         re-initialization of the management system, and at other
         times as indicated by the value of
         ifCounterDiscontinuityTime."
    ::= { ieee8021PfcIfEntry 3 }


-- ****************************************************************
```

```
-- IEEE 802.1Qbb MIB Module - Conformance Information
-- ********************************************************************

   ieee8021PfcCompliances
       OBJECT IDENTIFIER ::= { ieee8021PfcConformance 1 }
   ieee8021PfcGroups
       OBJECT IDENTIFIER ::= { ieee8021PfcConformance 2 }


-- ********************************************************************
-- Units of conformance
-- ********************************************************************

ieee8021PfcGlobalReqdGroup OBJECT-GROUP
    OBJECTS {
      ieee8021PfcLinkDelayAllowance,
      ieee8021PfcRequests,
      ieee8021PfcIndications
    }
    STATUS      current
    DESCRIPTION
       "Objects in the global required group."
    ::= { ieee8021PfcGroups 1 }


-- ********************************************************************
-- MIB Module Compliance statements
-- ********************************************************************

ieee8021PfcCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
       "The compliance statement for support by a system of
        the IEEE8021-PFC-MIB module."

    MODULE SNMPv2-MIB -- The SNMPv2-MIB, RFC 3418
        MANDATORY-GROUPS {
            systemGroup
        }

    MODULE IF-MIB -- The interfaces MIB, RFC 2863
        MANDATORY-GROUPS {
            ifGeneralInformationGroup
        }

    MODULE
        MANDATORY-GROUPS {
            ieee8021PfcGlobalReqdGroup
        }
    ::= { ieee8021PfcCompliances 1 }


END
```

17.7.18 Definitions for the IEEE8021-TEIPS-V2-MIB module

```
IEEE8021-TEIPS-V2-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for IEEE 802.1Q TEIPS Devices
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    NOTIFICATION-TYPE,
    OBJECT-TYPE,
    Unsigned32
        FROM SNMPv2-SMI
    RowStatus,
    StorageType,
    TruthValue
        FROM SNMPv2-TC
    ieee802dot1mibs,
    IEEE8021BridgePortNumber,
    IEEE8021TeipsIpgConfigActiveRequests,
    IEEE8021TeipsIpgid,
    IEEE8021TeipsIpgConfigAdmin,
    IEEE8021PbbTeTSidId
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId
        FROM IEEE8021-BRIDGE-MIB
    MODULE-COMPLIANCE,
    NOTIFICATION-GROUP,
    OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021TeipsV2Mib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"

    DESCRIPTION
       "MIB Module for managing systems that provide Provider
        Backbone Bridge Traffic Engineering (PBB-TE) Infrastructure
        Segment Protection.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
```

```
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            Module and object names changed to V2 and base arc
            changed from 24 to 27 to remove conflicting OID
            allocation (see comments below). The old version of
            this MIB, and its object names, SHOULD NOT BE USED."

    REVISION "201108170000Z" -- (YYYYMMDDHHMM Zulu=GMT)

    DESCRIPTION
      "Version 1 of the TEIPS MIB module based upon IEEE 802.1Qbf"
    ::= { iso(1) org(3) ieee(111)
         standards-association-numbers-series-standards (2)
         lan-man-stds (802) ieee802dot1 (1) ieee802dot1mibs (1) 27 }

--
-- An earlier version of this MIB was
-- inadvertently published under the wrong root arc:
-- { iso(1) org(3) ieee(111)
--    standards-association-numbers-series-standards (2)
--    lan-man-stds (802) ieee802dot1 (1) ieee802dot1mibs (1) 24 }
-- That version of the MIB, and its object names, SHOULD NOT BE USED.
--

ieee8021TeipsV2Notifications OBJECT IDENTIFIER ::= { ieee8021TeipsV2Mib 0 }
ieee8021TeipsV2Objects       OBJECT IDENTIFIER ::= { ieee8021TeipsV2Mib 1 }
ieee8021TeipsV2Conformance   OBJECT IDENTIFIER ::= { ieee8021TeipsV2Mib 2 }

--
--TEIPS MIB Objects
--

-- ============================================================
-- the ieee8021TeipsV2IpgTable
-- ============================================================
ieee8021TeipsV2IpgTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021TeipsV2IpgEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The IPG table.  Each entry in this table corresponds to an
        Infrastructure Protection Group (IPG) associated with a PBB
        supporting Infrastructure Protection Switching (IPS)."
    REFERENCE
        "12.24.1"
    ::= { ieee8021TeipsV2Objects 1 }

ieee8021TeipsV2IpgEntry OBJECT-TYPE
    SYNTAX Ieee8021TeipsV2IpgEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The IPG table entry."
    INDEX {ieee8021BridgeBaseComponentId,
           ieee8021TeipsV2Ipgid }
    ::= { ieee8021TeipsV2IpgTable 1 }

Ieee8021TeipsV2IpgEntry ::=
    SEQUENCE {
        ieee8021TeipsV2Ipgid                    IEEE8021TeipsIpgid,
        ieee8021TeipsV2IpgWorkingMA             Unsigned32,
        ieee8021TeipsV2IpgProtectionMA          Unsigned32,
        ieee8021TeipsV2IpgWorkingPortNumber     IEEE8021BridgePortNumber,
        ieee8021TeipsV2IpgProtectionPortNumber  IEEE8021BridgePortNumber,
        ieee8021TeipsV2IpgStorageType           StorageType,
        ieee8021TeipsV2IpgRowStatus             RowStatus
    }

ieee8021TeipsV2Ipgid OBJECT-TYPE
    SYNTAX      IEEE8021TeipsIpgid
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
         "Uniquely identifies an IPG within the PBB."
    REFERENCE
        "12.24.1.1.3 a"
    ::= { ieee8021TeipsV2IpgEntry 1 }


ieee8021TeipsV2IpgWorkingMA OBJECT-TYPE
    SYNTAX     Unsigned32
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "Identifies the Segment MA that corresponds to
        the IPG's working entity.  The MA index in
        this column must hold a value that is the
        value of dot1agCfmStackMaIndex column for
        some entry in the dot1agCfmStackTable before
        the RowStatus for this row can be set to
        Active.  Furthermore, this column may not be
        modified when the RowStatus for this row is
        Active."
    REFERENCE
        "12.24.1.1.3 b)"
::= { ieee8021TeipsV2IpgEntry 2 }

ieee8021TeipsV2IpgProtectionMA OBJECT-TYPE
    SYNTAX     Unsigned32
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "Identifies the Segment MA that corresponds to the
        IPG's protection entity.  The MA index in this
        column must hold a value that is the value of
        dot1agCfmStackMaIndex column for some entry in
        the dot1agCfmStackTable before the RowStatus
        for this row can be set to Active.  Furthermore,
        this column may not be modified when the
        RowStatus for this row is Active."
    REFERENCE
        "12.24.1.1.3 c)"
::= { ieee8021TeipsV2IpgEntry 3 }

ieee8021TeipsV2IpgWorkingPortNumber OBJECT-TYPE
    SYNTAX     IEEE8021BridgePortNumber
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
       "Identifies the local Port associated with the
        IPG Working Segment."
    REFERENCE
        "12.24.1.1.3 b)"
::= { ieee8021TeipsV2IpgEntry 4 }

ieee8021TeipsV2IpgProtectionPortNumber OBJECT-TYPE
    SYNTAX     IEEE8021BridgePortNumber
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
       "Identifies the local Port associated with the
        IPG Protection Segment."
    REFERENCE
        "12.24.1.1.3 c)"
::= { ieee8021TeipsV2IpgEntry 5 }

ieee8021TeipsV2IpgStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this
        entry. All read-create columns must be
        writable if this column is set to permanent."
```

```
    DEFVAL { nonVolatile }
    ::= { ieee8021TeipsV2IpgEntry 6 }

ieee8021TeipsV2IpgRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "The status of this row.
        The writable columns in a row cannot be
        changed if the row is active.  The
        TeipsIpgWorkingMA and TeipsIpgProtectionMA
        columns must be specified before the row
        can be activated."
    REFERENCE
        "12.24.1.2"
    ::= { ieee8021TeipsV2IpgEntry 7 }

-- ============================================================
-- the ieee8021TeipsV2TesiTable
-- ============================================================
ieee8021TeipsV2TesiTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021TeipsV2TesiEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The IPG TE-SID table contains identifies
         the TE service instances associated with
         an IPG."
    REFERENCE
        "12.24.2.1.3 e)"
    ::= { ieee8021TeipsV2Objects 2 }

ieee8021TeipsV2TesiEntry  OBJECT-TYPE
    SYNTAX     Ieee8021TeipsV2TesiEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The TE-IPS TESI entry.  Each entry identifies
         a TESI associated with an IPG."
    INDEX { ieee8021TeipsV2Ipgid,
      ieee8021TeipsV2TesiIndex }
    ::= { ieee8021TeipsV2TesiTable 1 }

Ieee8021TeipsV2TesiEntry ::=
    SEQUENCE {
        ieee8021TeipsV2TesiIndex       Unsigned32,
        ieee8021TeipsV2TesiId          IEEE8021PbbTeTSidId,
        ieee8021TeipsV2TesiStorageType StorageType,
        ieee8021TeipsV2TesiRowStatus   RowStatus
    }

ieee8021TeipsV2TesiIndex OBJECT-TYPE
    SYNTAX     Unsigned32 (1..4294967295)
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This is an identifier, of local significance to a
         particular PBB-TE TE-SID associated with an IPG."
    REFERENCE
        "12.24.2.1.3 e"
    ::= { ieee8021TeipsV2TesiEntry 1 }

ieee8021TeipsV2TesiId OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeTSidId
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the TESI identifier corresponding
         to a TE service instance associated with an IPG."
    REFERENCE
        "12.24.2.1.3 e"
```

```
    ::= { ieee8021TeipsV2TesiEntry 2 }

ieee8021TeipsV2TesiStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence of this
        entry. All read-create columns must be
        writable for permanent rows."
    DEFVAL { nonVolatile }
    ::= { ieee8021TeipsV2TesiEntry 3 }

ieee8021TeipsV2TesiRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.
         When the status is active, no columns of
         this table may be modified.  All columns
         must have a valid value before the row
         can be activated."
    ::= { ieee8021TeipsV2TesiEntry 4 }

-- ============================================================
-- the ieee8021TeipsV2CandidatePsTable
-- ============================================================
ieee8021TeipsV2CandidatePsTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021TeipsV2CandidatePsEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The Candidate PS table lists, in priority order,
         from highest priority to lowest priority, the
         Maintenance Associations corresponding to
         candidate Protection Segments associated with
         an IPG."
    REFERENCE
        "12.24.2.1.3 d)"
    ::= { ieee8021TeipsV2Objects 3 }

ieee8021TeipsV2CandidatePsEntry  OBJECT-TYPE
    SYNTAX     Ieee8021TeipsV2CandidatePsEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "A Candidate PS entry.  Each entry identifies a
         candidate Protection Segment associated with an IPG."
    INDEX { ieee8021TeipsV2Ipgid,
      ieee8021TeipsV2CandidatePsIndex }
    ::= { ieee8021TeipsV2CandidatePsTable 1 }

Ieee8021TeipsV2CandidatePsEntry ::=
    SEQUENCE {
        ieee8021TeipsV2CandidatePsIndex Unsigned32,
        ieee8021TeipsV2CandidatePsMA    Unsigned32,
        ieee8021TeipsV2CandidatePsPort  IEEE8021BridgePortNumber,
        ieee8021TeipsV2CandidatePsOper        TruthValue,
        ieee8021TeipsV2CandidatePsStorageType StorageType,
        ieee8021TeipsV2CandidatePsRowStatus   RowStatus
    }

ieee8021TeipsV2CandidatePsIndex OBJECT-TYPE
    SYNTAX     Unsigned32 (1..4294967295)
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This is an identifier, of local significance
         to a particular candidate Protection Segment
         associated with an IPG."
    REFERENCE
```

```
        "12.24.2.1.3 d)"
    ::= { ieee8021TeipsV2CandidatePsEntry 1 }

ieee8021TeipsV2CandidatePsMA OBJECT-TYPE
    SYNTAX     Unsigned32
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the candidate Protection
         Segment MA corresponding to a candidate
         Protection Segment associated with an IPG."
    REFERENCE
        "12.24.2.1.3 d)"
    ::= { ieee8021TeipsV2CandidatePsEntry 2 }

ieee8021TeipsV2CandidatePsPort OBJECT-TYPE
    SYNTAX     IEEE8021BridgePortNumber
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column holds the Port Number
         corresponding to the candidate Protection
         Segment associated with an IPG."
    REFERENCE
        "12.24.2.1.3 d)"
    ::= { ieee8021TeipsV2CandidatePsEntry 3 }

ieee8021TeipsV2CandidatePsOper OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates whether or not
         the candidate Protection Segment is
         operational."
    REFERENCE
        "12.24.2.1.3 d)"
    ::= { ieee8021TeipsV2CandidatePsEntry 4 }

ieee8021TeipsV2CandidatePsStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
       "This object indicates the persistence
        of this entry. All read-create
        columns must be writable for permanent rows."
    DEFVAL { nonVolatile }
    ::= { ieee8021TeipsV2CandidatePsEntry 5 }

ieee8021TeipsV2CandidatePsRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.
         When the status is active, no columns
         of this table may be modified.  All
         columns must have a valid value before the row
         can be activated."
    ::= { ieee8021TeipsV2CandidatePsEntry 6 }

-- ============================================================
-- the ieee8021TeipsV2IpgConfigTable
-- ============================================================
ieee8021TeipsV2IpgConfigTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021TeipsV2IpgConfigEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The PBB-TE IPS IPG config table contains
         configuration and status information for
```

```
          each IPG configured in the system.
          Entries in this table are created implicitly
          by the creation of entries in the
          ieee8021TeipsV2IpgTable."
      REFERENCE
          "12.24.2.1.3 f,g,h,i,j,k)"
      ::= { ieee8021TeipsV2Objects 4 }

ieee8021TeipsV2IpgConfigEntry OBJECT-TYPE
    SYNTAX     Ieee8021TeipsV2IpgConfigEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The IPG configuration table entry.  Rows are
         created in this table implicitly when a row
         is added to the ieee8021TeipsV2IpgTable."
    INDEX { ieee8021BridgeBaseComponentId,
            ieee8021TeipsV2Ipgid }
    ::= { ieee8021TeipsV2IpgConfigTable 1 }

Ieee8021TeipsV2IpgConfigEntry ::=
    SEQUENCE {
        ieee8021TeipsV2IpgConfigState INTEGER,
        ieee8021TeipsV2IpgConfigCommandStatus
            IEEE8021TeipsIpgConfigAdmin,
        ieee8021TeipsV2IpgConfigCommandLast
            IEEE8021TeipsIpgConfigAdmin,
        ieee8021TeipsV2IpgConfigCommandAdmin
            IEEE8021TeipsIpgConfigAdmin,
        ieee8021TeipsV2IpgConfigActiveRequests
            IEEE8021TeipsIpgConfigActiveRequests,
        ieee8021TeipsV2IpgConfigWTR          Unsigned32,
        ieee8021TeipsV2IpgConfigHoldOff      Unsigned32,
        ieee8021TeipsV2IpgM1ConfigState      INTEGER,
        ieee8021TeipsV2IpgConfigMWTR         Unsigned32,
        ieee8021TeipsV2IpgConfigNotifyEnable TruthValue,
        ieee8021TeipsV2IpgConfigStorageType  StorageType
    }
ieee8021TeipsV2IpgConfigState OBJECT-TYPE
    SYNTAX   INTEGER {
               workingSegment(1),
               protectionSegment(2),
               waitToRestore(3),
               protAdmin(4)
             }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates the current state of the
         protection switching state machine for an IPG.
         The value can be one of the following:

        workingSegment(1)    The protection switching state machine
                             is in the WORKING_PATH state.
        protectionSegment(2) The protection switching state machine
                             is in the PROTECTION_PATH state.
        waitToRestore(3)     The protection switching state machine
                             is in the WTR state.
        protAdmin(4)         The protection switching state machine
                             is in the PROT_ADMIN state."

    REFERENCE "12.24.2.1.3 f)"
    ::= { ieee8021TeipsV2IpgConfigEntry 1 }

ieee8021TeipsV2IpgConfigCommandStatus OBJECT-TYPE
    SYNTAX     IEEE8021TeipsIpgConfigAdmin
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates the status of
         administrative commands within the
         protection group.  It reflects the current
```

```
          operational administrative command being
          acted upon by the IPG."
      REFERENCE "12.24.2.1.3 f)"
     ::= { ieee8021TeipsV2IpgConfigEntry 2 }

ieee8021TeipsV2IpgConfigCommandLast OBJECT-TYPE
     SYNTAX     IEEE8021TeipsIpgConfigAdmin
     MAX-ACCESS read-only
     STATUS     current
     DESCRIPTION
         "This column indicates the last attempted administrative
          command applied to the IPG.  It is changed
          whenever a write is made to the CommandAdmin column of
          this table and is essentially record of the last attempted
          administrative operation."
      REFERENCE "12.24.2.1.3 f)"
     ::= { ieee8021TeipsV2IpgConfigEntry 3 }

ieee8021TeipsV2IpgConfigCommandAdmin OBJECT-TYPE
     SYNTAX     IEEE8021TeipsIpgConfigAdmin
     MAX-ACCESS read-create
     STATUS     current
     DESCRIPTION
        "This column is used by the operator to request
         that the IPG state machine perform some
         administrative operation.  The operator requests
         a command by writing the command value to this
         column.  The state machine indicates the command
         that it is performing by setting the value of the
         CommandStatus column of this table.  This column
         always reads back as clear(1)."
      REFERENCE "12.24.2.1.3 f"
      DEFVAL { clear }
     ::= { ieee8021TeipsV2IpgConfigEntry 4 }

ieee8021TeipsV2IpgConfigActiveRequests OBJECT-TYPE
     SYNTAX     IEEE8021TeipsIpgConfigActiveRequests
     MAX-ACCESS read-only
     STATUS     current
     DESCRIPTION
         "This column shows the status of active requests
          associated with the IPG."
     REFERENCE "12.24.2.1.3 f)"
     ::= { ieee8021TeipsV2IpgConfigEntry 5 }

ieee8021TeipsV2IpgConfigWTR OBJECT-TYPE
     SYNTAX     Unsigned32 ( 0 | 5..12 )
     UNITS      "minutes"
     MAX-ACCESS read-create
     STATUS     current
     DESCRIPTION
         "This column is used to configure the
          wait-to-restore timer for the IPG operation.
          The timer may be configured in steps of 1 minute
          between 5 and 12 minutes, the default being 5.
          Additionally, the value 0 is used to indicate
          that the IPG is to operate non-revertively.  The
          value 0 is not permitted if the IPG is configured
          for M:1 IPS operation."
     REFERENCE "12.24.2.1.3 h)"
     DEFVAL { 5 }
     ::= { ieee8021TeipsV2IpgConfigEntry 6 }

ieee8021TeipsV2IpgConfigHoldOff OBJECT-TYPE
     SYNTAX     Unsigned32( 0..100 )
     UNITS      "deciseconds"
     MAX-ACCESS read-create
     STATUS     current
     DESCRIPTION
        "This column is used to configure the hold off
         timer.  The purpose is to allow IPS to fix the problem
         before a higher-layer mechanism, such as PBB-TE TESI
```

```
        protection, is invoked or to allow an inner IPG to fix
        the problem before IPS is invoked by the outer IPG when
        IPGs are nested.  The hold off timer has a period of
        from 0 to 10 seconds, the default being 0, with a 100ms
        granularity."
    REFERENCE "12.24.2.1.3 i)"
    DEFVAL { 0 }
    ::= { ieee8021TeipsV2IpgConfigEntry 7 }

ieee8021TeipsV2IpgM1ConfigState OBJECT-TYPE
    SYNTAX   INTEGER {
               psAssigned(1),
               segmentOk(2),
               segmentFailed(3),
               assignNewPs(4),
               revertToBetterPs(5)
             }
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "This column indicates the current state of the M:1 protection
         switching state machine for an IPG if M:1 IPS is supported.
         The value can be one of the following:

        psAssigned(1)        The protection switching state machine
                             is in the PS_ASSIGNED state.
        segmentOk(2)         The protection switching state machine
                             is in the SEGMENT_OK state.
        segmentFailed(3)     The protection switching state machine
                             is in the SEGMENT_FAILED state.
        assignNewPs(4)       The protection switching state machine
                             is in the ASSIGN_NEW_PS state.
        revertToBetterPs(5)  The protection switching state machine
                             is in the REVERT_T0_BETTER_PS state."

    REFERENCE "12.24.2.1.3 j)"
    ::= { ieee8021TeipsV2IpgConfigEntry 8 }

ieee8021TeipsV2IpgConfigMWTR OBJECT-TYPE
    SYNTAX     Unsigned32 ( 0 | 5..12 )
    UNITS      "minutes"
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column is used to configure the M:1 wait-to-restore
         timer for the IPG operation if M:1 protection is
         supported.  The timer may be configured in steps of
         1 minute between 5 and 12 minutes, the default being 5.
         Additionally, the value 0 is used to indicate that the
         IPG is to operate non-revertively."
    REFERENCE "12.24.2.1.3 k)"
    DEFVAL { 5 }
    ::= { ieee8021TeipsV2IpgConfigEntry 9 }


ieee8021TeipsV2IpgConfigNotifyEnable OBJECT-TYPE
    SYNTAX     TruthValue
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column is used to enable or disable transmission
         of ieee8021TeipsV2IpgAdminFailure notifications.
         These notifications are generated whenever an
         administrative command cannot be performed by the IPG."
    DEFVAL { false }
    ::= { ieee8021TeipsV2IpgConfigEntry 10 }

ieee8021TeipsV2IpgConfigStorageType OBJECT-TYPE
    SYNTAX     StorageType
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
```

```
        "This object indicates the persistence of this entry. For
         permanent objects the ieee8021TeipsV2IpgConfigCommandAdmin
         column must be writable."

    DEFVAL { nonVolatile }
    ::= { ieee8021TeipsV2IpgConfigEntry 11 }


-- ****************************************************************
-- NOTIFICATIONS (TRAPS)
-- These notifications will be sent to the management entity
-- whenever an IPG admin command cannot be performed
-- ****************************************************************

ieee8021TeipsV2IpgAdminFailure NOTIFICATION-TYPE
    OBJECTS {
        ieee8021TeipsV2IpgConfigState,
        ieee8021TeipsV2IpgConfigCommandStatus,
        ieee8021TeipsV2IpgConfigCommandLast
    }
    STATUS  current
    DESCRIPTION
        "An IPG generates this notification whenever
         an administrative command cannot be
         executed by the IPS state machine.  For
         example, when a requested  manual switch
         cannot be performed because of a signal
         failure condition.

         The management entity receiving the
         notification can identify
         the system from the network source
         address of the notification and can
         identify the IPG by the indices of
         the OID of the ieee8021TeipsV2IpgConfigState
         variable in the notification:

         ieee8021BridgeBaseComponentId - Identifies
         the  component on the Bridge where the
         protection group is configured.

         ieee8021TeipsV2Ipgid - The ID of the protection group.
        "
    ::= { ieee8021TeipsV2Notifications 1 }

--
-- MIB Module Compliance Statements
--

ieee8021TeipsV2Compliances OBJECT IDENTIFIER ::= { ieee8021TeipsV2Conformance 1 }
ieee8021TeipsV2Groups      OBJECT IDENTIFIER ::= { ieee8021TeipsV2Conformance 2 }

--
-- Units of Conformance

ieee8021TeipsV2IpgGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TeipsV2IpgWorkingMA,
        ieee8021TeipsV2IpgProtectionMA,
        ieee8021TeipsV2IpgWorkingPortNumber,
        ieee8021TeipsV2IpgProtectionPortNumber,
        ieee8021TeipsV2IpgStorageType,
        ieee8021TeipsV2IpgRowStatus
    }
    STATUS  current
    DESCRIPTION
        "Objects for the IPG group."
    ::= { ieee8021TeipsV2Groups 1 }

ieee8021TeipsV2CandidatePsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TeipsV2CandidatePsMA,
```

```
        ieee8021TeipsV2CandidatePsPort,
        ieee8021TeipsV2CandidatePsOper,
        ieee8021TeipsV2CandidatePsStorageType,
        ieee8021TeipsV2CandidatePsRowStatus
    }
    STATUS  current
    DESCRIPTION
        "Objects for the Candidate PS group."
    ::= { ieee8021TeipsV2Groups 2 }

ieee8021TeipsV2IpgTesiGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TeipsV2TesiId,
        ieee8021TeipsV2TesiStorageType,
        ieee8021TeipsV2TesiRowStatus
    }
    STATUS  current
    DESCRIPTION
        "Objects for the IPG Tuple group."
    ::= { ieee8021TeipsV2Groups 3 }

ieee8021TeipsV2IpgConfigManGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TeipsV2IpgConfigState,
        ieee8021TeipsV2IpgConfigCommandStatus,
        ieee8021TeipsV2IpgConfigCommandLast,
        ieee8021TeipsV2IpgConfigCommandAdmin,
        ieee8021TeipsV2IpgConfigActiveRequests,
        ieee8021TeipsV2IpgConfigNotifyEnable,
        ieee8021TeipsV2IpgConfigStorageType
    }
    STATUS current
    DESCRIPTION
        "Mandatory objects for the TeipsConfiguration group."
    ::= { ieee8021TeipsV2Groups 4 }

ieee8021TeipsV2IpgConfigOptGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TeipsV2IpgConfigWTR,
        ieee8021TeipsV2IpgConfigMWTR,
        ieee8021TeipsV2IpgM1ConfigState,
        ieee8021TeipsV2IpgConfigHoldOff
    }
    STATUS current
    DESCRIPTION
        "Optional 0bjects for the TeipsConfiguration group."
    ::= { ieee8021TeipsV2Groups 5 }

ieee8021TeipsV2NotificationsGroup NOTIFICATION-GROUP
    NOTIFICATIONS {
       ieee8021TeipsV2IpgAdminFailure
    }
    STATUS    current
    DESCRIPTION
        "Objects for the notifications group."
    ::= { ieee8021TeipsV2Groups 6 }

ieee8021TeipsV2Compliance MODULE-COMPLIANCE
    STATUS    current
    DESCRIPTION
        "The compliance statement for support
         of the TEIPS MIB module."
    MODULE
        MANDATORY-GROUPS {
            ieee8021TeipsV2IpgGroup,
            ieee8021TeipsV2IpgTesiGroup,
            ieee8021TeipsV2IpgConfigManGroup,
            ieee8021TeipsV2NotificationsGroup
        }
        GROUP ieee8021TeipsV2IpgConfigOptGroup
        DESCRIPTION
           "This group allows implementation to
```

```
            optionally change the WaitToRestore,
            M:1 WaitToRestore, and HoldOff timers
            for IPGs."

        GROUP ieee8021TeipsV2CandidatePsGroup
        DESCRIPTION
           "This group allows implementation to
            optionally list candidate Protection
            Segments when M:1 IPS is deployed."


    OBJECT ieee8021TeipsV2IpgConfigWTR
    MIN-ACCESS not-accessible
    DESCRIPTION "This object is optional."

    OBJECT ieee8021TeipsV2IpgConfigHoldOff
    MIN-ACCESS not-accessible
    DESCRIPTION"This object is optional."

    OBJECT ieee8021TeipsV2IpgConfigMWTR
    MIN-ACCESS not-accessible
    DESCRIPTION "This object is optional."

    OBJECT ieee8021TeipsV2IpgRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    OBJECT ieee8021TeipsV2TesiRowStatus
      SYNTAX       RowStatus { active(1), notInService(2) }
      WRITE-SYNTAX RowStatus { notInService(2), createAndGo(4),
                               destroy(6) }
      DESCRIPTION "Support for createAndWait is not required."

    ::= { ieee8021TeipsV2Compliances 1 }

END
```

17.7.19 Definitions for the IEEE8021-SPB-MIB module

```
IEEE8021-SPB-MIB DEFINITIONS ::= BEGIN

-- ============================================================
--  IEEE 802.1 Shortest Path Bridging (SPB) MIB                --
-- ============================================================

IMPORTS
        MODULE-IDENTITY, OBJECT-TYPE, Integer32, Unsigned32
                FROM SNMPv2-SMI
        RowStatus, MacAddress, TruthValue, TEXTUAL-CONVENTION
                FROM SNMPv2-TC
        ieee802dot1mibs, IEEE8021PbbIngressEgress,
        IEEE8021BridgePortNumber, IEEE8021PbbServiceIdentifier,
         IEEE8021PbbTeEsp
                FROM IEEE8021-TC-MIB
        ieee8021BridgeBasePort
                FROM IEEE8021-BRIDGE-MIB
        VlanId, VlanIdOrNone, VlanIdOrAny
                FROM Q-BRIDGE-MIB
        dot1agCfmMepEntry, dot1agCfmMdIndex, dot1agCfmMaIndex
                FROM IEEE8021-CFM-MIB
        InterfaceIndexOrZero
                FROM IF-MIB
        SnmpAdminString
                FROM SNMP-FRAMEWORK-MIB
        MODULE-COMPLIANCE, OBJECT-GROUP
                FROM SNMPv2-CONF;

ieee8021SpbMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"

    DESCRIPTION
        "The MIB module for managing the support of
        Shortest Path Bridging (SPB) in IEEE 802.1Q Bridges.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected.
            Contact details corrected. Syntax error in
            ieee8021SpbEctDynamicEntryIngressCheckDiscards
            corrected."

       REVISION  "201506230000Z"  -- June 23, 2015
       DESCRIPTION  "802.1Qca additions"
```

```
        REVISION  "201305130000Z"  -- May 13, 2013
        DESCRIPTION  "802.1Qbp additions and corrections"

        REVISION  "201202030000Z"  -- February 3, 2012
        DESCRIPTION  "802.1 Shortest Path Bridging MIB Initial Version"

        ::= { ieee802dot1mibs 26 }

-- ================================================================
--  TYPE DEFINITIONS                                              --
-- ================================================================

IEEE8021SpbAreaAddress ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x:"
        STATUS current
        DESCRIPTION
                "This identifier is the 3 Byte IS-IS Area Address.
                Domain Specific part(DSP)."
        REFERENCE "12.25.1.1.2 a), 12.25.1.2.2 a), 12.25.1.3.2 a), 12.25.1.4.2 a)"
        SYNTAX OCTET STRING (SIZE(3))

IEEE8021SpbEctAlgorithm ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x-"
        STATUS current
        DESCRIPTION
                "The 4 byte Equal Cost Multiple Tree Algorithm identifier.
                This identifies the tree computation algorithm and tie breakers."
        REFERENCE "12.3 q)"
        SYNTAX OCTET STRING (SIZE(4))

IEEE8021SpbMode ::= TEXTUAL-CONVENTION
        STATUS current
        DESCRIPTION
                "Auto allocation control for this instance
                of SPB. For SPBV it controls SPVIDs and for SPBM it controls
                SPSourceID."
        REFERENCE "27.10"
        SYNTAX INTEGER { auto(1), manual(2) }

IEEE8021SpbEctMode ::= TEXTUAL-CONVENTION
        STATUS current
        DESCRIPTION
                "The mode of the Base VID assigned for this instance of SPB.
                Modes are assigned in the FID to MSTI Allocation table."
        REFERENCE "12.25.5.1.3 c), 12.25.9.1.3 e)"
        SYNTAX INTEGER { disabled(1), spbm(2), spbv(3) }

IEEE8021SpbDigestConvention ::= TEXTUAL-CONVENTION
        STATUS current
        DESCRIPTION
                "The mode of the current Agreement Digest. This
                determines the level of loop prevention."
        REFERENCE "28.4.3"
        SYNTAX INTEGER { off(1), loopFreeBoth(2), loopFreeMcastOnly(3) }

IEEE8021SpbLinkMetric ::= TEXTUAL-CONVENTION

        DISPLAY-HINT "d"
        STATUS current
        DESCRIPTION
                "The 24 bit cost of an SPB link. A lower metric
                value means better. Value 16777215 equals Infinity."
        REFERENCE "28.2"
        SYNTAX Integer32(1..16777215)

IEEE8021SpbAdjState ::= TEXTUAL-CONVENTION
        STATUS current
        DESCRIPTION
                "The current state of this SPB adjacency or port.
                The values are up, down, and testing."
        REFERENCE "12.25.6.1.3 d), 12.25.6.2.3 d), 12.25.7.1.3 (e"
        SYNTAX INTEGER { up(1), down(2), testing(3) }
```

```
IEEE8021SpbmSPsourceId ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x:"
        STATUS current
        DESCRIPTION
                "It is the high order 3 bytes for Group Address DA from this
                bridge.
                Note that only the 20 bits not including the top 4 bits are
                the SPSourceID."
        REFERENCE "27.15"
        SYNTAX OCTET STRING (SIZE(3))

IEEE8021SpbDigest ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x"
        STATUS current
        DESCRIPTION
               "The Topology Agreement digest hex string."
        REFERENCE "28.4"
        SYNTAX OCTET STRING (SIZE(32))

IEEE8021SpbMCID ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x"
        STATUS current
        DESCRIPTION
               "MST Configuration Identifier digest hex string."
        REFERENCE "13.8"
        SYNTAX OCTET STRING (SIZE(51))

IEEE8021SpbBridgePriority ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "1x"
        STATUS current
        DESCRIPTION
               "The Bridge priority is the top 2 bytes of the Bridge Identifier.
               Lower values represent a better priority."
        REFERENCE "13.26.3"
        SYNTAX OCTET STRING (SIZE(2))

IEEE8021SpbMTID ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS current
        DESCRIPTION
               "The IS-IS Multi Topology Identifier."
        REFERENCE "3.158, 3.159"
        SYNTAX Unsigned32

IEEE8021SpbServiceIdentifierOrAny ::= TEXTUAL-CONVENTION
        DISPLAY-HINT "d"
        STATUS current
        DESCRIPTION
               "The service instance identifier is used at the Customer Backbone
                port in SPBM to distinguish a service instance.
                The special value of 0xFFFFFF is used for wildcard.
                This range also includes the default I-SID. "
        REFERENCE "3.158, 3.159"
        SYNTAX Unsigned32 (255..16777215)

-- ================================================================
--  OBJECT DEFINITIONS                                            --
-- ================================================================

-- ================================================================
-- ieee8021SpbObjects:
-- ================================================================
ieee8021SpbObjects OBJECT IDENTIFIER
        ::= { ieee8021SpbMib 1 }

-- ================================================================
-- ieee8021PcrObjects:
-- ================================================================
ieee8021PcrObjects OBJECT IDENTIFIER ::= { ieee8021SpbMib 3 }

-- ================================================================
```

```
-- ieee8021SpbSys:
-- ================================================================
ieee8021SpbSys OBJECT IDENTIFIER
        ::= { ieee8021SpbObjects 1 }

ieee8021SpbSysAreaAddress OBJECT-TYPE
        SYNTAX IEEE8021SpbAreaAddress
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "The three byte IS-IS Area Address to join. Normally
                 SPB will use area 00:00:00 however if SPB is being
                 used in conjunction with IPV4/V6 it can operate
                 using the IS-IS area address already in use.
                 This object is persistent."
        REFERENCE "12.25.1.3.2, 12.25.1.3.3"
        ::= { ieee8021SpbSys 1 }

ieee8021SpbSysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "SYS ID used for all SPB instances on this bridge.
                 A six byte network wide unique identifier. This is
                 defaulted to the Bridge Address initially but can
                 be overridden.
                 This object is persistent."
        REFERENCE "12.25.1.3.3, 3.244"
        ::= { ieee8021SpbSys 2 }

ieee8021SpbSysControlAddr OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "Group MAC that the ISIS control plane will use. SPB can
                 use a number of different addresses for SPB Hello and
                 LSP exchange. Section 27.2, 8.13.5.1 and Table 8-16 cover
                 the different choices. The choices are as follows:
                 01:80:C2:00:00:14 = All Level 1 Intermediate Systems
                 01:80:C2:00:00:15 = All Level 2 Intermediate Systems
                 09:00:2B:00:00:05 = All Intermediate Systems.
                 01:80:C2:00:00:2E = All Provider Bridge Intermediate Systems.
                 01:80:C2:00:00:2F = All Customer Bridge Intermediate Systems.
                 This object is persistent."
        REFERENCE "12.25.1.1.2, 8.13.5.1"
        ::= { ieee8021SpbSys 3 }

ieee8021SpbSysName OBJECT-TYPE
        SYNTAX SnmpAdminString (SIZE(0..32))
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Name to be used to refer to this SPB bridge. This is advertised
                 in IS-IS and used for management."
        REFERENCE "12.25.1.3.3"
        ::= { ieee8021SpbSys 4 }

ieee8021SpbSysBridgePriority OBJECT-TYPE
        SYNTAX IEEE8021SpbBridgePriority
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "This is a 16-bit quantity that ranks this SPB Bridge
                 relative to others when breaking ties. This priority
                 is the high 16 bits of the Bridge Identifier. Its impact
                 depends on the tie breaking algorithm. Recommend
                 values 0..15 be assigned to core switches to ensure
                 diversity of the ECT Algorithms."
        REFERENCE "12.25.1.3.3, 13.26.3"
        ::= { ieee8021SpbSys 5 }
```

```
ieee8021SpbmSysSPSourceId OBJECT-TYPE
        SYNTAX IEEE8021SpbmSPsourceId
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "The Shortest Path Source Identifier.
                 It is the high order 3 bytes for Group Address DA from this
                 bridge.
                 Note that only the 20 bits not including the top 4 bits are
                 the SPSourceID.
                 This object is persistent."
        REFERENCE "12.25.1.3.3, 3.250, 27.15"
        ::= { ieee8021SpbSys 6 }

ieee8021SpbvSysMode OBJECT-TYPE
        SYNTAX IEEE8021SpbMode
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "Indication of supporting SPBV mode
                 auto(=1)/manual(=2)
                 auto => auto allocate SPVIDs.
                 manual => manually assign SPVIDs.
                 This object is persistent."
        REFERENCE "12.25.1.3.3, 3.255"
        DEFVAL {auto}
        ::= { ieee8021SpbSys 7 }

ieee8021SpbmSysMode OBJECT-TYPE
        SYNTAX IEEE8021SpbMode
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "Indication of supporting SPBM mode
                 auto(=1)/manual(=2)
                 auto => enable SPBM mode and auto allocate SPsourceID.
                 manual => enable SPBM mode and manually assign SPsourceID.
                 This object is persistent."
        REFERENCE "12.25.1.3.3, 3.245"
        DEFVAL {auto}
        ::= { ieee8021SpbSys 8 }

ieee8021SpbSysDigestConvention OBJECT-TYPE
        SYNTAX IEEE8021SpbDigestConvention
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "The Agreement Digest convention setting
                 off(=1)/loopFreeBoth(=2)/loopFreeMcastOnly(=3)
                 off => disable agreement digest checking in hellos
                 loopFreeBoth => block unsafe group and individual
                 traffic when digests disagree.
                 loopFreeMcastOnly =>block unsafe group traffic when digests
                 disagree.
                 This object is persistent."
        REFERENCE "12.25.1.3.3, 28.4.3"
        DEFVAL {loopFreeBoth}
        ::= { ieee8021SpbSys 9 }

-- ================================================================
-- ieee8021SpbMtidStaticTable:
-- ================================================================
ieee8021SpbMtidStaticTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbMtidStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "A Table of multiple logical topologies - MT."
        REFERENCE "12.25.2"
        ::= { ieee8021SpbObjects 2 }
```

```
ieee8021SpbMtidStaticTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbMtidStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table configures a MTID to a topology index. A
                 topology index uniquely identifies a specific ISIS
                 topology enabling multiple instances or multiple
                 MTIDs within an instance. "
        REFERENCE "12.25.2"
        INDEX {
                 ieee8021SpbMtidStaticEntryMtid,
                 ieee8021SpbTopIx
               }
        ::= { ieee8021SpbMtidStaticTable 1 }

Ieee8021SpbMtidStaticTableEntry ::=
        SEQUENCE {
            ieee8021SpbMtidStaticEntryMtid IEEE8021SpbMTID,
            ieee8021SpbMTidStaticEntryMtidOverload TruthValue,
            ieee8021SpbMtidStaticEntryRowStatus RowStatus,
            ieee8021SpbTopIx IEEE8021SpbMTID
        }

ieee8021SpbMtidStaticEntryMtid OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "ISIS Multi Topology Identifier MTID
                 Each MTID defines logical topology and is used
                 to enable multiple SPB instances within one ISIS instance."
        REFERENCE "12.25.1.3.2, 12.25.2.3.3, 28.12"
        ::= { ieee8021SpbMtidStaticTableEntry 1 }

ieee8021SpbMTidStaticEntryMtidOverload OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "When set for this logical topology this bridge can only
                 originate or terminate traffic. It cannot transit SPB
                 encapsulated traffic. This is the IS-IS overload feature
                 specific to an SPB IS-IS MTID logical topology.
                 This object is persistent."
        REFERENCE "12.25.2.3.3, 27.8.1"
        DEFVAL {false}
        ::= { ieee8021SpbMtidStaticTableEntry 2 }

ieee8021SpbMtidStaticEntryRowStatus OBJECT-TYPE
        SYNTAX RowStatus
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "The object indicates the status of an entry, and is used
                 to create/delete entries. This object is persistent.
                 This object is persistent."
        REFERENCE "12.25.2.3.3"
        ::= { ieee8021SpbMtidStaticTableEntry 3 }

ieee8021SpbTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Unique identifier of this SPB topology
                 This is index is allocated for this ISIS/MT instance.
                 It is used as an index to most other SPB tables below and to
                 select the exact ISIS instance and the MT instance together."
        REFERENCE "12.25.2.3.3"
        ::= { ieee8021SpbMtidStaticTableEntry 4 }
```

```
-- ====================================================================
-- ieee8021SpbTopIxDynamicTable:
-- ====================================================================
ieee8021SpbTopIxDynamicTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbTopIxDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table is for SPB dynamic information. The dynamic
                 information that is sent in this bridges Hellos."
        REFERENCE "12.25.3"
        ::= { ieee8021SpbObjects 3 }

ieee8021SpbTopIxDynamicTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbTopIxDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table displays the digest information computed for this bridge.
                 A bridge configures this information in MTID 0 only.  "
        REFERENCE "12.25.3"
        INDEX {
                ieee8021SpbTopIxDynamicEntryTopIx
              }
        ::= { ieee8021SpbTopIxDynamicTable 1 }

Ieee8021SpbTopIxDynamicTableEntry ::=
        SEQUENCE {
            ieee8021SpbTopIxDynamicEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbTopIxDynamicEntryAgreeDigest IEEE8021SpbDigest,
            ieee8021SpbTopIxDynamicEntryMCID IEEE8021SpbMCID,
            ieee8021SpbTopIxDynamicEntryAuxMCID IEEE8021SpbMCID
        }

ieee8021SpbTopIxDynamicEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "ISIS-SPB Topology Index identifier
                 Each Topology Index defines logical topology and is used
                 to enable multiple SPB instances within several ISIS instances."
        REFERENCE "12.25.3.1.2, 28.12"
        ::= { ieee8021SpbTopIxDynamicTableEntry 1 }

ieee8021SpbTopIxDynamicEntryAgreeDigest OBJECT-TYPE
        SYNTAX IEEE8021SpbDigest
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The topology agreement digest value. Digest of all
                 topology information, as in clause 28.4."
        REFERENCE "12.25.3.1.3, 28.4"
        ::= { ieee8021SpbTopIxDynamicTableEntry 2 }

ieee8021SpbTopIxDynamicEntryMCID OBJECT-TYPE
        SYNTAX IEEE8021SpbMCID
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The MST Identifier MCID. The MCID is a digest of the
                 VID to MSTID configuration table, which determines the Base VIDs
                 enabled for SPBV and SPBM."
        REFERENCE "12.25.3.1.3, 13.8"
        ::= { ieee8021SpbTopIxDynamicTableEntry 3 }

ieee8021SpbTopIxDynamicEntryAuxMCID OBJECT-TYPE
        SYNTAX IEEE8021SpbMCID
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The aux MST Identifier for migration.
```

```
                Either MCID or AuxMCID has to match for adjacency to form."
        REFERENCE "12.25.3.1.3, 28.9"
        ::= { ieee8021SpbTopIxDynamicTableEntry 4 }

-- ================================================================
-- ieee8021SpbEctStaticTable:
-- ================================================================
ieee8021SpbEctStaticTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbEctStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The Equal Cost Tree (ECT)  static configuration table."
        REFERENCE "12.25.4"
        ::= { ieee8021SpbObjects 4 }

ieee8021SpbEctStaticTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbEctStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The Equal Cost Tree static configuration Table defines the
                 ECT-ALGORITHM for the Base VID and if SPBV is used for the SPVID.  "
        REFERENCE "12.25.4"
        INDEX {
                ieee8021SpbEctStaticEntryTopIx,
                ieee8021SpbEctStaticEntryBaseVid
               }
        ::= { ieee8021SpbEctStaticTable 1 }

Ieee8021SpbEctStaticTableEntry ::=
        SEQUENCE {
            ieee8021SpbEctStaticEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbEctStaticEntryBaseVid VlanIdOrAny,
            ieee8021SpbEctStaticEntryEctAlgorithm IEEE8021SpbEctAlgorithm,
            ieee8021SpbvEctStaticEntrySpvid VlanIdOrNone,
            ieee8021SpbEctStaticEntryRowStatus RowStatus
        }

ieee8021SpbEctStaticEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.4.2.2, 12.25.4.2.3, 28.12"
        ::= { ieee8021SpbEctStaticTableEntry 1 }

ieee8021SpbEctStaticEntryBaseVid OBJECT-TYPE
        SYNTAX VlanIdOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Base VID to use for this ECT-ALGORITHM.
                 Traffic B-VID (SPBM) or Management VID (SPBV).
                 A Base VID value of 4095 is a wildcard for any Base VID
                 assigned to SPB operation."
        REFERENCE "12.25.4.2.3, 3.21"
        ::= { ieee8021SpbEctStaticTableEntry 2 }

ieee8021SpbEctStaticEntryEctAlgorithm OBJECT-TYPE
        SYNTAX IEEE8021SpbEctAlgorithm
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "This identifies the method and the algorithm used
                 to determine the active topology. The standard ECT
                 Algorithm values are specified by Table 28-1,
                 Table 44-1, and Table 45-1.
```

```
                Table 28-1 values identify the tie-breaking algorithms
                used in Shortest Path Tree computation;
                values range from 00-80-c2-01 to 00-80-c2-10.
                Table 44-1 values (00-80-c2-11 and 00-80-c2-12)
                identify ECMP operations.
                Table 45-1 values identify explicit path control;
                values are 00-80-c2-17, 00-80-c2-18, 00-80-c2-19,
                and the range from 00-80-c2-21 to 00-80-c2-40.
                The default is 00-80-c2-01, which is the LowPATHID
                from Table 28-1.
                This object is persistent."
        REFERENCE "12.25.4.1, 12.25.4.2.3, 3.158"
        DEFVAL {"00-80-c2-01"}
        ::= { ieee8021SpbEctStaticTableEntry 3 }

ieee8021SpbvEctStaticEntrySpvid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "If SPBV mode this is the VID originating from this bridge.
                 This input is ignored if ieee8021SpbvSysMode is auto(1),
                 but the output always returns the SPVID in use.
                 Otherwise in SPBM this is empty, should be set = 0.
                 This object is persistent."
        REFERENCE "12.25.4.2.3, 3.252"
        ::= { ieee8021SpbEctStaticTableEntry 4 }

ieee8021SpbEctStaticEntryRowStatus OBJECT-TYPE
        SYNTAX RowStatus
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "The object indicates the status of an entry, and is used
                 to create/delete entries.
                 This object is persistent."
        REFERENCE "12.25.4.2.3"
        ::= { ieee8021SpbEctStaticTableEntry 5 }

-- ================================================================
-- ieee8021SpbEctDynamicTable:
-- ================================================================
ieee8021SpbEctDynamicTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbEctDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "A table containing Data about the ECT behavior on this bridge"
        REFERENCE "12.25.5"
        ::= { ieee8021SpbObjects 5 }

ieee8021SpbEctDynamicTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbEctDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table can be used to check that neighbor bridges are
                 using the same ECT Algorithm. "
        REFERENCE "12.25.5"
        INDEX {
                ieee8021SpbEctDynamicEntryTopIx,
                ieee8021SpbEctDynamicEntryBaseVid
              }
        ::= { ieee8021SpbEctDynamicTable 1 }

Ieee8021SpbEctDynamicTableEntry ::=
        SEQUENCE {
            ieee8021SpbEctDynamicEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbEctDynamicEntryBaseVid VlanId,
            ieee8021SpbEctDynamicEntryMode IEEE8021SpbEctMode,
            ieee8021SpbEctDynamicEntryLocalUse TruthValue,
            ieee8021SpbEctDynamicEntryRemoteUse TruthValue,
```

```
            ieee8021SpbEctDynamicEntryIngressCheckDiscards Unsigned32
        }

ieee8021SpbEctDynamicEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.5.1.2, 12.25.5.1.3, 28.12"
        ::= { ieee8021SpbEctDynamicTableEntry 1 }

ieee8021SpbEctDynamicEntryBaseVid OBJECT-TYPE
        SYNTAX VlanId
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The Base VID being queried. Base VID
                 define the mode in the VID to MSTID table. "
        REFERENCE "12.25.5.1.2, 12.25.5.1.3, 3.21"
        ::= { ieee8021SpbEctDynamicTableEntry 2 }

ieee8021SpbEctDynamicEntryMode OBJECT-TYPE
        SYNTAX IEEE8021SpbEctMode
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The Operating mode of this Base VID.
                 SPBM (=2), SPBV (=3), or disabled or none (1)."
        REFERENCE "12.25.5.1.3, 28.12.4"
        ::= { ieee8021SpbEctDynamicTableEntry 3 }

ieee8021SpbEctDynamicEntryLocalUse OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "This value indicates the ECT is in use locally
                 (True/False) for this Base Vid. ECTs can be defined before
                 services are assigned. "
        REFERENCE "112.25.5.1.3, 28.12.4"
        ::= { ieee8021SpbEctDynamicTableEntry 4 }

ieee8021SpbEctDynamicEntryRemoteUse OBJECT-TYPE
        SYNTAX TruthValue
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "This value indicates the remote ECT is in use
                 (True/False) for this Base Vid. ECTs can be defined before
                 services are assigned."
        REFERENCE "12.25.5.1.3, 28.12.4"
        ::= { ieee8021SpbEctDynamicTableEntry 5 }

ieee8021SpbEctDynamicEntryIngressCheckDiscards OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The number of ingress check failures on this ECT VID.
                 This is referred to as the ingress check, and this
                 counter increments whenever a frame is discarded
                 for this VID because it has not come from an
                 interface that is on the shortest path to its SA
                 or because it is not upstream for the individual DA if
                 relaxed ingress checking is applied."
        REFERENCE "12.25.5.1.3, 8.4, 45.3.1"
        ::= { ieee8021SpbEctDynamicTableEntry 6 }
```

```
-- ====================================================================
-- ieee8021SpbAdjStaticTable:
-- ====================================================================
ieee8021SpbAdjStaticTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbAdjStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "A table containing the SPB configuration data for a neighbor"
        REFERENCE "12.25.6"
        ::= { ieee8021SpbObjects 6 }

ieee8021SpbAdjStaticTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbAdjStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table can be used to display the interfaces and metrics
                 of a neighbor bridge. "
        REFERENCE "12.25.6"
        INDEX {
                 ieee8021SpbAdjStaticEntryTopIx,
                 ieee8021SpbAdjStaticEntryIfIndex
               }
        ::= { ieee8021SpbAdjStaticTable 1 }

Ieee8021SpbAdjStaticTableEntry ::=
        SEQUENCE {
            ieee8021SpbAdjStaticEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbAdjStaticEntryIfIndex InterfaceIndexOrZero,
            ieee8021SpbAdjStaticEntryMetric IEEE8021SpbLinkMetric,
            ieee8021SpbAdjStaticEntryIfAdminState IEEE8021SpbAdjState,
            ieee8021SpbAdjStaticEntryRowStatus RowStatus
        }

ieee8021SpbAdjStaticEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.6.1.2, 12.25.6.1.3, 28.12"
        ::= { ieee8021SpbAdjStaticTableEntry 1 }

ieee8021SpbAdjStaticEntryIfIndex OBJECT-TYPE
        SYNTAX InterfaceIndexOrZero
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System interface/index that defines this
                 adjacency. A value of 0 is a wildcard for any
                 interface on which SPB Operation is supported."
        REFERENCE "12.25.6.1.2, 12.25.6.1.3"
        ::= { ieee8021SpbAdjStaticTableEntry 2 }

ieee8021SpbAdjStaticEntryMetric OBJECT-TYPE
        SYNTAX IEEE8021SpbLinkMetric
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "The ieee8021Spb metric (incremental cost) to this peer.
                 The contribution of this link to total path cost.
                 Recommended values are inversely proportional to link speed.
                 Range is (1..16777215) where 16777215 (0xFFFFFF) is
                 infinity; infinity signifies that the adjacency is
                 UP, but is not to be used for traffic.
                 This object is persistent."
        REFERENCE "12.25.6.1.2, 12.25.6.1.3, 28.12.7"
        ::= { ieee8021SpbAdjStaticTableEntry 3 }
```

```
ieee8021SpbAdjStaticEntryIfAdminState OBJECT-TYPE
        SYNTAX IEEE8021SpbAdjState
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "The administrative state of this interface/port.
                 Up is the default.
                 This object is persistent."
        REFERENCE "12.25.6.1.2, 12.25.6.1.3"
        ::= { ieee8021SpbAdjStaticTableEntry 4 }

ieee8021SpbAdjStaticEntryRowStatus OBJECT-TYPE
        SYNTAX RowStatus
        MAX-ACCESS read-create
        STATUS current
        DESCRIPTION
                "The object indicates the status of an entry, and is used
                 to create/delete entries.
                 This object is persistent."
        REFERENCE "12.25.6.1.3"
        ::= { ieee8021SpbAdjStaticTableEntry 5 }

-- ================================================================
-- ieee8021SpbAdjDynamicTable:
-- ================================================================
ieee8021SpbAdjDynamicTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbAdjDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The SPB neighbor dynamic information table."
        REFERENCE "12.25.7"
        ::= { ieee8021SpbObjects 7 }

ieee8021SpbAdjDynamicTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbAdjDynamicTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table is used to determine operational values of digests
                 and interfaces of neighbor bridges."
        REFERENCE "12.25.7"
        INDEX {
                ieee8021SpbAdjDynamicEntryTopIx,
                ieee8021SpbAdjDynamicEntryIfIndex,
                ieee8021SpbAdjDynamicEntryPeerSysId
              }
        ::= { ieee8021SpbAdjDynamicTable 1 }

Ieee8021SpbAdjDynamicTableEntry ::=
        SEQUENCE {
            ieee8021SpbAdjDynamicEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbAdjDynamicEntryIfIndex InterfaceIndexOrZero,
            ieee8021SpbAdjDynamicEntryPeerSysId MacAddress,
            ieee8021SpbAdjDynamicEntryPort IEEE8021BridgePortNumber,
            ieee8021SpbAdjDynamicEntryIfOperState IEEE8021SpbAdjState,
            ieee8021SpbAdjDynamicEntryPeerSysName SnmpAdminString,
            ieee8021SpbAdjDynamicEntryPeerAgreeDigest IEEE8021SpbDigest,
            ieee8021SpbAdjDynamicEntryPeerMCID IEEE8021SpbMCID,
            ieee8021SpbAdjDynamicEntryPeerAuxMCID IEEE8021SpbMCID,
            ieee8021SpbAdjDynamicEntryLocalCircuitID Unsigned32,
            ieee8021SpbAdjDynamicEntryPeerLocalCircuitID Unsigned32,
            ieee8021SpbAdjDynamicEntryPortIdentifier Unsigned32,
            ieee8021SpbAdjDynamicEntryPeerPortIdentifier Unsigned32,
            ieee8021SpbAdjDynamicEntryIsisCircIndex Unsigned32
        }

ieee8021SpbAdjDynamicEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
```

```
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.7.1.2, 12.25.7.1.3, 28.12"
        ::= { ieee8021SpbAdjDynamicTableEntry 1 }

ieee8021SpbAdjDynamicEntryIfIndex OBJECT-TYPE
        SYNTAX InterfaceIndexOrZero
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "System interface/index that defines this adjacency
                 A value of 0 is a wildcard for any interface
                 on which SPB Operation is enabled."
        REFERENCE "12.25.7.1.2, 12.25.7.1.3"
        ::= { ieee8021SpbAdjDynamicTableEntry 2 }

ieee8021SpbAdjDynamicEntryPeerSysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The SPB System Identifier of this peer. This is used to
                 identify a neighbor uniquely."
        REFERENCE "12.25.7.1.3, 3.244"
        ::= { ieee8021SpbAdjDynamicTableEntry 3 }

ieee8021SpbAdjDynamicEntryPort OBJECT-TYPE
        SYNTAX IEEE8021BridgePortNumber
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The port number to reach this adjacency."
        REFERENCE "12.25.7.1.3"
        ::= { ieee8021SpbAdjDynamicTableEntry 4 }

ieee8021SpbAdjDynamicEntryIfOperState OBJECT-TYPE
        SYNTAX IEEE8021SpbAdjState
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The operational state of this port.
                 up, down, or testing (in test)."
        REFERENCE "12.25.7.1.3"
        ::= { ieee8021SpbAdjDynamicTableEntry 5 }

ieee8021SpbAdjDynamicEntryPeerSysName OBJECT-TYPE
        SYNTAX SnmpAdminString (SIZE(0..32))
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "IS-IS system name of peer.
                 This is the ASCII name assigned to the bridge to aid
                 management. It is the same as the ieee8021SpbSysName. "
        REFERENCE "12.25.7.1.3"
        ::= { ieee8021SpbAdjDynamicTableEntry 6 }

ieee8021SpbAdjDynamicEntryPeerAgreeDigest OBJECT-TYPE
        SYNTAX IEEE8021SpbDigest
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The peer topology agreement digest value
                 (all of the elements defined in 28.4).
                 If it does not match this bridge's digest it indicates loss of
                 synchronization."
        REFERENCE "12.25.7.1.3, 28.4"
        ::= { ieee8021SpbAdjDynamicTableEntry 7 }

ieee8021SpbAdjDynamicEntryPeerMCID OBJECT-TYPE
```

```
        SYNTAX IEEE8021SpbMCID
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The peer MST Identifier MCID. The MCID is a digest of the
                 VID to MSTID configuration table, which determines the Base VIDs
                 enabled for SPBV and SPBM."
        REFERENCE "12.25.7.1.3, 13.8"
        ::= { ieee8021SpbAdjDynamicTableEntry 8 }

ieee8021SpbAdjDynamicEntryPeerAuxMCID OBJECT-TYPE
        SYNTAX IEEE8021SpbMCID
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The  peer auxiliary  MST Identifier. This MCID is
                 used for migration."
        REFERENCE "12.25.7.1.3, 27.4.1, 28.12.2"
        ::= { ieee8021SpbAdjDynamicTableEntry 9 }

ieee8021SpbAdjDynamicEntryLocalCircuitID OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The value used by IS-IS to identify this adjacency locally."
        REFERENCE "12.25.7.1.3, 28.11"
        ::= { ieee8021SpbAdjDynamicTableEntry 10 }

ieee8021SpbAdjDynamicEntryPeerLocalCircuitID OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The value used by peer IS-IS to identify this adjacency remotely."
        REFERENCE "12.25.7.1.3, 28.11"
        ::= { ieee8021SpbAdjDynamicTableEntry 11 }

ieee8021SpbAdjDynamicEntryPortIdentifier OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The value for this bridge that has been selected by
                 IS-IS to form this adjacency if there is more than 1 candidate link."
        REFERENCE "12.25.7.1.3, 28.11"
        ::= { ieee8021SpbAdjDynamicTableEntry 12 }

ieee8021SpbAdjDynamicEntryPeerPortIdentifier OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The value for peer port Identifier selected by IS-IS
                 to form this adjacency if there is more than 1 candidate link."
        REFERENCE "12.25.7.1.3, 28.11"
        ::= { ieee8021SpbAdjDynamicTableEntry 13 }

ieee8021SpbAdjDynamicEntryIsisCircIndex OBJECT-TYPE
        SYNTAX Unsigned32
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The isisCircTable reference. This allows cross referencing
                 to an IS-IS MIB."
        REFERENCE "12.25.7.1.3"
        ::= { ieee8021SpbAdjDynamicTableEntry 14 }

-- ============================================================================
-- ieee8021SpbTopNodeTable:
-- ============================================================================
ieee8021SpbTopNodeTable OBJECT-TYPE
```

```
        SYNTAX SEQUENCE OF Ieee8021SpbTopNodeTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Table of network specific bridge information."
        REFERENCE "12.25.8"
        ::= { ieee8021SpbObjects 8 }

ieee8021SpbTopNodeTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbTopNodeTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table is used to display system level information about
                 bridges in the network.   "
        REFERENCE "12.25.8"
        INDEX {
                ieee8021SpbTopNodeEntryTopIx,
                ieee8021SpbTopNodeEntrySysId
              }
        ::= { ieee8021SpbTopNodeTable 1 }

Ieee8021SpbTopNodeTableEntry ::=
        SEQUENCE {
            ieee8021SpbTopNodeEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbTopNodeEntrySysId MacAddress,
            ieee8021SpbTopNodeEntryBridgePriority IEEE8021SpbBridgePriority,
            ieee8021SpbmTopNodeEntrySPsourceID IEEE8021SpbmSPsourceId,
            ieee8021SpbTopNodeEntrySysName SnmpAdminString
        }

ieee8021SpbTopNodeEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.8.1.2, 12.25.8.1.3, 28.12"
        ::= { ieee8021SpbTopNodeTableEntry 1 }

ieee8021SpbTopNodeEntrySysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The IS-IS System ID of a bridge in the SPB
                 LSP database and hence the network.
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.8.1.2, 12.25.8.1.3, 3.244"
        ::= { ieee8021SpbTopNodeTableEntry 2 }

ieee8021SpbTopNodeEntryBridgePriority OBJECT-TYPE
        SYNTAX IEEE8021SpbBridgePriority
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The Bridge Priority of the bridge in the LSP database.
                 This is a 16-bit quantity that ranks this SPB Bridge
                 relative to others when breaking ties. This priority
                 is the high 16 bits of the Bridge Identifier. Its impact
                 depends on the tie breaking algorithm. Recommend
                 values 0..15 be assigned to core switches to ensure
                 diversity of the ECT Algorithms."
        REFERENCE "12.25.8.1.3, 13.26.3"
        ::= { ieee8021SpbTopNodeTableEntry 3 }

ieee8021SpbmTopNodeEntrySPsourceID OBJECT-TYPE
        SYNTAX IEEE8021SpbmSPsourceId
        MAX-ACCESS read-only
```

```
        STATUS current
        DESCRIPTION
                "The Shortest Path Source Identifier.
                 It is the high order 3 bytes for Group Address DA from this
                 bridge. Note that only the 20 bits not including the
                 top 4 bits are the SPSourceID."
        REFERENCE "12.25.8.1.3, 3.253"
        ::= { ieee8021SpbTopNodeTableEntry 4 }

ieee8021SpbTopNodeEntrySysName OBJECT-TYPE
        SYNTAX SnmpAdminString (SIZE(0..32))
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The System Name. A Human readable name of this bridge
                 This is used to aid in management and is used in
                 place of the System identifier in many commands and displays."
        REFERENCE "12.25.8.1.3"
        ::= { ieee8021SpbTopNodeTableEntry 5 }

-- ================================================================
-- ieee8021SpbTopEctTable:
-- ================================================================
ieee8021SpbTopEctTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbTopEctTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Table of all ECT use in the network"
        REFERENCE "12.25.9"
        ::= { ieee8021SpbObjects 9 }

ieee8021SpbTopEctTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbTopEctTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table lists bridges and the ECT Algorithms configured and in use. "
        REFERENCE "12.25.9"
        INDEX {
                ieee8021SpbTopEctEntryTopIx,
                ieee8021SpbTopEctEntrySysId,
                ieee8021SpbTopEctEntryBaseVid
              }
        ::= { ieee8021SpbTopEctTable 1 }

Ieee8021SpbTopEctTableEntry ::=
        SEQUENCE {
            ieee8021SpbTopEctEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbTopEctEntrySysId MacAddress,
            ieee8021SpbTopEctEntryBaseVid VlanIdOrAny,
            ieee8021SpbTopEctEntryEctAlgorithm IEEE8021SpbEctAlgorithm,
            ieee8021SpbTopEctEntryMode IEEE8021SpbEctMode,
            ieee8021SpbvTopEctSysMode IEEE8021SpbMode,
            ieee8021SpbvTopEctEntrySpvid VlanIdOrNone,
            ieee8021SpbTopEctEntryLocalUse TruthValue
        }

ieee8021SpbTopEctEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.9.1.2, 12.25.9.1.3"
        ::= { ieee8021SpbTopEctTableEntry 1 }

ieee8021SpbTopEctEntrySysId OBJECT-TYPE
        SYNTAX MacAddress
```

```
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The system ID that is using a particular ECT.
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.9.1.2, 12.25.9.1.3, 3.244"
        ::= { ieee8021SpbTopEctTableEntry 2 }

ieee8021SpbTopEctEntryBaseVid OBJECT-TYPE
        SYNTAX VlanIdOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Base VID related to this algorithm.
                 In the case of SPBM this is the B-VID that carries
                 traffic for this ECT-ALGORITHM. In the case of SPBV
                 this is the Base-VID used for management.
                 A Base VID value of 4095 is a wildcard for any Base VID
                 assigned to SPB operation."
        REFERENCE "12.25.9.1.2, 12.25.9.1.3, 3.21"
        ::= { ieee8021SpbTopEctTableEntry 3 }

ieee8021SpbTopEctEntryEctAlgorithm OBJECT-TYPE
        SYNTAX IEEE8021SpbEctAlgorithm
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The ECT-ALGORITHM in use.
                 A 32 bit number. The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances.; the upper 24 bits are an OUI
                 and the lower 8 bits are an index. This creates a
                 world-wide unique identity for the computation that
                 will be using the VID thus ensuring consistency."
        REFERENCE "12.25.9.1.3, 3.158"
        ::= { ieee8021SpbTopEctTableEntry 4 }

ieee8021SpbTopEctEntryMode OBJECT-TYPE
        SYNTAX IEEE8021SpbEctMode
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Operating mode : SPBM (=2) or SPBV (=3)"
        REFERENCE "12.25.9.1.3"
        ::= { ieee8021SpbTopEctTableEntry 5 }

ieee8021SpbvTopEctSysMode OBJECT-TYPE
        SYNTAX IEEE8021SpbMode
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Indication of supporting SPBV mode
                 auto(=1)/manual(=2)
                 auto => SPBV mode and auto allocate SPVIDs.
                 manual => SPBV mode and manually assign SPVIDs."
        REFERENCE "12.25.9.1.3, 3.254"
        ::= { ieee8021SpbTopEctTableEntry 6 }

ieee8021SpbvTopEctEntrySpvid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "SPVID in V mode
                 The VID this bridge will use to originate traffic
                 using this ECT-ALGORITHM when running in SPBV mode."
        REFERENCE "12.25.9.1.3, 3.250"
        ::= { ieee8021SpbTopEctTableEntry 7 }

ieee8021SpbTopEctEntryLocalUse OBJECT-TYPE
        SYNTAX TruthValue
```

```
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Is this ECT-ALGORITHM in use locally by advertising
                 bridge :- TRUE or FALSE. This is used to help with
                 disruption-free migration between ECT-ALGORITHMs.
                 Changes are only allowed if this flag is FALSE."
        REFERENCE "12.25.9.1.3, 28.12.5"
        ::= { ieee8021SpbTopEctTableEntry 8 }

-- ====================================================================
-- ieee8021SpbTopEdgeTable:
-- ====================================================================
ieee8021SpbTopEdgeTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbTopEdgeTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "A Table of edges in network (not duplicated),
                 but each link will appear as two entries, one
                 ordered {near-far}, the other {far-near}."
        REFERENCE "12.25.10"
        ::= { ieee8021SpbObjects 10 }

ieee8021SpbTopEdgeTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbTopEdgeTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The table lists information about bridge edges (links)."
        REFERENCE "12.25.10"
        INDEX {
                ieee8021SpbTopEdgeEntryTopIx,
                ieee8021SpbTopEdgeEntrySysIdNear,
                ieee8021SpbTopEdgeEntrySysIdFar
              }
        ::= { ieee8021SpbTopEdgeTable 1 }

Ieee8021SpbTopEdgeTableEntry ::=
        SEQUENCE {
            ieee8021SpbTopEdgeEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbTopEdgeEntrySysIdNear MacAddress,
            ieee8021SpbTopEdgeEntrySysIdFar MacAddress,
            ieee8021SpbTopEdgeEntryMetricNear2Far IEEE8021SpbLinkMetric,
            ieee8021SpbTopEdgeEntryMetricFar2Near IEEE8021SpbLinkMetric
        }

ieee8021SpbTopEdgeEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.10.1.2, 12.25.10.1.3, 28.12"
        ::= { ieee8021SpbTopEdgeTableEntry 1 }

ieee8021SpbTopEdgeEntrySysIdNear OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System ID of near bridge (the bridge
                 reporting the adjacency).
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.10.1.2, 12.25.10.1.3, 3.244"
        ::= { ieee8021SpbTopEdgeTableEntry 2 }

ieee8021SpbTopEdgeEntrySysIdFar OBJECT-TYPE
        SYNTAX MacAddress
```

```
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System ID of far bridge (the neighbor
                 of the bridge reporting).
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.10.1.2, 12.25.10.1.3, 3.244"
        ::= { ieee8021SpbTopEdgeTableEntry 3 }

ieee8021SpbTopEdgeEntryMetricNear2Far OBJECT-TYPE
        SYNTAX IEEE8021SpbLinkMetric
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The metric used on this edge advertised by near end
                 This is the raw value. If it is less than the
                 MetricFar2Near (below), the MetricFar2Near is
                 used as the SPF metric in both directions."
        REFERENCE "12.25.10.1.3, 28.12.7"
        ::= { ieee8021SpbTopEdgeTableEntry 4 }

ieee8021SpbTopEdgeEntryMetricFar2Near OBJECT-TYPE
        SYNTAX IEEE8021SpbLinkMetric
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The metric used on this edge advertised by far end
                 This is the raw value. If it is less than the
                 MetricNear2Far (above), the MetricNear2Far is
                 used as the SPF metric in both directions."
        REFERENCE "12.25.10.1.3, 28.12.7"
        ::= { ieee8021SpbTopEdgeTableEntry 5 }

-- ============================================================================
-- ieee8021SpbmTopSrvTable:
-- ============================================================================
ieee8021SpbmTopSrvTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbmTopSrvTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "All SPBM PBB encapsulated services in this network."
        REFERENCE "12.25.11"
        ::= { ieee8021SpbObjects 11 }

ieee8021SpbmTopSrvTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbmTopSrvTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table displays information about PBB services received
                 in the LSP data base. The Service Identifier is associated with
                 the MAC address and Base VID of the bridge that originates or
                 terminates the service. "
        REFERENCE "12.25.11"
        INDEX {
                ieee8021SpbmTopSrvEntryTopIx,
                ieee8021SpbmTopSrvEntrySysId,
                ieee8021SpbmTopSrvEntryIsid,
                ieee8021SpbmTopSrvEntryBaseVid,
                ieee8021SpbmTopSrvEntryMac
              }
        ::= { ieee8021SpbmTopSrvTable 1 }

Ieee8021SpbmTopSrvTableEntry ::=
        SEQUENCE {
            ieee8021SpbmTopSrvEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbmTopSrvEntrySysId MacAddress,
            ieee8021SpbmTopSrvEntryIsid IEEE8021SpbServiceIdentifierOrAny,
            ieee8021SpbmTopSrvEntryBaseVid VlanIdOrAny,
            ieee8021SpbmTopSrvEntryMac MacAddress,
            ieee8021SpbmTopSrvEntryIsidFlags IEEE8021PbbIngressEgress
```

```
        }

ieee8021SpbmTopSrvEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Entry of one The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.11.1.2, 12.25.11.1.3, 28.12"
        ::= { ieee8021SpbmTopSrvTableEntry 1 }

ieee8021SpbmTopSrvEntrySysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System identifier this service originates/terminates on.
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.11.1.2, 12.25.11.1.3, 3.244"
        ::= { ieee8021SpbmTopSrvTableEntry 2 }

ieee8021SpbmTopSrvEntryIsid OBJECT-TYPE
        SYNTAX IEEE8021SpbServiceIdentifierOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "An ISID (service) originating/terminating on this bridge.
                 A value of 0 is a wildcard for any ISID."
        REFERENCE "12.25.11.1.2, 12.25.11.1.3, 28.12.10"
        ::= { ieee8021SpbmTopSrvTableEntry 3 }

ieee8021SpbmTopSrvEntryBaseVid OBJECT-TYPE
        SYNTAX VlanIdOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The Base VID associated with this service. The Base VID determines
                 the ECT Algorithm that is associated with this service.
                 A Base VID value of 4095 is a wildcard for any Base VID
                 assigned to SPB operation."
        REFERENCE "12.25.11.1.2, 12.25.11.1.3, 28.12.10"
        ::= { ieee8021SpbmTopSrvTableEntry 4 }

ieee8021SpbmTopSrvEntryMac OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The MAC address associated with a service.
                 An additional nodal MAC address by which an I-SID
                 can be reached can be advertised, in which case
                 traffic to this MAC follows a forwarding path identical
                 to that taken to reach the corresponding SYSID (nodal) MAC.
                 If no additional MAC is advertised, this will be the SYSID MAC.
                 A value of 0 is a wildcard for the MAC address."
        REFERENCE "12.25.11.1.3, 28.12.10"
        ::= { ieee8021SpbmTopSrvTableEntry 5 }

ieee8021SpbmTopSrvEntryIsidFlags OBJECT-TYPE
        SYNTAX IEEE8021PbbIngressEgress
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "A pair of flags defining the attributes of this
                 service.  These specify independently whether
                 ingress frames to the SPBM region should be
                 transmitted within it, and whether frames
                 received from the SPBM region are required
```

```
                egress it."
        REFERENCE "12.25.11.1.2, 12.25.11.1.3, 28.12.10"
        ::= { ieee8021SpbmTopSrvTableEntry 6 }

-- ================================================================
-- ieee8021SpbvTopSrvTable:
-- ================================================================
ieee8021SpbvTopSrvTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021SpbvTopSrvTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The SPBV group services in this network"
        REFERENCE "12.25.12"
        ::= { ieee8021SpbObjects 12 }

ieee8021SpbvTopSrvTableEntry OBJECT-TYPE
        SYNTAX Ieee8021SpbvTopSrvTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table displays information about SPBV group address.
                 The group address is a associated with MAC address and Base
                 VID of the bridge that originates or terminates the service."
        REFERENCE "12.25.12"
        INDEX {
                ieee8021SpbvTopSrvEntryTopIx,
                ieee8021SpbvTopSrvEntrySysId,
                ieee8021SpbvTopSrvEntryMMac
              }
        ::= { ieee8021SpbvTopSrvTable 1 }

Ieee8021SpbvTopSrvTableEntry ::=
        SEQUENCE {
            ieee8021SpbvTopSrvEntryTopIx IEEE8021SpbMTID,
            ieee8021SpbvTopSrvEntrySysId MacAddress,
            ieee8021SpbvTopSrvEntryMMac MacAddress,
            ieee8021SpbvTopSrvEntryBaseVid VlanId,
            ieee8021SpbvTopSrvEntryMMacFlags IEEE8021PbbIngressEgress
        }

ieee8021SpbvTopSrvEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The ISIS Topology Index identifier to which this
                 instance belongs. Each Topology Index defines logical topology
                 and is used to enable multiple SPB instances within several
                 ISIS instances."
        REFERENCE "12.25.12.1.2, 12.25.12.1.3, 28.12"
        ::= { ieee8021SpbvTopSrvTableEntry 1 }

ieee8021SpbvTopSrvEntrySysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System identifier advertising this group address.
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.25.12.1.2, 12.25.12.1.3, 3.244"
        ::= { ieee8021SpbvTopSrvTableEntry 2 }

ieee8021SpbvTopSrvEntryMMac OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This Group MAC address entry.
                 A value of 0 is a wildcard for any Group MAC address. "
        REFERENCE "12.25.12.1.2, 12.25.12.1.3, 28.12.9"
        ::= { ieee8021SpbvTopSrvTableEntry 3 }
```

```
ieee8021SpbvTopSrvEntryBaseVid OBJECT-TYPE
        SYNTAX VlanId
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "The Base VID associated with this service. The Base VID determines
                 the ECT Algorithm that is associated with this service."
        REFERENCE "12.25.12.1.3, 3.21"
        ::= { ieee8021SpbvTopSrvTableEntry 4 }

ieee8021SpbvTopSrvEntryMMacFlags OBJECT-TYPE
        SYNTAX IEEE8021PbbIngressEgress
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "A pair of {ingress, egress} flags for this
                 Group Address, defining transmit/receive or both. This enables
                 filtering of Group addresses to interwork with MMRP."
        REFERENCE "12.25.12.1.3, 28.12.9"
        ::= { ieee8021SpbvTopSrvTableEntry 5 }

-- ================================================================
-- ieee8021SpbmBsiStaticTable:
-- ================================================================
ieee8021SpbmBsiStaticTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Ieee8021SpbmBsiStaticEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "Table of BSIs configured on this system and assigned to
         an SPBM VID.
         The table is indexed by
         - ieee8021SpbTopIx from ieee8021SpbMtidStaticTable
             indicating the ISIS-SPB topology instance into
             which the BSI will be advertised,
         - ieee8021BridgeBasePort from ieee8021PbbCbpTable
             identifying the CPB on which the BSI is configured,
         - an I-SID value identifying the BSI, and
         - a VID value identifying a B-VID for which forwarding
             state is to be installed for the BSI"
    REFERENCE "12.25.8"
    ::= { ieee8021SpbObjects 13 }

ieee8021SpbmBsiStaticEntry OBJECT-TYPE
    SYNTAX Ieee8021SpbmBsiStaticEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This table contains information about backbone services
         configured on this system to be advertised by ISIS-SPB."
    REFERENCE "12.25.8"
    INDEX {
            ieee8021SpbTopIx,
            ieee8021BridgeBasePort,
            ieee8021SpbmBsiStaticEntryIsid,
            ieee8021SpbmBsiStaticEntryBaseVid
          }
    ::= { ieee8021SpbmBsiStaticTable 1 }

Ieee8021SpbmBsiStaticEntry ::=
    SEQUENCE {
        ieee8021SpbmBsiStaticEntryIsid
                                IEEE8021PbbServiceIdentifier,
        ieee8021SpbmBsiStaticEntryBaseVid       VlanId,
        ieee8021SpbmBsiStaticEntryTBit          TruthValue,
        ieee8021SpbmBsiStaticEntryRBit          TruthValue,
        ieee8021SpbmBsiStaticEntryTsBit         TruthValue,
        ieee8021SpbmBsiStaticEntryTieBreakMask  Integer32,
        ieee8021SpbmBsiStaticEntryRowStatus     RowStatus
    }
```

```
ieee8021SpbmBsiStaticEntryIsid OBJECT-TYPE
    SYNTAX      IEEE8021PbbServiceIdentifier
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An I-SID registered on the CBP identified
         by ieee8021BridgeBasePort."
    ::= { ieee8021SpbmBsiStaticEntry 1 }

ieee8021SpbmBsiStaticEntryBaseVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "An B-VID registered on the CBP identified
         by ieee8021BridgeBasePort."
    ::= { ieee8021SpbmBsiStaticEntry 2 }

ieee8021SpbmBsiStaticEntryTBit OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "If true(1), indicates the BSI transmits multicast
         frames from this CBP.
         This object is persistent."
    ::= { ieee8021SpbmBsiStaticEntry 3 }

ieee8021SpbmBsiStaticEntryRBit OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "If true(1), indicates the BSI wishes to receive
         multicast frames at this CBP.
         This object is persistent."
    ::= { ieee8021SpbmBsiStaticEntry 4 }

ieee8021SpbmBsiStaticEntryTsBit OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "If true(1), indicates the BSI transmits multicast
         frames on a shared tree from this CBP.
         This object is persistent."
    ::= { ieee8021SpbmBsiStaticEntry 5 }

ieee8021SpbmBsiStaticEntryTieBreakMask OBJECT-TYPE
    SYNTAX      Integer32 (0..15)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The value used to create the Tie-Break Mask
         for calculating multicast trees.
         This object is persistent."
    ::= { ieee8021SpbmBsiStaticEntry 6 }

ieee8021SpbmBsiStaticEntryRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.
         When the status is active, no columns of this table can be
         modified.
         This object is persistent."
    ::= { ieee8021SpbmBsiStaticEntry 7 }

-- ================================================================
-- SPBM MEP configurable objects
```

```
-- ====================================================================
dot1agCfmMepSpbmTable OBJECT-TYPE
    SYNTAX SEQUENCE OF Dot1agCfmMepSpbmEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "The additional objects configurable in SPBM MEPs"
    REFERENCE "27.18"
    ::= { ieee8021SpbObjects 14 }

dot1agCfmMepSpbmEntry OBJECT-TYPE
    SYNTAX      Dot1agCfmMepSpbmEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
       "The SPBM MEP table additions."

    AUGMENTS { dot1agCfmMepEntry }
    ::= { dot1agCfmMepSpbmTable 1 }

Dot1agCfmMepSpbmEntry ::=
    SEQUENCE {
        dot1agCfmMepTransmitLbmSpbmDA   MacAddress,
        dot1agCfmMepTransmitLtmSpbmDA   MacAddress
    }

dot1agCfmMepTransmitLbmSpbmDA OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The MAC Address to be used as the LBM destination address
        in an SPBM MA: A unicast or multicast address."
    REFERENCE
       "12.14.7.3.2:g"
    ::= { dot1agCfmMepSpbmEntry 1 }

dot1agCfmMepTransmitLtmSpbmDA OBJECT-TYPE
    SYNTAX      MacAddress
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
       "The MAC Address to be used as the LTM destination address
        in an SPBM MA: A unicast or multicast address."
    REFERENCE
       "12.14.7.4.2:f"
    ::= { dot1agCfmMepSpbmEntry 2 }

-- ====================================================================
-- SPBM path MA and ECMP path MA TE-SIDs
-- ====================================================================
dot1agCfmMepSpbmEspTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Dot1agCfmMepSpbmEspEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "The SPBM ESP table contains path-tesid information for each
         SPBM path MA known to a system.

         This table uses three indices. The first two indices are the
         indices of the Maintenance Domain and MA tables, the reason
         being that a path-tesid is always related to an MA and
         Maintenance Domain."
    REFERENCE
        "12.14.5.3.2:c, 27.18.1"
    ::= { ieee8021SpbObjects 15 }

dot1agCfmMepSpbmEspEntry OBJECT-TYPE
    SYNTAX     Dot1agCfmMepSpbmEspEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
```

```
        "The SPBM path MA ESP entry.  Each entry refers to an
         ESP by identifier and contains information about
         one of the ESPs that comprise an SPBM path MA.
         The "
    INDEX { dot1agCfmMdIndex,
            dot1agCfmMaIndex,
            dot1agCfmMepSpbmEspIndex
          }
    ::= { dot1agCfmMepSpbmEspTable 1 }

Dot1agCfmMepSpbmEspEntry ::=
    SEQUENCE {
        dot1agCfmMepSpbmEspIndex       Unsigned32,
        dot1agCfmMepSpbmEspEsp         IEEE8021PbbTeEsp,
        dot1agCfmMepSpbmEspRowStatus   RowStatus
    }

dot1agCfmMepSpbmEspIndex OBJECT-TYPE
    SYNTAX     Unsigned32 (1..4294967295)
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "This is an identifier, of local significance to a particular
         SPBM path MA that is used to index the ESPs associated
         with that MA."
    ::= { dot1agCfmMepSpbmEspEntry 1 }

dot1agCfmMepSpbmEspEsp OBJECT-TYPE
    SYNTAX     IEEE8021PbbTeEsp
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the ESP identifier for one of the Ethernet
         Switched Paths that define the SPBM path MA.
         This object is persistent."
    REFERENCE
        "12.14.5.3.2:c, 27.18.1"
    ::= { dot1agCfmMepSpbmEspEntry 2 }

dot1agCfmMepSpbmEspRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.
         When the status is active, no columns of this table can be
         modified.
         This object is persistent."
    ::= { dot1agCfmMepSpbmEspEntry 3 }

-- ================================================================
--  PCR objects:
-- ================================================================

-- ================================================================
--  ieee8021PcrEctStaticTable:
-- ================================================================
ieee8021PcrEctStaticTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021PcrEctStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The Path Control and Reservation (PCR)
                 static configuration table."
        REFERENCE "12.28.1"
        ::= { ieee8021PcrObjects 1 }

ieee8021PcrEctStaticTableEntry OBJECT-TYPE
        SYNTAX Ieee8021PcrEctStaticTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
```

```
                "The PCR static configuration Table defines the
                 MRT VIDs for the Base VID if MRT is used."
        REFERENCE "12.28.1"
        INDEX {
                ieee8021PcrEctStaticEntryTopIx,
                ieee8021PcrEctStaticEntryBaseVid
              }
        ::= { ieee8021PcrEctStaticTable 1 }

Ieee8021PcrEctStaticTableEntry ::=
        SEQUENCE {
            ieee8021PcrEctStaticEntryTopIx IEEE8021SpbMTID,
            ieee8021PcrEctStaticEntryBaseVid VlanIdOrAny,
                ieee8021PcrEctStaticEntryMrtBlueVid VlanIdOrNone,
                ieee8021PcrEctStaticEntryMrtRedVid VlanIdOrNone,
                ieee8021PcrEctStaticEntryRowStatus RowStatus
        }

ieee8021PcrEctStaticEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The IS-IS Topology Index identifier to which this
                 instance belongs."
        REFERENCE "12.28.1.1.2"
        ::= { ieee8021PcrEctStaticTableEntry 1 }

ieee8021PcrEctStaticEntryBaseVid OBJECT-TYPE
        SYNTAX VlanIdOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Base VID to use for the MRT ECT-Algorithm or for the
                 MRTG ECT Algorithm.
                 In the case of a non-learning VLAN, this is the VID
                 that carries traffic. In the case of a learning VLAN,
                 this is the Base-VID used for management.
                 A Base VID value of 4095 is a wildcard for any Base VID
                 assigned to MRT operation."
        REFERENCE "12.28.1.1.2"
        ::= { ieee8021PcrEctStaticTableEntry 2 }

ieee8021PcrEctStaticEntryMrtBlueVid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "MRT-Blue VID.
                 The VID this bridge will use to originate traffic
                 on MRT-Blue for the VLAN if the VLAN is associated
                 with MRT operation.
                 This object is persistent."
        REFERENCE "12.28.1.1.2, 45.3.3, 45.3.4"
        ::= { ieee8021PcrEctStaticTableEntry 3 }

ieee8021PcrEctStaticEntryMrtRedVid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-write
        STATUS current
        DESCRIPTION
                "MRT-Red VID.
                 The VID this bridge will use to originate traffic
                 on MRT-Red for the VLAN if the VLAN is associated
                 with MRT operation.
                 This object is persistent."
        REFERENCE "12.28.1.1.2, 45.3.3, 45.3.4"
        ::= { ieee8021PcrEctStaticTableEntry 4 }

ieee8021PcrEctStaticEntryRowStatus OBJECT-TYPE
        SYNTAX RowStatus
        MAX-ACCESS read-create
```

```
        STATUS current
        DESCRIPTION
                "The object indicates the status of an entry and is used
                 to create/delete entries.
                 This object is persistent."
        REFERENCE "12.28.1.2.3"
        ::= { ieee8021PcrEctStaticTableEntry 5 }

-- ================================================================
--  ieee8021PcrTopEctTable:
-- ================================================================
ieee8021PcrTopEctTable OBJECT-TYPE
        SYNTAX SEQUENCE OF Ieee8021PcrTopEctTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Table of MRT use in the network."
        REFERENCE "12.28.2"
        ::= { ieee8021PcrObjects 2 }

ieee8021PcrTopEctTableEntry OBJECT-TYPE
        SYNTAX Ieee8021PcrTopEctTableEntry
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "This table lists bridges configured to use MRT."
        REFERENCE "12.25.9"
        INDEX {
                ieee8021PcrTopEctEntryTopIx,
                ieee8021PcrTopEctEntrySysId,
                ieee8021PcrTopEctEntryBaseVid
              }
        ::= { ieee8021PcrTopEctTable 1 }

Ieee8021PcrTopEctTableEntry ::=
        SEQUENCE {
            ieee8021PcrTopEctEntryTopIx IEEE8021SpbMTID,
            ieee8021PcrTopEctEntrySysId MacAddress,
            ieee8021PcrTopEctEntryBaseVid VlanIdOrAny,
            ieee8021PcrTopEctEntryMode IEEE8021SpbEctMode,
            ieee8021PcrTopEctEntryMrtBlueVid VlanIdOrNone,
            ieee8021PcrTopEctEntryMrtRedVid VlanIdOrNone
        }

ieee8021PcrTopEctEntryTopIx OBJECT-TYPE
        SYNTAX IEEE8021SpbMTID
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The IS-IS Topology Index identifier to which this
                 instance belongs."
        REFERENCE "12.28.2.1.2, 12.28.2.1.3"
        ::= { ieee8021PcrTopEctTableEntry 1 }

ieee8021PcrTopEctEntrySysId OBJECT-TYPE
        SYNTAX MacAddress
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "The System ID that is using MRT.
                 A value of 0 is a wildcard for all System identifiers."
        REFERENCE "12.28.2.1.2, 12.28.2.1.3"
        ::= { ieee8021PcrTopEctTableEntry 2 }

ieee8021PcrTopEctEntryBaseVid OBJECT-TYPE
        SYNTAX VlanIdOrAny
        MAX-ACCESS not-accessible
        STATUS current
        DESCRIPTION
                "Base VID related to this algorithm.
                 In the case of a non-learning VLAN, this is the VID
                 that carries traffic. In the case of a learning VLAN,
```

```
                this is the Base-VID used for management.
                A Base VID value of 4095 is a wildcard for any Base VID
                assigned to MRT operation."
        REFERENCE "12.28.2.1.2, 12.28.2.1.3"
        ::= { ieee8021PcrTopEctTableEntry 3 }

ieee8021PcrTopEctEntryMode OBJECT-TYPE
        SYNTAX IEEE8021SpbEctMode
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "Operating mode : non-learning (=2) or learning (=3)"
        REFERENCE "12.28.2.1.3"
        ::= { ieee8021PcrTopEctTableEntry 4 }

ieee8021PcrTopEctEntryMrtBlueVid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "MRT-Blue VID.
                 The VID this bridge will use to originate traffic
                 on MRT-Blue for the VLAN if the VLAN is associated
                 with MRT operation."
        REFERENCE "12.28.2.1.3, 45.3.3, 45.3.4"
        ::= { ieee8021PcrTopEctTableEntry 5 }

ieee8021PcrTopEctEntryMrtRedVid OBJECT-TYPE
        SYNTAX VlanIdOrNone
        MAX-ACCESS read-only
        STATUS current
        DESCRIPTION
                "MRT-Red VID.
                 The VID this bridge will use to originate traffic
                 on MRT-Red for the VLAN if the VLAN is associated
                 with MRT operation."
        REFERENCE "12.28.2.1.3, 45.3.3, 45.3.4"
        ::= { ieee8021PcrTopEctTableEntry 6 }

-- ============================================================
-- Conformance Information
-- ============================================================

ieee8021SpbConformance OBJECT IDENTIFIER ::= { ieee8021SpbMib 2}
ieee8021SpbGroups      OBJECT IDENTIFIER ::= { ieee8021SpbConformance 1}
ieee8021SpbCompliances OBJECT IDENTIFIER ::= { ieee8021SpbConformance 2}

ieee8021PcrConformance OBJECT IDENTIFIER ::= { ieee8021SpbMib 4 }
ieee8021PcrGroups      OBJECT IDENTIFIER ::= { ieee8021PcrConformance 1}
ieee8021PcrCompliances OBJECT IDENTIFIER ::= { ieee8021PcrConformance 2}

-- ============================================================
-- SPBM Units of conformance
-- ============================================================

ieee8021SpbSysGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbSysAreaAddress,
                ieee8021SpbSysId,
                ieee8021SpbSysControlAddr,
                ieee8021SpbSysName,
                ieee8021SpbSysBridgePriority,
                ieee8021SpbmSysSPSourceId,
                ieee8021SpbmSysMode,
                ieee8021SpbSysDigestConvention
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbSys"
        ::= { ieee8021SpbGroups 1 }
```

```
ieee8021SpbMtidStaticTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbMTidStaticEntryMtidOverload,
                ieee8021SpbMtidStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbMtidStaticTable"
        ::= { ieee8021SpbGroups 2 }

ieee8021SpbTopIxDynamicTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopIxDynamicEntryAgreeDigest,
                ieee8021SpbTopIxDynamicEntryMCID,
                ieee8021SpbTopIxDynamicEntryAuxMCID
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopIxDynamicTable"
        ::= { ieee8021SpbGroups 3 }

ieee8021SpbEctStaticTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctStaticEntryEctAlgorithm,
                ieee8021SpbEctStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctStaticTable"
        ::= { ieee8021SpbGroups 4 }

ieee8021SpbEctDynamicTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctDynamicEntryMode,
                ieee8021SpbEctDynamicEntryLocalUse,
                ieee8021SpbEctDynamicEntryRemoteUse,
                ieee8021SpbEctDynamicEntryIngressCheckDiscards
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctDynamicTable"
        ::= { ieee8021SpbGroups 5 }

ieee8021SpbAdjStaticTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjStaticEntryMetric,
                ieee8021SpbAdjStaticEntryIfAdminState,
                ieee8021SpbAdjStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjStaticTable"
        ::= { ieee8021SpbGroups 6 }

ieee8021SpbAdjDynamicTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjDynamicEntryPort,
                ieee8021SpbAdjDynamicEntryIfOperState,
                ieee8021SpbAdjDynamicEntryPeerSysName,
                ieee8021SpbAdjDynamicEntryPeerAgreeDigest,
                ieee8021SpbAdjDynamicEntryPeerMCID,
                ieee8021SpbAdjDynamicEntryPeerAuxMCID,
                ieee8021SpbAdjDynamicEntryLocalCircuitID,
                ieee8021SpbAdjDynamicEntryPeerLocalCircuitID,
                ieee8021SpbAdjDynamicEntryPortIdentifier,
                ieee8021SpbAdjDynamicEntryPeerPortIdentifier,
                ieee8021SpbAdjDynamicEntryIsisCircIndex
```

```
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjDynamicTable"
        ::= { ieee8021SpbGroups 7 }

ieee8021SpbTopNodeTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopNodeEntryBridgePriority,
                ieee8021SpbmTopNodeEntrySPsourceID,
                ieee8021SpbTopNodeEntrySysName
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopNodeTable"
        ::= { ieee8021SpbGroups 8 }

ieee8021SpbTopEctTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopEctEntryEctAlgorithm,
                ieee8021SpbTopEctEntryMode,
                ieee8021SpbTopEctEntryLocalUse
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopEctTable"
        ::= { ieee8021SpbGroups 9 }

ieee8021SpbTopEdgeTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopEdgeEntryMetricNear2Far,
                ieee8021SpbTopEdgeEntryMetricFar2Near
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopEdgeTable"
        ::= { ieee8021SpbGroups 10 }

ieee8021SpbmTopSrvTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                ieee8021SpbmTopSrvEntryIsidFlags
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbmTopSrvTable"
        ::= { ieee8021SpbGroups 11 }

-- See below for additional SPBM Units of conformance (after SPBV section)

-- ================================================================
-- SPBV Units of conformance
-- ================================================================

ieee8021SpbSysGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbSysAreaAddress,
                ieee8021SpbSysId,
                ieee8021SpbSysControlAddr,
                ieee8021SpbSysName,
                ieee8021SpbSysBridgePriority,
                ieee8021SpbvSysMode,
                ieee8021SpbSysDigestConvention
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbSys"
```

```
        ::= { ieee8021SpbGroups 12 }

ieee8021SpbMtidStaticTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbMTidStaticEntryMtidOverload,
                ieee8021SpbMtidStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbMtidStaticTable"
        ::= { ieee8021SpbGroups 13 }

ieee8021SpbTopIxDynamicTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopIxDynamicEntryAgreeDigest,
                ieee8021SpbTopIxDynamicEntryMCID,
                ieee8021SpbTopIxDynamicEntryAuxMCID
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopIxDynamicTable"
        ::= { ieee8021SpbGroups 14 }

ieee8021SpbEctStaticTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctStaticEntryEctAlgorithm,
                ieee8021SpbvEctStaticEntrySpvid,
                ieee8021SpbEctStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctStaticTable"
        ::= { ieee8021SpbGroups 15 }

ieee8021SpbEctDynamicTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctDynamicEntryMode,
                ieee8021SpbEctDynamicEntryLocalUse,
                ieee8021SpbEctDynamicEntryRemoteUse,
                ieee8021SpbEctDynamicEntryIngressCheckDiscards
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctDynamicTable"
        ::= { ieee8021SpbGroups 16 }

ieee8021SpbAdjStaticTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjStaticEntryMetric,
                ieee8021SpbAdjStaticEntryIfAdminState,
                ieee8021SpbAdjStaticEntryRowStatus
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjStaticTable"
        ::= { ieee8021SpbGroups 17 }

ieee8021SpbAdjDynamicTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjDynamicEntryPort,
                ieee8021SpbAdjDynamicEntryIfOperState,
                ieee8021SpbAdjDynamicEntryPeerSysName,
                ieee8021SpbAdjDynamicEntryPeerAgreeDigest,
                ieee8021SpbAdjDynamicEntryPeerMCID,
                ieee8021SpbAdjDynamicEntryPeerAuxMCID,
                ieee8021SpbAdjDynamicEntryLocalCircuitID,
                ieee8021SpbAdjDynamicEntryPeerLocalCircuitID,
```

```
                ieee8021SpbAdjDynamicEntryPortIdentifier,
                ieee8021SpbAdjDynamicEntryPeerPortIdentifier,
                ieee8021SpbAdjDynamicEntryIsisCircIndex
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjDynamicTable"
        ::= { ieee8021SpbGroups 18 }

ieee8021SpbTopNodeTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopNodeEntryBridgePriority,
                ieee8021SpbTopNodeEntrySysName
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopNodeTable"
        ::= { ieee8021SpbGroups 19 }

ieee8021SpbTopEctTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopEctEntryEctAlgorithm,
                ieee8021SpbTopEctEntryMode,
                ieee8021SpbvTopEctSysMode,
                ieee8021SpbvTopEctEntrySpvid,
                ieee8021SpbTopEctEntryLocalUse
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopEctTable"
        ::= { ieee8021SpbGroups 20 }

ieee8021SpbTopEdgeTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopEdgeEntryMetricNear2Far,
                ieee8021SpbTopEdgeEntryMetricFar2Near
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopEdgeTable"
        ::= { ieee8021SpbGroups 21 }

ieee8021SpbvTopSrvTableGroupSPBV OBJECT-GROUP
        OBJECTS {
                ieee8021SpbvTopSrvEntryBaseVid,
                ieee8021SpbvTopSrvEntryMMacFlags
        }

        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbvTopSrvTable"
        ::= { ieee8021SpbGroups 22 }

-- ============================================================
-- Additional SPBM Units of conformance
-- ============================================================

ieee8021SpbmBsiStaticTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                 ieee8021SpbmBsiStaticEntryTBit,
                 ieee8021SpbmBsiStaticEntryRBit,
                 ieee8021SpbmBsiStaticEntryTsBit,
                 ieee8021SpbmBsiStaticEntryTieBreakMask,
                 ieee8021SpbmBsiStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbmBsiStaticTable"
```

```
        ::= { ieee8021SpbGroups 23 }

dot1agCfmMepSpbmTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                 dot1agCfmMepTransmitLbmSpbmDA,
                 dot1agCfmMepTransmitLtmSpbmDA
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent dot1agCfmMepSpbmTable"
        ::= { ieee8021SpbGroups 24 }

dot1agCfmMepSpbmEspTableGroupSPBM OBJECT-GROUP
        OBJECTS {
                 dot1agCfmMepSpbmEspEsp,
                 dot1agCfmMepSpbmEspRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent dot1agCfmMepSpbmEspTable"
        ::= { ieee8021SpbGroups 25 }

-- ============================================================
-- PCR Units of conformance
-- ============================================================

ieee8021PcrSysGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbSysAreaAddress,
                ieee8021SpbSysId,
                ieee8021SpbSysControlAddr,
                ieee8021SpbSysName,
                ieee8021SpbSysBridgePriority,
                ieee8021SpbmSysSPSourceId,
                ieee8021SpbmSysMode,
                ieee8021SpbvSysMode,
                ieee8021SpbSysDigestConvention
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbSys for PCR."
        ::= { ieee8021PcrGroups 1 }

ieee8021PcrMtidStaticTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbMTidStaticEntryMtidOverload,
                ieee8021SpbMtidStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbMtidStaticTable for PCR."
        ::= { ieee8021PcrGroups 2 }

ieee8021PcrTopIxDynamicTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopIxDynamicEntryAgreeDigest,
                ieee8021SpbTopIxDynamicEntryMCID,
                ieee8021SpbTopIxDynamicEntryAuxMCID
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopIxDynamicTable for PCR."
        ::= { ieee8021PcrGroups 3 }

ieee8021PcrEctStaticTableGroupMAC OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctStaticEntryEctAlgorithm,
                ieee8021SpbEctStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctStaticTable for PCR,
```

```
        for non-learning VLAN, i.e., MAC-based."
        ::= { ieee8021PcrGroups 4 }

ieee8021PcrEctStaticTableGroupVID OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctStaticEntryEctAlgorithm,
                ieee8021SpbvEctStaticEntrySpvid,
                ieee8021SpbEctStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctStaticTable for PCR,
        for learning VLAN, i.e., VID-based."
        ::= { ieee8021PcrGroups 5 }

ieee8021PcrEctStaticTableGroupMrt OBJECT-GROUP
        OBJECTS {
                ieee8021PcrEctStaticEntryMrtBlueVid,
                ieee8021PcrEctStaticEntryMrtRedVid,
                ieee8021PcrEctStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021PcrEctStaticTable,
        for MRT operation."
        ::= { ieee8021PcrGroups 6 }

ieee8021PcrEctDynamicTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbEctDynamicEntryMode,
                ieee8021SpbEctDynamicEntryLocalUse,
                ieee8021SpbEctDynamicEntryRemoteUse,
                ieee8021SpbEctDynamicEntryIngressCheckDiscards
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbEctDynamicTable for PCR."
        ::= { ieee8021PcrGroups 7 }

ieee8021PcrAdjStaticTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjStaticEntryMetric,
                ieee8021SpbAdjStaticEntryIfAdminState,
                ieee8021SpbAdjStaticEntryRowStatus
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjStaticTable for PCR."
        ::= { ieee8021PcrGroups 8 }

ieee8021PcrAdjDynamicTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbAdjDynamicEntryPort,
                ieee8021SpbAdjDynamicEntryIfOperState,
                ieee8021SpbAdjDynamicEntryPeerSysName,
                ieee8021SpbAdjDynamicEntryPeerAgreeDigest,
                ieee8021SpbAdjDynamicEntryPeerMCID,
                ieee8021SpbAdjDynamicEntryPeerAuxMCID,
                ieee8021SpbAdjDynamicEntryLocalCircuitID,
                ieee8021SpbAdjDynamicEntryPeerLocalCircuitID,
                ieee8021SpbAdjDynamicEntryPortIdentifier,
                ieee8021SpbAdjDynamicEntryPeerPortIdentifier,
                ieee8021SpbAdjDynamicEntryIsisCircIndex
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbAdjDynamicTable for PCR."
        ::= { ieee8021PcrGroups 9 }

ieee8021PcrTopNodeTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopNodeEntryBridgePriority,
```

```
                ieee8021SpbmTopNodeEntrySPsourceID,
                ieee8021SpbTopNodeEntrySysName
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopNodeTable for PCR."
        ::= { ieee8021PcrGroups 10 }

ieee8021PcrTopEctTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021PcrTopEctEntryMode,
                ieee8021PcrTopEctEntryMrtBlueVid,
                ieee8021PcrTopEctEntryMrtRedVid
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021PcrTopEctTable."
        ::= { ieee8021PcrGroups 11 }

ieee8021PcrTopEdgeTableGroup OBJECT-GROUP
        OBJECTS {
                ieee8021SpbTopEdgeEntryMetricNear2Far,
                ieee8021SpbTopEdgeEntryMetricFar2Near
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbTopEdgeTable for PCR."
        ::= { ieee8021PcrGroups 12 }

ieee8021PcrTopSrvTableGroupVid OBJECT-GROUP
        OBJECTS {
                ieee8021SpbvTopSrvEntryBaseVid,
                ieee8021SpbvTopSrvEntryMMacFlags
        }
        STATUS current
        DESCRIPTION
        "The collection of objects used to represent ieee8021SpbvTopSrvTable for PCR,
        i.e., when the service is provided by a VID."
        ::= { ieee8021PcrGroups 13 }

-- ================================================================
-- Compliance statements SPBM
-- ================================================================

ieee8021SpbComplianceSPBM MODULE-COMPLIANCE
        STATUS current
        DESCRIPTION
                "Compliance to IEEE 802.1 SPBM mode"
        MODULE
                MANDATORY-GROUPS {
                        ieee8021SpbSysGroupSPBM ,
                        ieee8021SpbMtidStaticTableGroupSPBM ,
                        ieee8021SpbTopIxDynamicTableGroupSPBM ,
                        ieee8021SpbEctStaticTableGroupSPBM ,
                        ieee8021SpbEctDynamicTableGroupSPBM ,
                        ieee8021SpbAdjStaticTableGroupSPBM ,
                        ieee8021SpbAdjDynamicTableGroupSPBM ,
                        ieee8021SpbTopNodeTableGroupSPBM ,
                        ieee8021SpbTopEctTableGroupSPBM ,
                        ieee8021SpbTopEdgeTableGroupSPBM ,
                        ieee8021SpbmTopSrvTableGroupSPBM ,
                        ieee8021SpbmBsiStaticTableGroupSPBM
                }

                 GROUP   dot1agCfmMepSpbmTableGroupSPBM
                 DESCRIPTION
                     "This group is mandatory ONLY for devices supporting
                      SPBM VID MAs."


                 GROUP   dot1agCfmMepSpbmEspTableGroupSPBM
                 DESCRIPTION
```

```
                    "This group is mandatory ONLY for devices supporting
                     SPBM path MAs or ECMP path MAs."

        ::= { ieee8021SpbCompliances 1 }

-- ============================================================
-- Compliance statements SPBV
-- ============================================================

ieee8021SpbComplianceSPBV MODULE-COMPLIANCE
        STATUS current
        DESCRIPTION
                "Compliance to IEEE 802.1 SPBV mode"
        MODULE
                MANDATORY-GROUPS {
                        ieee8021SpbSysGroupSPBV ,
                        ieee8021SpbMtidStaticTableGroupSPBV ,
                        ieee8021SpbTopIxDynamicTableGroupSPBV ,
                        ieee8021SpbEctStaticTableGroupSPBV ,
                        ieee8021SpbEctDynamicTableGroupSPBV ,
                        ieee8021SpbAdjStaticTableGroupSPBV ,
                        ieee8021SpbAdjDynamicTableGroupSPBV ,
                        ieee8021SpbTopNodeTableGroupSPBV ,
                        ieee8021SpbTopEctTableGroupSPBV ,
                        ieee8021SpbTopEdgeTableGroupSPBV ,
                        ieee8021SpbvTopSrvTableGroupSPBV
                }
        ::= { ieee8021SpbCompliances 2 }

-- ============================================================
-- Compliance statements PCR
-- ============================================================

ieee8021PcrCompliance MODULE-COMPLIANCE
        STATUS current
        DESCRIPTION
                "Compliance to IEEE 802.1 PCR"
        MODULE
                MANDATORY-GROUPS {
                        ieee8021PcrSysGroup ,
                        ieee8021PcrMtidStaticTableGroup ,
                        ieee8021PcrTopIxDynamicTableGroup ,
                        ieee8021PcrEctStaticTableGroupMAC ,
                        ieee8021PcrEctStaticTableGroupVID ,
                        ieee8021PcrEctStaticTableGroupMrt,
                        ieee8021PcrEctDynamicTableGroup ,
                        ieee8021PcrAdjStaticTableGroup ,
                        ieee8021PcrAdjDynamicTableGroup ,
                        ieee8021PcrTopNodeTableGroup ,
                        ieee8021PcrTopEctTableGroup ,
                        ieee8021PcrTopEdgeTableGroup ,
                        ieee8021PcrTopSrvTableGroupVid
                }
        ::= { ieee8021PcrCompliances 1 }

END
```

17.7.20 Definitions for the IEEE8021-EVB-MIB module

```
IEEE8021-EVB-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- IEEE 802.1Q MIB for EVB Bridges and EVB Stations
-- ============================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE,
    Integer32,Counter32,Unsigned32, TimeTicks
        FROM SNMPv2-SMI
    MacAddress, TruthValue, RowStatus, StorageType
        FROM SNMPv2-TC

    ieee802dot1mibs, IEEE8021PbbComponentIdentifier,
    IEEE8021BridgePortNumber
        FROM IEEE8021-TC-MIB
    VlanIndex
        FROM Q-BRIDGE-MIB
    InterfaceIndexOrZero
        FROM IF-MIB
    ieee8021BridgePhyPort
        FROM IEEE8021-BRIDGE-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021BridgeEvbMib  MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The EVB MIB module for managing devices that support
        Edge Virtual Bridging.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            ieee8021BridgeEvbVSIMvFormat added.
            ieee8021BridgeEvbVsiMgrID16 added and
            ieee8021BridgeEvbVsiMgrID deprecated.
            ieee8021BridgeEvbVDPCounterDiscontinuity description
            clarified. Conformance and groups fixed.
            Fixed maintenance item to IEEE Std 802.1Qbg-2012."
```

```
    REVISION     "201202150000Z" -- February 15, 2012
    DESCRIPTION
         "Initial version published in IEEE Std 802.1Qbg."
    ::= { ieee802dot1mibs 24 }

-- ================================================================
-- subtrees in the EVB MIB
-- ================================================================

ieee8021BridgeEvbNotifications
    OBJECT IDENTIFIER ::= { ieee8021BridgeEvbMib 0 }

ieee8021BridgeEvbObjects
    OBJECT IDENTIFIER ::= { ieee8021BridgeEvbMib 1 }

ieee8021BridgeEvbConformance
    OBJECT IDENTIFIER ::= { ieee8021BridgeEvbMib 2 }

--  ==========================
--  EVB Bridge managed object
--  ==========================

ieee8021BridgeEvbSys  OBJECT IDENTIFIER ::=   { ieee8021BridgeEvbObjects 1  }

ieee8021BridgeEvbSysType    OBJECT-TYPE
   SYNTAX        INTEGER {
                  evbBridge (1),
                  evbStation (2)
                 }
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION   "The evbSysType determines if this is an EVB Bridge
                  or EVB station."
   REFERENCE     "5.23,5.24"

   ::= { ieee8021BridgeEvbSys 1}

ieee8021BridgeEvbSysNumExternalPorts  OBJECT-TYPE
   SYNTAX        Unsigned32 (1..4095)
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION   "The evbSysNumExternalPorts parameter indicates how
                  many externally accessible port are available."
   REFERENCE     "12.4.2, 12.5.1"
   ::= {ieee8021BridgeEvbSys 2}

ieee8021BridgeEvbSysEvbLldpTxEnable  OBJECT-TYPE
   SYNTAX        TruthValue
   MAX-ACCESS    read-write
   STATUS        current
   DESCRIPTION   "This object is used to initialize the LLDP EVB
                  objects for new SBPs and URPS.
                  When set to 'true' a new SBP or URP will place the local
                  EVB objects in the LLDP nearest Customer database;
                  when set to 'false' a new SBP or URP will not place
                  the local EVB objects in the LLDP database."
   REFERENCE     "D.2.12"
   DEFVAL        { true }
   ::= {ieee8021BridgeEvbSys 3}


ieee8021BridgeEvbSysEvbLldpManual  OBJECT-TYPE
   SYNTAX        TruthValue
   MAX-ACCESS    read-write
   STATUS        current
   DESCRIPTION   "This object is used to initialize the LLDP EVB
                  objects for new SBPs and URPS.
                  When set to 'false' the operating configuration
                  will be determined by the comparison between
                  the local and remote LLDP EVB objects
                  (automatic), regardless of the setting of
```

```
                ieee8021BridgeEvbSysLldpTxEnable.
                When ieee8021BridgeEvbSysLldpManual is 'true' the
                configuration will be determined by the setting
                of the local EVB objects only (manual)."
   REFERENCE     "D.2.12"
   DEFVAL        { false }
   ::= {ieee8021BridgeEvbSys 4}

ieee8021BridgeEvbSysEvbLldpGidCapable  OBJECT-TYPE
   SYNTAX        TruthValue
   MAX-ACCESS    read-write
   STATUS        current
   DESCRIPTION   "The value of this object is used as the default
                 value of the BGID or SGID bit of the EVB LLDP TLV string."
   REFERENCE     "D.2.12"
   ::= {ieee8021BridgeEvbSys 5}

ieee8021BridgeEvbSysEcpAckTimer  OBJECT-TYPE
   SYNTAX        Integer32
   MAX-ACCESS    read-write
   STATUS        deprecated
   DESCRIPTION
        "A value indicating the  Bridge Proposed ECP ackTimer."
   REFERENCE
        "D.2.12.6, 43.3.6.1"
   ::= { ieee8021BridgeEvbSys 6 }

ieee8021BridgeEvbSysEcpDfltAckTimerExp  OBJECT-TYPE
   SYNTAX        Integer32 (0..31)
   MAX-ACCESS    read-write
   STATUS        current
   DESCRIPTION
        "The exponent of 2 indicating the  Bridge Proposed ECP ackTimer
        in tens of microseconds."
   REFERENCE
        "D.2.12.6, 43.3.6.1"
   ::= { ieee8021BridgeEvbSys 11 }

ieee8021BridgeEvbSysEcpMaxRetries  OBJECT-TYPE
    SYNTAX       Integer32 (0..7)
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
         "A value indicating the Bridge ECP maxRetries."
    REFERENCE
         "D.2.12.5, 43.3.7.4"
    DEFVAL       { 3 }
    ::= { ieee8021BridgeEvbSys 7 }


ieee8021BridgeEvbSysVdpDfltRsrcWaitDelay OBJECT-TYPE
    SYNTAX       Integer32
    MAX-ACCESS   read-write
    STATUS       deprecated
    DESCRIPTION
    "A value indicating the  Bridge Resource VDP Timeout."
    REFERENCE   "D.2.12, 41.5.5.7"
    ::= { ieee8021BridgeEvbSys 8 }

ieee8021BridgeEvbSysVdpDfltRsrcWaitDelayExp OBJECT-TYPE
    SYNTAX       Integer32 (0..31)
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
    "The exponent of 2 indicating the  Bridge Resource VDP
     Timeout in tens of microseconds."
    REFERENCE   "D.2.12, 41.5.5.7"
    ::= { ieee8021BridgeEvbSys 12 }

ieee8021BridgeEvbSysVdpDfltReinitKeepAlive OBJECT-TYPE
    SYNTAX       Integer32
    MAX-ACCESS   read-write
```

```
    STATUS       deprecated
    DESCRIPTION
    "A value indicating the Bridge Proposed VDP Keep Alive Timeout."
    REFERENCE "D.2.12, 41.5.5.5"
    ::= { ieee8021BridgeEvbSys 9 }

ieee8021BridgeEvbSysVdpDfltReinitKeepAliveExp OBJECT-TYPE
    SYNTAX       Integer32 (0..31)
    MAX-ACCESS   read-write
    STATUS       current
    DESCRIPTION
    "The exponent of 2 indicating the Bridge Proposed VDP Keep
     Alive Timeout in tens of microseconds."
    REFERENCE "D.2.12, 41.5.5.5"
    ::= { ieee8021BridgeEvbSys 13 }

-- ======================================
-- Station facing Bridge Port table
-- ======================================

ieee8021BridgeEvbSbpTable OBJECT-TYPE
     SYNTAX      SEQUENCE OF Ieee8021BridgeEvbSbpEntry
     MAX-ACCESS  not-accessible
     STATUS      current
     DESCRIPTION
         "A table that contains Station-facing Bridge Port (SBP)
          details."
     REFERENCE   "12.26.2"
     ::= { ieee8021BridgeEvbSys 10}

 ieee8021BridgeEvbSbpEntry OBJECT-TYPE
     SYNTAX      Ieee8021BridgeEvbSbpEntry
     MAX-ACCESS  not-accessible
     STATUS      current
     DESCRIPTION
         "A list of objects describing SBP."
     INDEX  { ieee8021BridgeEvbSbpComponentID,
              ieee8021BridgeEvbSbpPortNumber
            }
     ::= { ieee8021BridgeEvbSbpTable 1 }

 Ieee8021BridgeEvbSbpEntry ::=
     SEQUENCE {
      ieee8021BridgeEvbSbpComponentID
                  IEEE8021PbbComponentIdentifier,
      ieee8021BridgeEvbSbpPortNumber
                  IEEE8021BridgePortNumber,
      ieee8021BridgeEvbSbpLldpManual            TruthValue,
      ieee8021BridgeEvbSbpVdpOperRsrcWaitDelay   Unsigned32,
      ieee8021BridgeEvbSbpVdpOperReinitKeepAlive Unsigned32,
      ieee8021BridgeEvbSbpVdpOperToutKeepAlive   Unsigned32,
      ieee8021BridgeEvbSbpVdpOperRsrcWaitDelayExp Unsigned32,
      ieee8021BridgeEvbSbpVdpOperReinitKeepAliveExp Unsigned32
     }

ieee8021BridgeEvbSbpComponentID  OBJECT-TYPE
   SYNTAX        IEEE8021PbbComponentIdentifier
   MAX-ACCESS    not-accessible
   STATUS        current
   DESCRIPTION
   "The SBP component ID"
   REFERENCE   "12.4.1.5"
   ::= { ieee8021BridgeEvbSbpEntry 1 }

ieee8021BridgeEvbSbpPortNumber OBJECT-TYPE
   SYNTAX        IEEE8021BridgePortNumber
   MAX-ACCESS    not-accessible
   STATUS        current
   DESCRIPTION   "The SBP port number."
   REFERENCE     "12.4.2"
   ::= { ieee8021BridgeEvbSbpEntry 2 }
```

```
ieee8021BridgeEvbSbpLldpManual   OBJECT-TYPE
   SYNTAX        TruthValue
   MAX-ACCESS    read-write
   STATUS        current
   DESCRIPTION
   "The evbSbpLldpManual parameter switches EVB TLVs to manual mode.
    In manual mode the running parameters are determined solely from
    the local LLDP database values."
   ::= { ieee8021BridgeEvbSbpEntry 3 }

ieee8021BridgeEvbSbpVdpOperRsrcWaitDelay     OBJECT-TYPE
   SYNTAX       Unsigned32
   UNITS        "micro-seconds"
   MAX-ACCESS   read-only
   STATUS       deprecated
   DESCRIPTION  "The value used to initialize the waitWhile timer
                (41.5.5.7) by the station VDP state machine when
                the state machine is waiting for a response."
   REFERENCE  "D.2.12, 41.5.5.7"
   ::= { ieee8021BridgeEvbSbpEntry 4 }

ieee8021BridgeEvbSbpVdpOperRsrcWaitDelayExp     OBJECT-TYPE
   SYNTAX       Unsigned32 (0..31)
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION  "The exponent of 2 used to calculate the value to initialize
                the waitWhile timer
                (41.5.5.7) by the station VDP state machine when
                the state machine is waiting for a response."
   REFERENCE  "D.2.12, 41.5.5.7"
   ::= { ieee8021BridgeEvbSbpEntry 7 }


ieee8021BridgeEvbSbpVdpOperReinitKeepAlive   OBJECT-TYPE
   SYNTAX       Unsigned32
   UNITS        "micro-seconds"
   MAX-ACCESS   read-only
   STATUS       deprecated
   DESCRIPTION  "The value used to initialize the waitWhile timer
                 (41.5.5.5) by the station VDP state machine in
                 order to determine when to transmit a keep alive
                 message."
   REFERENCE  "D.2.12, 41.5.5.5"
   ::= { ieee8021BridgeEvbSbpEntry 5 }

ieee8021BridgeEvbSbpVdpOperReinitKeepAliveExp   OBJECT-TYPE
   SYNTAX       Unsigned32 (0..31)
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION  "The exponent of 2 used to calculate the value to initialize
                 the waitWhile timer
                 (41.5.5.5) by the station VDP state machine in
                 order to determine when to transmit a keep alive
                 message."
   REFERENCE  "D.2.12, 41.5.5.5"
   ::= { ieee8021BridgeEvbSbpEntry 8 }

ieee8021BridgeEvbSbpVdpOperToutKeepAlive     OBJECT-TYPE
   SYNTAX       Unsigned32
   UNITS        "micro-seconds"
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION  "The value used to initialize the waitWhile timer
                 (41.5.5.13) by the EVBCB VDP state machine in order to
                 determine when to transmit a keep alive message."
   REFERENCE  "D.2.12, 41.5.5.13"
   ::= { ieee8021BridgeEvbSbpEntry 6 }

-- ============================
-- VSI Database
-- ============================
```

```
ieee8021BridgeEvbVSIDBObjects OBJECT IDENTIFIER ::= { ieee8021BridgeEvbObjects 2 }

ieee8021BridgeEvbVSIDBTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeEvbVSIDBEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains database of the active Virtual Station
         Interfaces."
    REFERENCE   "12.26.3"
    ::= { ieee8021BridgeEvbVSIDBObjects 1}

ieee8021BridgeEvbVSIDBEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeEvbVSIDBEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing database of the active Virtual Station
         Interfaces."
    INDEX  { ieee8021BridgeEvbVSIComponentID,
             ieee8021BridgeEvbVSIPortNumber,
             ieee8021BridgeEvbVSIIDType,
             ieee8021BridgeEvbVSIID
           }
    ::= { ieee8021BridgeEvbVSIDBTable 1 }

Ieee8021BridgeEvbVSIDBEntry ::=
    SEQUENCE {
      ieee8021BridgeEvbVSIComponentID
                IEEE8021PbbComponentIdentifier,
      ieee8021BridgeEvbVSIPortNumber
                IEEE8021BridgePortNumber,
      ieee8021BridgeEvbVSIIDType           INTEGER,
      ieee8021BridgeEvbVSIID               OCTET STRING,
      ieee8021BridgeEvbVSITimeSinceCreate  Unsigned32,
      ieee8021BridgeEvbVsiVdpOperCmd       INTEGER,
      ieee8021BridgeEvbVsiOperRevert       TruthValue,
      ieee8021BridgeEvbVsiOperHard         TruthValue,
      ieee8021BridgeEvbVsiOperReason       BITS,
      ieee8021BridgeEvbVSIMgrID            OCTET STRING,
      ieee8021BridgeEvbVSIType             Integer32,
      ieee8021BridgeEvbVSITypeVersion      OCTET STRING,
      ieee8021BridgeEvbVSIMvFormat         INTEGER,
      ieee8021BridgeEvbVSINumMACs          Integer32,
      ieee8021BridgeEvbVDPMachineState     INTEGER,
      ieee8021BridgeEvbVDPCommandsSucceeded Counter32,
      ieee8021BridgeEvbVDPCommandsFailed    Counter32,
      ieee8021BridgeEvbVDPCommandReverts    Counter32,
      ieee8021BridgeEvbVDPCounterDiscontinuity TimeTicks,
      ieee8021BridgeEvbVSIMgrID16           OCTET STRING,
      ieee8021BridgeEvbVSIFilterFormat      INTEGER
    }

ieee8021BridgeEvbVSIComponentID  OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifier
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION "The evbVSIComponentID is the ComponentID for the
                C-VLAN component of the EVB Bridge or for the edge
                relay of the EVB station."
   REFERENCE "12.4.1.5"
   ::= { ieee8021BridgeEvbVSIDBEntry 1}

ieee8021BridgeEvbVSIPortNumber  OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumber
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION "The evbVSIPortNumber is the Port Number for the SBP
                or URP where the VSI is accessed."
   REFERENCE "12.4.2"
   ::= { ieee8021BridgeEvbVSIDBEntry 2 }
```

```
ieee8021BridgeEvbVSIIDType  OBJECT-TYPE
   SYNTAX         INTEGER{
                     vsiidIpv4 (1),
                     vsiidIpv6 (2),
                     vsiidMAC (3),
                     vsiidLocal (4),
                     vsiidUUID (5)
                  }
   MAX-ACCESS     not-accessible
   STATUS         current
   DESCRIPTION
   "This object specifies the VSIID Type for the VSIID in the DCN "
   REFERENCE   "41.2.6"
   ::= { ieee8021BridgeEvbVSIDBEntry 3 }


ieee8021BridgeEvbVSIID  OBJECT-TYPE
   SYNTAX         OCTET STRING (SIZE (16))
   MAX-ACCESS     not-accessible
   STATUS         current
   DESCRIPTION
   "This object specifies the VSIID that uniquely identifies the VSI
    in the DCN "
   REFERENCE   "41.2.7"
   ::= { ieee8021BridgeEvbVSIDBEntry 4 }


ieee8021BridgeEvbVSITimeSinceCreate OBJECT-TYPE
   SYNTAX        Unsigned32
   UNITS        "centi-seconds"
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
      "This object specifies the time since creation "
   REFERENCE   "41"
   ::= { ieee8021BridgeEvbVSIDBEntry 5 }


ieee8021BridgeEvbVsiVdpOperCmd OBJECT-TYPE
   SYNTAX     INTEGER
              {
               preAssociate (1),
               preAssociateWithRsrcReservation (2),
               associate (3),
               deAssociate (4)
              }
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "This object identifies the type of TLV."
   REFERENCE   "41.2.1"
   ::= { ieee8021BridgeEvbVSIDBEntry 6 }

ieee8021BridgeEvbVsiOperRevert   OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION "The evbOperRevert status indicator shows the most
                recent value of the KEEP indicator from the VDP
                protocol exchange."
   REFERENCE     "41.2.3"
   ::= { ieee8021BridgeEvbVSIDBEntry 7 }

ieee8021BridgeEvbVsiOperHard   OBJECT-TYPE
   SYNTAX       TruthValue
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION "The evbVsiHard status indicator shows the most
                recent value of the HARD indicator from the VDP
                protocol exchange."
   REFERENCE     "41.2.3"
```

```
::= { ieee8021BridgeEvbVSIDBEntry 8 }

ieee8021BridgeEvbVsiOperReason  OBJECT-TYPE
   SYNTAX        BITS
                 {
                   success (0),
                   invalidFormat (1),
                   insufficientResources (2),
                   otherfailure(3)
                 }
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION
   "This object indicates the outcome of a request."
   REFERENCE     "41.2.3"


   ::= { ieee8021BridgeEvbVSIDBEntry 9 }


ieee8021BridgeEvbVSIMgrID      OBJECT-TYPE
   SYNTAX        OCTET STRING (SIZE (1))
   MAX-ACCESS    read-only
   STATUS        deprecated
   DESCRIPTION
   "This object identifies the VSI Manager with a database that holds
    the detailed  VSI type and or instance definitions."

   REFERENCE   "41.1.3"
   ::= { ieee8021BridgeEvbVSIDBEntry 10 }


ieee8021BridgeEvbVSIType OBJECT-TYPE
   SYNTAX     Integer32
   MAX-ACCESS read-only
   STATUS     current
   DESCRIPTION " The VTID is an integer value used to identify
                 a pre-configured set of  controls and attributes
                 that are associated with a set of VSIs."
   REFERENCE  "41.2.4"
   ::= { ieee8021BridgeEvbVSIDBEntry 11 }


ieee8021BridgeEvbVSITypeVersion  OBJECT-TYPE
   SYNTAX        OCTET STRING (SIZE (1))
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "The VSI Type Version is an integer identifier designating the
   expected/desired VTID version.  The VTID version allows a VSI
   Manager Database to contain multiple versions of a  given VSI
   Type, allowing smooth migration to newer VSI types."

   REFERENCE   "41.2.5"
   ::= { ieee8021BridgeEvbVSIDBEntry 12 }


ieee8021BridgeEvbVSIMvFormat       OBJECT-TYPE
   SYNTAX        INTEGER
                 {
                   basic (1),
                   partial (2),
                   vlanOnly (3)
                 }
   MAX-ACCESS    read-only
   STATUS        deprecated
   DESCRIPTION
   "This object specifies the MAC/VLAN format.
    basic   - Basic MAC/VLAN format
    partial - Partial MAC/VLAN format
    vlanOnly - Vlan-only MAC/VLAN format
   "
```

```
   REFERENCE   "41.2.8"
   ::= { ieee8021BridgeEvbVSIDBEntry 13 }

ieee8021BridgeEvbVSINumMACs    OBJECT-TYPE
   SYNTAX        Integer32
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object specifies the the number of MAC address/VLAN ID pairs
   contained in the repeated portion of the MAC/VLANs field in the
   VDP TLV."
   REFERENCE   "41.2.9"
   ::= { ieee8021BridgeEvbVSIDBEntry 14 }


ieee8021BridgeEvbVDPMachineState   OBJECT-TYPE
   SYNTAX      INTEGER
               {
               preAssociate (1),
               preAssociateWithRsrcReservation (2),
               associate (3),
               deAssociate (4)
               }
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "This object specifies the VDP state machine. "
   REFERENCE   "41.5.5.14"
   ::= { ieee8021BridgeEvbVSIDBEntry 15 }


ieee8021BridgeEvbVDPCommandsSucceeded  OBJECT-TYPE
   SYNTAX        Counter32
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object specifies the VDP number of successful commands since
    creation."
   REFERENCE   "41.5"
   ::= { ieee8021BridgeEvbVSIDBEntry 16 }

ieee8021BridgeEvbVDPCommandsFailed   OBJECT-TYPE
   SYNTAX        Counter32
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object specifies the VDP number of failed commands since
   creation "
   REFERENCE   "41.5"
   ::= { ieee8021BridgeEvbVSIDBEntry 17 }

ieee8021BridgeEvbVDPCommandReverts   OBJECT-TYPE
   SYNTAX        Counter32
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object specifies the VDP command reverts since creation  "
   REFERENCE   "41.5"
   ::= { ieee8021BridgeEvbVSIDBEntry 18 }


ieee8021BridgeEvbVDPCounterDiscontinuity OBJECT-TYPE
   SYNTAX        TimeTicks
   UNITS         "hundredths of a second"
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
             "The time (in hundredths of a second) since the
             last counter discontinuity for any of the counters
             in the row."
       ::= { ieee8021BridgeEvbVSIDBEntry 19}
```

```
ieee8021BridgeEvbVSIMgrID16      OBJECT-TYPE
   SYNTAX        OCTET STRING (SIZE (16))
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object identifies the VSI Manager with a database that holds
    the detailed  VSI type and or instance definitions."

   REFERENCE   "41.1.3"
   ::= { ieee8021BridgeEvbVSIDBEntry 20 }


ieee8021BridgeEvbVSIFilterFormat       OBJECT-TYPE
   SYNTAX        INTEGER
                 {
                   vid (1),
                   macVid (2),
                   groupidVid (3),
                   groupidMacVid (4)
                 }
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION
   "This object specifies the MAC/VLAN format:
    vid (see 41.2.9.1)
    macVid (see 41.2.9.2)
    groupidVid (see 41.2.9.3)
    groupidMacVid (see 41.2.9.4)
   "
   REFERENCE   "41.2.8, 41.2.9"
   ::= { ieee8021BridgeEvbVSIDBEntry 21 }


-- ================================
-- List of MAC/VLANs
-- ================================

ieee8021BridgeEvbVSIDBMacTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeEvbVSIDBMacEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains database of the active Virtual Station
        Interfaces."
    REFERENCE   "12.26.3"
    ::= { ieee8021BridgeEvbVSIDBObjects 2 }

ieee8021BridgeEvbVSIDBMacEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeEvbVSIDBMacEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing database of the MAC/VLANs
         associated with Virtual Station Interfaces."

    INDEX  { ieee8021BridgeEvbVSIComponentID,
             ieee8021BridgeEvbVSIPortNumber,
             ieee8021BridgeEvbVSIIDType,
             ieee8021BridgeEvbVSIID,
             ieee8021BridgeEvbGroupID,
             ieee8021BridgeEvbVSIMac,
             ieee8021BridgeEvbVSIVlanId

           }
    ::= { ieee8021BridgeEvbVSIDBMacTable 1 }

Ieee8021BridgeEvbVSIDBMacEntry ::=
    SEQUENCE {
       ieee8021BridgeEvbGroupID             Unsigned32,
       ieee8021BridgeEvbVSIMac              MacAddress,
       ieee8021BridgeEvbVSIVlanId           VlanIndex
```

```
   }

ieee8021BridgeEvbGroupID   OBJECT-TYPE
   SYNTAX        Unsigned32
   MAX-ACCESS    not-accessible
   STATUS        current
   DESCRIPTION   "Group ID"
   REFERENCE     "41.2.9"
   ::= { ieee8021BridgeEvbVSIDBMacEntry 1}

ieee8021BridgeEvbVSIMac OBJECT-TYPE
   SYNTAX         MacAddress
   MAX-ACCESS     not-accessible
   STATUS         current
   DESCRIPTION
   "The mac-address part of the MAC/VLANs for a VSI."
   REFERENCE  "41.2.9"
   ::= { ieee8021BridgeEvbVSIDBMacEntry 2}


ieee8021BridgeEvbVSIVlanId OBJECT-TYPE
   SYNTAX         VlanIndex
   MAX-ACCESS     read-only
   STATUS         current
   DESCRIPTION
   "The Vlan ID part of the MAC/VLANs for a VSI."
    REFERENCE  "41.2.9"
   ::= { ieee8021BridgeEvbVSIDBMacEntry 3}


-- ================================================
-- Uplink Access Port table entry managed object
-- ================================================

ieee8021BridgeEvbSChannelObjects OBJECT IDENTIFIER ::=
                              { ieee8021BridgeEvbObjects 3 }


ieee8021BridgeEvbUAPConfigTable OBJECT-TYPE
     SYNTAX      SEQUENCE OF Ieee8021BridgeEvbUAPConfigEntry
     MAX-ACCESS  not-accessible
     STATUS      current
     DESCRIPTION
         "A table that contains  configuration parameters for UAP."
     REFERENCE   "12.26.4.1"
     ::= { ieee8021BridgeEvbSChannelObjects 1 }

ieee8021BridgeEvbUAPConfigEntry OBJECT-TYPE
     SYNTAX      Ieee8021BridgeEvbUAPConfigEntry
     MAX-ACCESS  not-accessible
     STATUS      current
     DESCRIPTION
         "A list of objects containing information to configure the
         attributes for UAP."
     INDEX  {
             ieee8021BridgePhyPort
             }
     ::= { ieee8021BridgeEvbUAPConfigTable 1 }

 Ieee8021BridgeEvbUAPConfigEntry ::=
     SEQUENCE {
     ieee8021BridgeEvbUAPComponentId
                          IEEE8021PbbComponentIdentifier,
     ieee8021BridgeEvbUAPPort
                          IEEE8021BridgePortNumber,
     ieee8021BridgeEvbUapConfigIfIndex
                          InterfaceIndexOrZero,
     ieee8021BridgeEvbUAPSchCdcpAdminEnable        INTEGER,
     ieee8021BridgeEvbUAPSchAdminCDCPRole          INTEGER,
     ieee8021BridgeEvbUAPSchAdminCDCPChanCap       Integer32,
     ieee8021BridgeEvbUAPSchOperCDCPChanCap        Integer32,
     ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolLow   VlanIndex,
```

```
     ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolHigh  VlanIndex,
     ieee8021BridgeEvbUAPSchOperState              INTEGER,
     ieee8021BridgeEvbSchCdcpRemoteEnabled         INTEGER,
     ieee8021BridgeEvbSchCdcpRemoteRole            INTEGER,
     ieee8021BridgeEvbUAPConfigStorageType         StorageType,
     ieee8021BridgeEvbUAPConfigRowStatus           RowStatus
    }

ieee8021BridgeEvbUAPComponentId OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifier
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "The ComponentID of the port for the UAP."
   ::= { ieee8021BridgeEvbUAPConfigEntry 1 }


ieee8021BridgeEvbUAPPort OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumber
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
   "The port number of the port for the UAP."
   ::= { ieee8021BridgeEvbUAPConfigEntry 2 }

ieee8021BridgeEvbUapConfigIfIndex  OBJECT-TYPE
   SYNTAX      InterfaceIndexOrZero
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION
        "The value of the instance of the IfIndex object,
         defined in the IF-MIB, for the interface corresponding
         to this port, or the value 0 if the port has not been
         bound to an underlying frame source and sink."
   ::= { ieee8021BridgeEvbUAPConfigEntry 3 }


ieee8021BridgeEvbUAPSchCdcpAdminEnable  OBJECT-TYPE
   SYNTAX     INTEGER
              {
                 enable (1),
                 disable (2)
              }
   MAX-ACCESS   read-create
   STATUS       current
   DESCRIPTION  "Administrative status of CDCP."
   REFERENCE    "42.4.2"

   ::= { ieee8021BridgeEvbUAPConfigEntry 4 }


ieee8021BridgeEvbUAPSchAdminCDCPRole  OBJECT-TYPE
   SYNTAX      INTEGER
               {
               cdcpRoleB(1),
               cdcpRoleS (2)
               }
   MAX-ACCESS  read-create
   STATUS      current
   DESCRIPTION  "The administratively configured value for the local
   port's role parameter. The value of AdminRole is not reflected in
   the S-channel TLV. The AdminRole may take the value S or B.
   S indicates  the sender is unwilling to accept S-channels
   configuration  (mode, # channels supported, channel index) from
   its neighbor and that the sender is willing to accept SVID
   assignments from the neighbor.  Stations usually take the S role.
   B indicates the sender is willing to accept  S-channels
   configuration (mode, # channels supported, channel index)
   from its neighbor and that the sender is willing do the best
   it can to fill  the SVID assignments
   from the neighbor. Bridges usually take the B role."
```

```
   REFERENCE  "42.4.2"
   DEFVAL  { 1 }

::= { ieee8021BridgeEvbUAPConfigEntry 5 }


ieee8021BridgeEvbUAPSchAdminCDCPChanCap OBJECT-TYPE
   SYNTAX             Integer32 (1 .. 167)
   MAX-ACCESS         read-create
   STATUS             current
   DESCRIPTION       "The administratively configured value for the
                      Number of Channels supported parameter. This
                      value is included as the ChanCap parameter in
                      the S-channel TLV."
   REFERENCE "42.4.1"

::= { ieee8021BridgeEvbUAPConfigEntry 6 }


ieee8021BridgeEvbUAPSchOperCDCPChanCap  OBJECT-TYPE
   SYNTAX         Integer32 (1 .. 167)
   MAX-ACCESS     read-only
   STATUS         current
   DESCRIPTION    "The operational value for the Number of Channels
                   supported parameter. This value is included
                   as the ChnCap parameter in the S-channel TLV."
   REFERENCE "42.4.8"
   ::= { ieee8021BridgeEvbUAPConfigEntry 7 }

ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolLow  OBJECT-TYPE
   SYNTAX           VlanIndex
   MAX-ACCESS       read-create
   STATUS           current
   DESCRIPTION      "Determines the lowest S-VIDs available for
                     assignment by CDCP."

   REFERENCE "42.4.7"
   ::= { ieee8021BridgeEvbUAPConfigEntry 8 }


ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolHigh  OBJECT-TYPE
   SYNTAX           VlanIndex
   MAX-ACCESS       read-create
   STATUS           current
   DESCRIPTION      "Determines the highest S-VIDs available for
                     assignment by CDCP."
   REFERENCE     "42.4.7"

   ::= { ieee8021BridgeEvbUAPConfigEntry 9 }


ieee8021BridgeEvbUAPSchOperState     OBJECT-TYPE
   SYNTAX       INTEGER
                {
                  running (1),
                  notRunning (2)
                 }
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION  "The current running state of CDCP."
   REFERENCE "42.4.14"

   ::= { ieee8021BridgeEvbUAPConfigEntry 10 }



ieee8021BridgeEvbSchCdcpRemoteEnabled  OBJECT-TYPE
   SYNTAX        INTEGER
                 {
                   enable (1),
                   disable (2)
                 }
```

```
   MAX-ACCESS    read-only
   STATUS        current
   DESCRIPTION  "CDCP state for the remote S-channel."
   REFERENCE   "42.4.14"
   ::= { ieee8021BridgeEvbUAPConfigEntry 11 }


ieee8021BridgeEvbSchCdcpRemoteRole   OBJECT-TYPE
   SYNTAX      INTEGER
               {
                  cdcpRoleB (1),
                  cdcpRoleS (2)
               }
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The  value for the remote port's role parameter."
   REFERENCE "42.4.12"
   ::= { ieee8021BridgeEvbUAPConfigEntry 12 }

ieee8021BridgeEvbUAPConfigStorageType            OBJECT-TYPE
   SYNTAX      StorageType
   MAX-ACCESS  read-create
   STATUS      current
   DESCRIPTION
        "The storage type for this row. Rows in this table that
         were created through an external process may have a storage
         type of readOnly or permanent.
         For a storage type of permanent, none of the columns have
         to be writable."
   DEFVAL { nonVolatile }
   ::= { ieee8021BridgeEvbUAPConfigEntry 13 }


ieee8021BridgeEvbUAPConfigRowStatus  OBJECT-TYPE
  SYNTAX       RowStatus
  MAX-ACCESS   read-create
  STATUS       current
  DESCRIPTION  "RowStatus for creating a UAP table entry."
  ::= { ieee8021BridgeEvbUAPConfigEntry 14 }



-- ====================================
-- S-Channel Interface Table
-- ====================================

ieee8021BridgeEvbCAPConfigTable OBJECT-TYPE
   SYNTAX      SEQUENCE OF Ieee8021BridgeEvbCAPConfigEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A table that contains  configuration information for
   the S-Channel Access Ports (CAP)."
   REFERENCE   "12.26.4.2"
   ::= { ieee8021BridgeEvbSChannelObjects 2 }

ieee8021BridgeEvbCAPConfigEntry OBJECT-TYPE
   SYNTAX      Ieee8021BridgeEvbCAPConfigEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A list of objects containing information for the S-Channel
    Access Ports (CAP)"
   INDEX  { ieee8021BridgePhyPort,
            ieee8021BridgeEvbSchID
   }
   ::= { ieee8021BridgeEvbCAPConfigTable 1 }

Ieee8021BridgeEvbCAPConfigEntry ::=
   SEQUENCE {
   ieee8021BridgeEvbSchID
                    Unsigned32,
```

```
   ieee8021BridgeEvbCAPComponentId
                     IEEE8021PbbComponentIdentifier,
   ieee8021BridgeEvbCapConfigIfIndex
                     InterfaceIndexOrZero,
   ieee8021BridgeEvbCAPPort
                     IEEE8021BridgePortNumber,
   ieee8021BridgeEvbCAPSChannelID
                     Unsigned32,
   ieee8021BridgeEvbCAPAssociateSBPOrURPCompID
                     IEEE8021PbbComponentIdentifier,
   ieee8021BridgeEvbCAPAssociateSBPOrURPPort
                     IEEE8021BridgePortNumber,
   ieee8021BridgeEvbCAPRowStatus
                     RowStatus
   }

ieee8021BridgeEvbSchID OBJECT-TYPE
   SYNTAX      Unsigned32 (1..4094)
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "This object represents the SVID for a ieee8021BridgeEvbSysType
    of evbBridge and a SCID(S-Channel ID) for a
    ieee8021BridgeEvbSysType of evbStation."
   REFERENCE  "42.4.3"
   ::= { ieee8021BridgeEvbCAPConfigEntry 1 }


ieee8021BridgeEvbCAPComponentId   OBJECT-TYPE
   SYNTAX       IEEE8021PbbComponentIdentifier
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION "Component ID for S-channel Access Port."
   ::= { ieee8021BridgeEvbCAPConfigEntry 2 }

ieee8021BridgeEvbCapConfigIfIndex   OBJECT-TYPE
   SYNTAX       InterfaceIndexOrZero
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION "The value of the instance of the IfIndex object,
         defined in the IF-MIB, for the interface corresponding
         to this port, or the value 0 if the port has not been
         bound to an underlying frame source and sink.
         The underlying IfEntry indexed by this column MUST be persistent
         across reinitializations of the management system."
   ::= { ieee8021BridgeEvbCAPConfigEntry 3 }


ieee8021BridgeEvbCAPPort   OBJECT-TYPE
   SYNTAX       IEEE8021BridgePortNumber
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION  "Port number for the S-Channel Access Port."
   ::= { ieee8021BridgeEvbCAPConfigEntry 4 }


ieee8021BridgeEvbCAPSChannelID    OBJECT-TYPE
   SYNTAX       Unsigned32
   MAX-ACCESS   read-only
   STATUS       current
   DESCRIPTION  "S-Channel ID (SCID) for this CAP."
   REFERENCE   "42.4.2"
   ::= { ieee8021BridgeEvbCAPConfigEntry 5 }

ieee8021BridgeEvbCAPAssociateSBPOrURPCompID   OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifier
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION "Component ID of the Server Edge Port to be
                associated with the CAP."
   REFERENCE    "12.4.1.5"
   ::= { ieee8021BridgeEvbCAPConfigEntry 6 }
```

```
ieee8021BridgeEvbCAPAssociateSBPOrURPPort    OBJECT-TYPE
   SYNTAX       IEEE8021BridgePortNumber
   MAX-ACCESS   read-write
   STATUS       current
   DESCRIPTION  "Port number of the Server Edge Port to be
   associated with the CAP."
   REFERENCE    "12.4.2"
::= { ieee8021BridgeEvbCAPConfigEntry 7 }


ieee8021BridgeEvbCAPRowStatus       OBJECT-TYPE
   SYNTAX        RowStatus
   MAX-ACCESS    read-create
   STATUS        current
   DESCRIPTION  "RowStatus to create/destroy this table."

   ::= { ieee8021BridgeEvbCAPConfigEntry 8 }

-- ====================================
-- Uplink Relay Port table entry
-- ====================================

ieee8021BridgeEvbURPTable OBJECT-TYPE
   SYNTAX      SEQUENCE OF Ieee8021BridgeEvbURPEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A table that contains  configuration information for
   the Uplink Relay Ports(URP)."
   REFERENCE   "12.26.5.1"
   ::= { ieee8021BridgeEvbSChannelObjects 3 }

ieee8021BridgeEvbURPEntry OBJECT-TYPE
   SYNTAX      Ieee8021BridgeEvbURPEntry
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION
   "A list of objects containing information for the Uplink
    Relay Ports(URP)."
   INDEX  { ieee8021BridgeEvbURPComponentId,
            ieee8021BridgeEvbURPPort
   }
   ::= { ieee8021BridgeEvbURPTable 1 }

Ieee8021BridgeEvbURPEntry ::=
   SEQUENCE {
     ieee8021BridgeEvbURPComponentId
                      IEEE8021PbbComponentIdentifier,
     ieee8021BridgeEvbURPPort
                      IEEE8021BridgePortNumber,
     ieee8021BridgeEvbURPIfIndex
                      InterfaceIndexOrZero,
     ieee8021BridgeEvbURPBindToISSPort
                      IEEE8021BridgePortNumber,
     ieee8021BridgeEvbURPLldpManual
                      TruthValue,
     ieee8021BridgeEvbURPVdpOperRsrcWaitDelay
                      Unsigned32,
     ieee8021BridgeEvbURPVdpOperRespWaitDelay
                      Unsigned32,
     ieee8021BridgeEvbURPVdpOperReinitKeepAlive
                      Unsigned32,
     ieee8021BridgeEvbURPVdpOperRsrcWaitDelayExp
                      Unsigned32,
     ieee8021BridgeEvbURPVdpOperReinitKeepAliveExp
                      Unsigned32
   }
```

```
ieee8021BridgeEvbURPComponentId        OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifier
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION "Component ID that the URP belongs to."
   ::= { ieee8021BridgeEvbURPEntry 1 }

ieee8021BridgeEvbURPPort               OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumber
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION "port number of the urp."
   ::= { ieee8021BridgeEvbURPEntry 2 }


ieee8021BridgeEvbURPIfIndex           OBJECT-TYPE
   SYNTAX      InterfaceIndexOrZero
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION "The value of the instance of the IfIndex object,
        defined in the IF-MIB, for the interface corresponding
        to this port, or the value 0 if the port has not been
        bound to an underlying frame source and sink.

        It is an implementation specific decision as to whether
        this object may be modified if it has been created or
        if 0 is a legal value.

        The underlying IfEntry indexed by this column MUST be
        persistent across reinitializations of the management
        system. "
   ::= { ieee8021BridgeEvbURPEntry 3 }

ieee8021BridgeEvbURPBindToISSPort      OBJECT-TYPE
   SYNTAX      IEEE8021BridgePortNumber
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION "The evbURPBindToISSPort is the ISS Port Number where
                the URP is attached.
                This binding is optional and only required in some
                systems."
   ::= { ieee8021BridgeEvbURPEntry 4 }


ieee8021BridgeEvbURPLldpManual         OBJECT-TYPE
   SYNTAX      TruthValue
   MAX-ACCESS  read-write
   STATUS      current
   DESCRIPTION  "The evbUrpLldpManual parameter control how the EVB
                 TLV determines the operating values for parameters.
                 When set TRUE only the local EVB TLV will be used to
                 determine the parameters."
   ::= { ieee8021BridgeEvbURPEntry 6 }


ieee8021BridgeEvbURPVdpOperRsrcWaitDelay     OBJECT-TYPE
   SYNTAX      Unsigned32
   UNITS       "micro-seconds"
   MAX-ACCESS  read-only
   STATUS      deprecated
   DESCRIPTION  "The parameter evbURPVdpOperRsrcWaitDelay is the
                 exponent of 2 used to set the VDP resourceWaitDelay
                 timer at the EVB Bridge."
   ::= { ieee8021BridgeEvbURPEntry 9 }

ieee8021BridgeEvbURPVdpOperRsrcWaitDelayExp     OBJECT-TYPE
   SYNTAX      Unsigned32 (0..31)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The parameter evbURPVdpOperRsrcWaitDelay is the
                 exponent of 2 used to set the VDP resourceWaitDelay
                 timer at the EVB Bridge."
```

```
    ::= { ieee8021BridgeEvbURPEntry 12 }

 ieee8021BridgeEvbURPVdpOperRespWaitDelay     OBJECT-TYPE
    SYNTAX     Unsigned32
    UNITS       "micro-seconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION  "The evbUrpVdpOperRespWaitDelay is how long a
                  EVb station VDP will wait for a response from
                  the EVB Bridge VDP."
    ::= { ieee8021BridgeEvbURPEntry 10 }


 ieee8021BridgeEvbURPVdpOperReinitKeepAlive   OBJECT-TYPE
    SYNTAX     Unsigned32
    UNITS      "micro-seconds"
    MAX-ACCESS  read-write
    STATUS      deprecated
    DESCRIPTION  "The evbURPVdpOperReinitKeepAlive is the exponent
                  of 2 used to determine the time interval of Keep
                  Alives transmitted by the EVB station."
    ::= { ieee8021BridgeEvbURPEntry 11 }

 ieee8021BridgeEvbURPVdpOperReinitKeepAliveExp   OBJECT-TYPE
    SYNTAX     Unsigned32 (0..31)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION  "The evbURPVdpOperReinitKeepAlive is the exponent
                  of 2 used to determine the time interval of Keep
                  Alives transmitted by the EVB station."
    ::= { ieee8021BridgeEvbURPEntry 13 }

-- ========================================
-- Edge Control Protocol Table
-- ========================================

ieee8021BridgeEvbEcpTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021BridgeEvbEcpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
    "A table that contains  configuration information for
    the Edge Control Protocol (ECP)."
    REFERENCE   "12.26.4.2"
    ::= { ieee8021BridgeEvbSChannelObjects 4 }

ieee8021BridgeEvbEcpEntry OBJECT-TYPE
    SYNTAX      Ieee8021BridgeEvbEcpEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
    "A list of objects containing information for theEdge Control
     Protocol (ECP)."
    INDEX  { ieee8021BridgeEvbEcpComponentId,
             ieee8021BridgeEvbEcpPort
    }
    ::= { ieee8021BridgeEvbEcpTable 1 }

    Ieee8021BridgeEvbEcpEntry ::=
       SEQUENCE {
       ieee8021BridgeEvbEcpComponentId
                  IEEE8021PbbComponentIdentifier,
       ieee8021BridgeEvbEcpPort
                  IEEE8021BridgePortNumber,
       ieee8021BridgeEvbEcpOperAckTimerInit    Unsigned32,
       ieee8021BridgeEvbEcpOperMaxRetries      Unsigned32,
       ieee8021BridgeEvbEcpTxFrameCount        Counter32,
       ieee8021BridgeEvbEcpTxRetryCount        Counter32,
       ieee8021BridgeEvbEcpTxFailures          Counter32,
       ieee8021BridgeEvbEcpRxFrameCount        Counter32,
       ieee8021BridgeEvbEcpOperAckTimerInitExp Unsigned32
       }
```

```
ieee8021BridgeEvbEcpComponentId        OBJECT-TYPE
   SYNTAX      IEEE8021PbbComponentIdentifier
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION  "Component ID ."
   ::= { ieee8021BridgeEvbEcpEntry 1 }

ieee8021BridgeEvbEcpPort               OBJECT-TYPE
   SYNTAX    IEEE8021BridgePortNumber
   MAX-ACCESS  not-accessible
   STATUS      current
   DESCRIPTION "Port number."
   ::= { ieee8021BridgeEvbEcpEntry 2 }


ieee8021BridgeEvbEcpOperAckTimerInit       OBJECT-TYPE
   SYNTAX      Unsigned32
   UNITS       "micro-seconds"
   MAX-ACCESS  read-only
   STATUS      deprecated
   DESCRIPTION  "The initial value used to initialize ackTimer
                     (43.3.6.1)."
   ::= { ieee8021BridgeEvbEcpEntry 3 }

ieee8021BridgeEvbEcpOperAckTimerInitExp       OBJECT-TYPE
   SYNTAX      Unsigned32 (0..31)
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The initial value used to initialize ackTimer.
                 Expressed as exp where 10*2exp microseconds is the
                 duration of the ack timer(43.3.6.1)."
   ::= { ieee8021BridgeEvbEcpEntry 9 }

ieee8021BridgeEvbEcpOperMaxRetries            OBJECT-TYPE
   SYNTAX      Unsigned32
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "This integer variable defines the maximum number
                  of times that the ECP transmit state machine will
                  retry a transmission if no ACK is received."
   ::= { ieee8021BridgeEvbEcpEntry 4 }

ieee8021BridgeEvbEcpTxFrameCount          OBJECT-TYPE
   SYNTAX      Counter32
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION "The evbECPTxFrameCount is the number of ECP frame
                transmitted since ECP was instanciated."
   ::= { ieee8021BridgeEvbEcpEntry 5 }


ieee8021BridgeEvbEcpTxRetryCount     OBJECT-TYPE
   SYNTAX      Counter32
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The evbECPTxRetryCount is the number of times
                  ECP re-tried transmission since ECP was
                  instanciated."
   ::= { ieee8021BridgeEvbEcpEntry 6 }

ieee8021BridgeEvbEcpTxFailures     OBJECT-TYPE
   SYNTAX      Counter32
   MAX-ACCESS  read-only
   STATUS      current
   DESCRIPTION  "The evbECPTxFailures is the number of times ECP
                 failed to successfully deliver a frame since ECP
                 was instanciated."
   ::= { ieee8021BridgeEvbEcpEntry 7 }
```

```
  ieee8021BridgeEvbEcpRxFrameCount   OBJECT-TYPE
     SYNTAX      Counter32
     MAX-ACCESS  read-only
     STATUS      current
     DESCRIPTION  "The evbECPRxFrameCount is the number
                   of frames received since ECP was instanciated."
     ::= { ieee8021BridgeEvbEcpEntry 8 }



-- ============================================================
-- Conformance Information
-- ============================================================

ieee8021BridgeEvbGroups
    OBJECT IDENTIFIER ::= { ieee8021BridgeEvbConformance 1 }

ieee8021BridgeEvbCompliances
    OBJECT IDENTIFIER ::= { ieee8021BridgeEvbConformance 2 }

-- ============================================================
-- Units of conformance
-- ============================================================

ieee8021BridgeEvbSysGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeEvbSysType,
        ieee8021BridgeEvbSysNumExternalPorts,
        ieee8021BridgeEvbSysEvbLldpTxEnable,
        ieee8021BridgeEvbSysEvbLldpGidCapable,
        ieee8021BridgeEvbSysEvbLldpManual,
        ieee8021BridgeEvbSysEcpAckTimer,
        ieee8021BridgeEvbSysEcpMaxRetries,
        ieee8021BridgeEvbSysVdpDfltRsrcWaitDelay,
        ieee8021BridgeEvbSysVdpDfltReinitKeepAlive


    }
    STATUS      deprecated
    DESCRIPTION
        "The collection of objects used to represent a EVB
         management objects."
    ::= { ieee8021BridgeEvbGroups 1 }


ieee8021BridgeEvbSbpGroup   OBJECT-GROUP
   OBJECTS {
        ieee8021BridgeEvbSbpLldpManual,
        ieee8021BridgeEvbSbpVdpOperRsrcWaitDelay ,
        ieee8021BridgeEvbSbpVdpOperReinitKeepAlive,
        ieee8021BridgeEvbSbpVdpOperToutKeepAlive
   }
   STATUS deprecated
   DESCRIPTION
   "The collection of objects used to represent a SBP
    management objects."
   ::= { ieee8021BridgeEvbGroups 3 }


ieee8021BridgeEvbVSIDBGroup OBJECT-GROUP
    OBJECTS {
           ieee8021BridgeEvbVSITimeSinceCreate ,
           ieee8021BridgeEvbVsiVdpOperCmd,
           ieee8021BridgeEvbVsiOperRevert,
           ieee8021BridgeEvbVsiOperHard,
           ieee8021BridgeEvbVsiOperReason,
           ieee8021BridgeEvbVSIMgrID,
           ieee8021BridgeEvbVSIType,
           ieee8021BridgeEvbVSITypeVersion ,
           ieee8021BridgeEvbVSIMvFormat,
           ieee8021BridgeEvbVSINumMACs ,
           ieee8021BridgeEvbVDPMachineState ,
```

```
        ieee8021BridgeEvbVDPCommandsSucceeded ,
        ieee8021BridgeEvbVDPCommandsFailed ,
        ieee8021BridgeEvbVDPCommandReverts ,
        ieee8021BridgeEvbVDPCounterDiscontinuity,
        ieee8021BridgeEvbVSIVlanId
  }
  STATUS      deprecated
  DESCRIPTION
      "The collection of objects used to represent a EVB VSI
       DB table."
  ::= { ieee8021BridgeEvbGroups 4 }


ieee8021BridgeEvbUAPGroup OBJECT-GROUP
   OBJECTS {
           ieee8021BridgeEvbUAPComponentId,
           ieee8021BridgeEvbUAPPort,
           ieee8021BridgeEvbUapConfigIfIndex,
           ieee8021BridgeEvbUAPSchCdcpAdminEnable,
           ieee8021BridgeEvbUAPSchAdminCDCPRole,
           ieee8021BridgeEvbUAPSchAdminCDCPChanCap,
           ieee8021BridgeEvbUAPSchOperCDCPChanCap,
           ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolLow,
           ieee8021BridgeEvbUAPSchAdminCDCPSVIDPoolHigh,
           ieee8021BridgeEvbUAPSchOperState,
           ieee8021BridgeEvbSchCdcpRemoteEnabled,
           ieee8021BridgeEvbSchCdcpRemoteRole,
           ieee8021BridgeEvbUAPConfigStorageType ,
           ieee8021BridgeEvbUAPConfigRowStatus
   }
   STATUS      current
   DESCRIPTION
       "The collection of objects used to represent a EVB UAP
        table."
   ::= { ieee8021BridgeEvbGroups 5 }


 ieee8021BridgeEvbCAPConfigGroup OBJECT-GROUP
     OBJECTS {
           ieee8021BridgeEvbCAPComponentId,
           ieee8021BridgeEvbCapConfigIfIndex,
           ieee8021BridgeEvbCAPPort,
           ieee8021BridgeEvbCAPSChannelID,
           ieee8021BridgeEvbCAPAssociateSBPOrURPCompID,
           ieee8021BridgeEvbCAPAssociateSBPOrURPPort,
           ieee8021BridgeEvbCAPRowStatus
     }
     STATUS      current
     DESCRIPTION
         "The collection of objects used to represent a EVB
          CAP management objects."
  ::= { ieee8021BridgeEvbGroups 6 }



  ieee8021BridgeEvbsURPGroup OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeEvbURPIfIndex,
        ieee8021BridgeEvbURPBindToISSPort ,
        ieee8021BridgeEvbURPLldpManual,
        ieee8021BridgeEvbURPVdpOperRsrcWaitDelay,
        ieee8021BridgeEvbURPVdpOperRespWaitDelay ,
        ieee8021BridgeEvbURPVdpOperReinitKeepAlive
    }
    STATUS      deprecated
    DESCRIPTION
        "The collection of objects used to represent a EVBS URP
         management objects."
::= { ieee8021BridgeEvbGroups 7 }


 ieee8021BridgeEvbEcpGroup OBJECT-GROUP
```

```
      OBJECTS {
      ieee8021BridgeEvbEcpOperAckTimerInit,
      ieee8021BridgeEvbEcpOperMaxRetries ,
      ieee8021BridgeEvbEcpTxFrameCount,
      ieee8021BridgeEvbEcpTxRetryCount,
      ieee8021BridgeEvbEcpTxFailures ,
      ieee8021BridgeEvbEcpRxFrameCount
      }
      STATUS      deprecated
      DESCRIPTION
      "The collection of objects used to represent a EVB CAP
       management objects."
      ::= { ieee8021BridgeEvbGroups 8 }


  ieee8021BridgeEvbSysV2Group OBJECT-GROUP
    OBJECTS {
        ieee8021BridgeEvbSysType,
        ieee8021BridgeEvbSysNumExternalPorts,
        ieee8021BridgeEvbSysEvbLldpTxEnable,
        ieee8021BridgeEvbSysEvbLldpGidCapable,
        ieee8021BridgeEvbSysEvbLldpManual,
        ieee8021BridgeEvbSysEcpDfltAckTimerExp,
        ieee8021BridgeEvbSysEcpMaxRetries,
        ieee8021BridgeEvbSysVdpDfltRsrcWaitDelayExp,
        ieee8021BridgeEvbSysVdpDfltReinitKeepAliveExp
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used to represent a EVB
         management objects."
    ::= { ieee8021BridgeEvbGroups 9 }

ieee8021BridgeEvbSbpV2Group   OBJECT-GROUP
   OBJECTS {
        ieee8021BridgeEvbSbpLldpManual,
        ieee8021BridgeEvbSbpVdpOperRsrcWaitDelayExp,
        ieee8021BridgeEvbSbpVdpOperReinitKeepAliveExp,
        ieee8021BridgeEvbSbpVdpOperToutKeepAlive
   }
   STATUS  current
   DESCRIPTION
   "The collection of objects used to represent a SBP
    management objects."
   ::= { ieee8021BridgeEvbGroups 10 }

ieee8021BridgeEvbVSIDBV2Group OBJECT-GROUP
    OBJECTS {
           ieee8021BridgeEvbVSITimeSinceCreate ,
           ieee8021BridgeEvbVsiVdpOperCmd,
           ieee8021BridgeEvbVsiOperRevert,
           ieee8021BridgeEvbVsiOperHard,
           ieee8021BridgeEvbVsiOperReason,
           ieee8021BridgeEvbVSIMgrID16,
           ieee8021BridgeEvbVSIType,
           ieee8021BridgeEvbVSITypeVersion ,
           ieee8021BridgeEvbVSIFilterFormat,
           ieee8021BridgeEvbVSINumMACs ,
           ieee8021BridgeEvbVDPMachineState ,
           ieee8021BridgeEvbVDPCommandsSucceeded ,
           ieee8021BridgeEvbVDPCommandsFailed ,
           ieee8021BridgeEvbVDPCommandReverts ,
           ieee8021BridgeEvbVDPCounterDiscontinuity,
           ieee8021BridgeEvbVSIVlanId
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used to represent a EVB VSI
         DB table."
    ::= { ieee8021BridgeEvbGroups 11 }
```

```
ieee8021BridgeEvbsURPV2Group OBJECT-GROUP
      OBJECTS {
          ieee8021BridgeEvbURPIfIndex,
          ieee8021BridgeEvbURPBindToISSPort ,
          ieee8021BridgeEvbURPLldpManual,
          ieee8021BridgeEvbURPVdpOperRsrcWaitDelayExp,
          ieee8021BridgeEvbURPVdpOperRespWaitDelay ,
          ieee8021BridgeEvbURPVdpOperReinitKeepAliveExp
      }
      STATUS  current
      DESCRIPTION
          "The collection of objects used to represent a EVBS URP
           management objects."
  ::= { ieee8021BridgeEvbGroups 12 }

ieee8021BridgeEvbEcpV2Group OBJECT-GROUP
      OBJECTS {
      ieee8021BridgeEvbEcpOperAckTimerInitExp,
      ieee8021BridgeEvbEcpOperMaxRetries ,
      ieee8021BridgeEvbEcpTxFrameCount,
      ieee8021BridgeEvbEcpTxRetryCount,
      ieee8021BridgeEvbEcpTxFailures ,
      ieee8021BridgeEvbEcpRxFrameCount
      }
      STATUS  current
      DESCRIPTION
      "The collection of objects used to represent a EVB CAP
       management objects."
      ::= { ieee8021BridgeEvbGroups 13 }

-- ================================================================
-- compliance statements
-- ================================================================

ieee8021BridgeEvbbCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for devices supporting EVB
        as defined in IEEE 802.1Q."
    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeEvbSysGroup,
            ieee8021BridgeEvbVSIDBGroup,
            ieee8021BridgeEvbSbpGroup,
            ieee8021BridgeEvbEcpGroup
        }

      GROUP  ieee8021BridgeEvbUAPGroup
      DESCRIPTION "This group is mandatory when S-Channels
                   are present."

      GROUP ieee8021BridgeEvbCAPConfigGroup
      DESCRIPTION "This group is mandatory when S-Channels
                   are present."

    ::= { ieee8021BridgeEvbCompliances 1 }

 ieee8021BridgeEvbsCompliance MODULE-COMPLIANCE
    STATUS      deprecated
    DESCRIPTION
        "The compliance statement for devices supporting EVBS
        as defined in IEEE 802.1Q."
    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeEvbSysGroup,
            ieee8021BridgeEvbVSIDBGroup,
            ieee8021BridgeEvbsURPGroup,
            ieee8021BridgeEvbEcpGroup

        }
        GROUP ieee8021BridgeEvbUAPGroup
        DESCRIPTION "This group is mandatory when S-Channels
```

```
                    are present."

        GROUP ieee8021BridgeEvbCAPConfigGroup
        DESCRIPTION "This group is mandatory when S-Channels
                    are present."

    ::= { ieee8021BridgeEvbCompliances 2 }

ieee8021BridgeEvbbComplianceV2 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting EVB
        as defined in IEEE 802.1Q."
    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeEvbSysV2Group,
            ieee8021BridgeEvbVSIDBV2Group,
            ieee8021BridgeEvbSbpV2Group,
            ieee8021BridgeEvbEcpV2Group
        }

      GROUP  ieee8021BridgeEvbUAPGroup
      DESCRIPTION "This group is mandatory when S-Channels
                  are present."

      GROUP ieee8021BridgeEvbCAPConfigGroup
      DESCRIPTION "This group is mandatory when S-Channels
                  are present."

    ::= { ieee8021BridgeEvbCompliances 3 }


 ieee8021BridgeEvbsComplianceV2 MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting EVBS
        as defined in IEEE 802.1Q."
    MODULE
        MANDATORY-GROUPS {
            ieee8021BridgeEvbSysV2Group,
            ieee8021BridgeEvbVSIDBV2Group,
            ieee8021BridgeEvbsURPV2Group,
            ieee8021BridgeEvbEcpV2Group

        }
        GROUP ieee8021BridgeEvbUAPGroup
        DESCRIPTION "This group is mandatory when S-Channels
                    are present."

        GROUP ieee8021BridgeEvbCAPConfigGroup
        DESCRIPTION "This group is mandatory when S-Channels
                    are present."

    ::= { ieee8021BridgeEvbCompliances 4 }

END
```

17.7.21 Definitions for the IEEE8021-ECMP-MIB module

```
IEEE8021-ECMP-MIB DEFINITIONS ::= BEGIN

-- ================================================================
--  IEEE 802.1 Equal Cost Multiple Paths (ECMP) MIB
-- ================================================================

IMPORTS
    MODULE-IDENTITY, OBJECT-TYPE, Integer32, Counter64
        FROM SNMPv2-SMI
    RowStatus, TruthValue
        FROM SNMPv2-TC
    ieee802dot1mibs
        FROM IEEE8021-TC-MIB
    PortList, VlanId
        FROM Q-BRIDGE-MIB
    ieee8021BridgeBasePortComponentId, ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    ieee8021QBridgeTpFdbEntry, ieee8021QBridgePortVlanStatisticsEntry
        FROM IEEE8021-Q-BRIDGE-MIB
    IEEE8021SpbBridgePriority, ieee8021SpbmTopSrvTableEntry,
    ieee8021SpbTopIx
        FROM IEEE8021-SPB-MIB
    MODULE-COMPLIANCE, OBJECT-GROUP
        FROM SNMPv2-CONF;

ieee8021EcmpMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "MIB Module for managing systems that provide
        802.1Q Equal Cost Multiple Paths.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected.
            Description replaced."

    REVISION  "201412150000Z"  -- December 15, 2014
    DESCRIPTION  "Incorporated into IEEE Std 802.1Q 2014 Revision.
                 Cross-references and front matter updated."

    REVISION  "201305130000Z"  -- May 13, 2013
    DESCRIPTION  "802.1 Equal Cost Multiple Paths MIB Initial Version"
    ::= { ieee802dot1mibs 28 }

ieee8021EcmpNotifications OBJECT IDENTIFIER ::= { ieee8021EcmpMib 0 }
```

```
ieee8021EcmpObjects       OBJECT IDENTIFIER ::= { ieee8021EcmpMib 1 }
ieee8021EcmpConformance   OBJECT IDENTIFIER ::= { ieee8021EcmpMib 2 }

-- ====================================================================
--  OBJECT DEFINITIONS
-- ====================================================================

-- ============================================================
--  ECMP FDB object for Individual Addresses
-- ============================================================

ieee8021QBridgeEcmpFdbTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021QBridgeEcmpFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains information about unicast entries
        for which the device has forwarding and/or filtering
        information.  This information is used by the
        ECMP next hop selection function in determining how to
        propagate a received frame."
    REFERENCE   "12.7.7.3, 8.8.3:c"
    ::= { ieee8021EcmpObjects 1 }

ieee8021QBridgeEcmpFdbEntry OBJECT-TYPE
    SYNTAX      Ieee8021QBridgeEcmpFdbEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "Information about a specific unicast MAC address for
        which the device has some forwarding and/or filtering
        information."
    AUGMENTS { ieee8021QBridgeTpFdbEntry }
    ::= { ieee8021QBridgeEcmpFdbTable 1 }

Ieee8021QBridgeEcmpFdbEntry ::=
    SEQUENCE {
        ieee8021QBridgeEcmpFdbPortList    PortList
    }

ieee8021QBridgeEcmpFdbPortList OBJECT-TYPE
    SYNTAX      PortList
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The complete set of ports, in this FID, to which
         frames destined for this individual MAC address may be
         forwarded."
    ::= { ieee8021QBridgeEcmpFdbEntry 1 }

-- ============================================================
--  Flow Filtering Control Table
-- ============================================================

ieee8021EcmpFlowFilterCtlTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021EcmpFlowFilterCtlEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "A table flow filtering control information for ports
         in a Bridge supporting F-Tag processing."
    REFERENCE "12.16.5.4, 12.16.5.5"
    ::= { ieee8021EcmpObjects 2 }

ieee8021EcmpFlowFilterCtlEntry OBJECT-TYPE
    SYNTAX     Ieee8021EcmpFlowFilterCtlEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "An entry in the Flow Filtering Control Table for a
         port (CPB or PNP)."
    INDEX   { ieee8021BridgeBasePortComponentId,
```

```
            ieee8021BridgePort,
            ieee8021EcmpFlowFilterCtlVid }
    ::= { ieee8021EcmpFlowFilterCtlTable 1 }

Ieee8021EcmpFlowFilterCtlEntry ::=
    SEQUENCE {
        ieee8021EcmpFlowFilterCtlVid        VlanId,
        ieee8021EcmpFlowFilterCtlEnabled    TruthValue,
        ieee8021EcmpFlowFilterCtlHashGen    TruthValue,
        ieee8021EcmpFlowFilterCtlTtl        Integer32
    }

ieee8021EcmpFlowFilterCtlVid OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A B-vID registered on the port."
    ::= { ieee8021EcmpFlowFilterCtlEntry 1 }

ieee8021EcmpFlowFilterCtlEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Indicates whether or not flow filtering behavior
         is enabled on the port for the VID
         (true(1) is enabled, false(2) is disabled)."
    ::= { ieee8021EcmpFlowFilterCtlEntry 2 }

ieee8021EcmpFlowFilterCtlHashGen OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "indicates whether or not flow hash generation
         is enabled on the port for the VID
         (true(1) is enabled, false(2) is disabled)."
    ::= { ieee8021EcmpFlowFilterCtlEntry 3 }

ieee8021EcmpFlowFilterCtlTtl OBJECT-TYPE
    SYNTAX      Integer32 (0..63)
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "the initial TTL value for frames entering
         the flow filtering SPT Domain.
         Valid values are 1..63, zero indicates the
         value has not been set.
         This object is persistent."
    ::= { ieee8021EcmpFlowFilterCtlEntry 4 }

-- ====================================================================
--  ECMP ECT Static Entry Table
-- ====================================================================

ieee8021EcmpEctStaticTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021EcmpEctStaticEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "Table containing alternate Bridge priorities for tie-breaker
         masks used in selecting shared tree root bridges.
         The table is indexed by
         - ieee8021SpbTopIx from ieee8021SpbMtidStaticTable
             indicating the ISIS-SPB topology instance into
             which the bridge priority will be advertised, and
         - ieee8021EcmpEctStaticEntryTieBreakMask
             the associated tie-break mask value."
    REFERENCE "12.25.14"
    ::= { ieee8021EcmpObjects 3 }
```

```
ieee8021EcmpEctStaticEntry OBJECT-TYPE
    SYNTAX Ieee8021EcmpEctStaticEntry
    MAX-ACCESS not-accessible
    STATUS current
    DESCRIPTION
        "This entry contains information about backbone services
         configured on this system to be advertised by ISIS-SPB."
    REFERENCE "12.25.8"
    INDEX {
            ieee8021SpbTopIx,
            ieee8021EcmpEctStaticEntryTieBreakMask
          }
    ::= { ieee8021EcmpEctStaticTable 1 }

Ieee8021EcmpEctStaticEntry ::=
    SEQUENCE {
        ieee8021EcmpEctStaticEntryTieBreakMask    Integer32,
        ieee8021EcmpEctStaticEntryBridgePriority  IEEE8021SpbBridgePriority,
        ieee8021EcmpEctStaticEntryRowStatus       RowStatus
    }

ieee8021EcmpEctStaticEntryTieBreakMask OBJECT-TYPE
    SYNTAX      Integer32 (0..15)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The value used to create the Tie-Break Mask
         for selecting a shared tree root bridge."
    ::= { ieee8021EcmpEctStaticEntry 1 }

ieee8021EcmpEctStaticEntryBridgePriority OBJECT-TYPE
    SYNTAX      IEEE8021SpbBridgePriority
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A Bridge Priority value to be used
         for selecting a shared tree root bridge,
         i.e., the most significant 4 bits of the
         Bridge Identifier.
         This object is persistent."
    ::= { ieee8021EcmpEctStaticEntry 2 }

ieee8021EcmpEctStaticEntryRowStatus OBJECT-TYPE
    SYNTAX     RowStatus
    MAX-ACCESS read-create
    STATUS     current
    DESCRIPTION
        "This column holds the status for this row.

         When the status is active, no columns of this table may be
         modified.  All columns must have a valid value before the row
         can be activated.
         This object is persistent."
    ::= { ieee8021EcmpEctStaticEntry 3 }

-- ================================================================
--  ECMP extensions to ieee8021SpbmTopSrvTable
-- ================================================================

ieee8021EcmpTopSrvTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021EcmpTopSrvEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "Added info for SPBM PBB encapsulated services in this network."
    REFERENCE "12.25.8"
    ::= { ieee8021EcmpObjects 4 }

ieee8021EcmpTopSrvEntry OBJECT-TYPE
    SYNTAX Ieee8021EcmpTopSrvEntry
    MAX-ACCESS not-accessible
    STATUS current
```

```
    DESCRIPTION
        "This table contains additional information about backbone
         services configured on this system to be advertised by
         ISIS-SPB."
    REFERENCE "12.25.8"
    AUGMENTS { ieee8021SpbmTopSrvTableEntry }
    ::= { ieee8021EcmpTopSrvTable 1 }

Ieee8021EcmpTopSrvEntry ::=
    SEQUENCE {
        ieee8021EcmpTopSrvEntryTsBit         TruthValue,
        ieee8021EcmpTopSrvEntryTieBreakMask  Integer32
    }

ieee8021EcmpTopSrvEntryTsBit OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "If true(1), indicates the BSI transmits multicast
         frames on a shared tree from this CBP."
    ::= { ieee8021EcmpTopSrvEntry 1 }

ieee8021EcmpTopSrvEntryTieBreakMask OBJECT-TYPE
    SYNTAX      Integer32 (0..15)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value used to create the Tie-Break Mask
         for calculating multicast trees."
    ::= { ieee8021EcmpTopSrvEntry 2 }

-- ============================================================
--  Per port VLAN TTL Statistics Table
-- ============================================================

ieee8021QBridgePortVlanTtlStatisticsTable OBJECT-TYPE
    SYNTAX     SEQUENCE OF Ieee8021QBridgePortVlanTtlStatisticsEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "A table containing per-port, per-VID TTL discard statistics."
    ::= { ieee8021EcmpObjects 5 }

ieee8021QBridgePortVlanTtlStatisticsEntry OBJECT-TYPE
    SYNTAX     Ieee8021QBridgePortVlanTtlStatisticsEntry
    MAX-ACCESS not-accessible
    STATUS     current
    DESCRIPTION
        "TTL discard statistics for a VID on an interface."
    AUGMENTS { ieee8021QBridgePortVlanStatisticsEntry }
    ::= { ieee8021QBridgePortVlanTtlStatisticsTable 1 }

Ieee8021QBridgePortVlanTtlStatisticsEntry ::=
    SEQUENCE {
        ieee8021QBridgeTpVlanPortTtlDiscards   Counter64
    }

ieee8021QBridgeTpVlanPortTtlDiscards OBJECT-TYPE
    SYNTAX     Counter64
    UNITS      "frames"
    MAX-ACCESS read-only
    STATUS     current
    DESCRIPTION
        "The number of valid frames received by this port from
        its segment that were classified as belonging to this
        VLAN and that were discarded due to TTL expiry.
        Discontinuities in the value of the counter can occur
        at re-initialization of the management system, and at
        other times as indicated by the value of
        ifCounterDiscontinuityTime object of the associated
        interface (if any)."
```

```
    REFERENCE "12.6.1.1.3"
    ::= { ieee8021QBridgePortVlanTtlStatisticsEntry 1 }

-- ================================================================
--  Conformance Information
-- ================================================================

ieee8021EcmpGroups      OBJECT IDENTIFIER ::= { ieee8021EcmpConformance 1}
ieee8021EcmpCompliances OBJECT IDENTIFIER ::= { ieee8021EcmpConformance 2}

-- ================================================================
--  Units of conformance
-- ================================================================

ieee8021QBridgeEcmpFdbGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeEcmpFdbPortList
    }
    STATUS current
    DESCRIPTION
    "FDB Port Map for ECMP Individual address"
    ::= { ieee8021EcmpGroups 1 }

ieee8021EcmpFlowFilterCtlGroup OBJECT-GROUP
    OBJECTS {
        ieee8021EcmpFlowFilterCtlEnabled,
        ieee8021EcmpFlowFilterCtlHashGen,
        ieee8021EcmpFlowFilterCtlTtl
    }
    STATUS current
    DESCRIPTION
    "Flow filtering control parameters on a CBP or PNP"
    ::= { ieee8021EcmpGroups 2 }

ieee8021EcmpEctStaticGroup OBJECT-GROUP
    OBJECTS {
        ieee8021EcmpEctStaticEntryBridgePriority,
        ieee8021EcmpEctStaticEntryRowStatus
    }
    STATUS current
    DESCRIPTION
    "Optional Bridge Priority for selecting shared tree root"
    ::= { ieee8021EcmpGroups 3 }

ieee8021EcmpTopSrvGroup OBJECT-GROUP
    OBJECTS {
        ieee8021EcmpTopSrvEntryTsBit,
        ieee8021EcmpTopSrvEntryTieBreakMask
    }
    STATUS current
    DESCRIPTION
    "Advertised I-SID parameters controlling multicast routing"
    ::= { ieee8021EcmpGroups 4 }

ieee8021QBridgePortVlanTtlStatisticsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021QBridgeTpVlanPortTtlDiscards
    }
    STATUS current
    DESCRIPTION
    "TTL discard statistics"
    ::= { ieee8021EcmpGroups 5 }

-- ================================================================
-- Compliance statements
-- ================================================================

ieee8021EcmpCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "Compliance to IEEE 802.1 SPBM ECMP"
    MODULE
```

```
        MANDATORY-GROUPS {
            ieee8021QBridgeEcmpFdbGroup,
            ieee8021EcmpEctStaticGroup,
            ieee8021EcmpTopSrvGroup
        }
    ::= { ieee8021EcmpCompliances 1 }

ieee8021EcmpFlowFilteringCompliance MODULE-COMPLIANCE
    STATUS current
    DESCRIPTION
        "Compliance to IEEE 802.1 SPBM ECMP with flow filtering"
    MODULE
        MANDATORY-GROUPS {
            ieee8021EcmpFlowFilterCtlGroup,
            ieee8021QBridgePortVlanTtlStatisticsGroup
        }
    ::= { ieee8021EcmpCompliances 2 }

END
```

17.7.22 Definitions for the IEEE8021-ST-MIB module

```
IEEE8021-ST-MIB DEFINITIONS ::= BEGIN

-- ================================================================
-- MIB for support of the Scheduled Traffic Enhancements
-- for IEEE 802.1Q Bridges.
-- ================================================================


IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32,
    Counter64
        FROM SNMPv2-SMI
    TEXTUAL-CONVENTION,
    TruthValue
        FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee802dot1mibs
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId,
    ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    ;

ieee8021STMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        the Scheduled Traffic Enhancements
        for IEEE 802.1Q Bridges.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201608150000Z" -- August 15, 2016
    DESCRIPTION
        "Revised to include Set-And-Hold-MAC and
        Set-And-Release-MAC in the description of
        ieee8021STAdminControlList and
        ieee8021STOperControlList.
        Published as part of IEEE Std 802.1Qbu."
```

```
REVISION "201602190000Z" -- February 19, 2016
    DESCRIPTION
            "Initial version published as part of IEEE Std 802.1Qbv."

       ::= { ieee802dot1mibs 30 }

-- ================================================================
-- Textual Conventions
-- ================================================================

IEEE8021STTrafficClassValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS      current
    DESCRIPTION
        "A traffic class value.
        This is the numerical value associated with a traffic
        class in a Bridge. Larger values are associated with
        higher priority traffic classes."
    REFERENCE   "12.29.1"
    SYNTAX      Unsigned32 (0..7)

IEEE8021STPTPtimeValue ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
        "A PTPtime value, represented as a 48-bit unsigned integer
        number of seconds and a 32-bit unsigned integer number of
        nanoseconds.
        The first 6 octets represent the number of seconds: the
        first octet is the most significant
        octet of the 48-bit seconds value and the sixth octet
        is the least significant octet of the seconds value.
        The remaining octets, 7 through 10,  represent the
        number of nanoseconds: the seventh octet
        is the most significant octet of the 32-bit nanoseconds
        value and the tenth octet is the
        least significant octet of the nanoseconds value."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    SYNTAX      OCTET STRING (SIZE(10))


-- ================================================================
-- subtrees in the ST MIB
-- ================================================================

ieee8021STNotifications
    OBJECT IDENTIFIER ::= { ieee8021STMib 0 }

ieee8021STObjects
    OBJECT IDENTIFIER ::= { ieee8021STMib 1 }

ieee8021STConformance
    OBJECT IDENTIFIER ::= { ieee8021STMib 2 }

ieee8021STMaxSDUSubtree
    OBJECT IDENTIFIER ::= { ieee8021STObjects 1 }

ieee8021STParameters
    OBJECT IDENTIFIER ::= { ieee8021STObjects 2 }

-- ================================================================
-- The ieee8021STMaxSDUSubtree subtree
-- This subtree defines the objects necessary for the management
-- of the max SDU size parameters for each traffic class on a Port.
-- ================================================================

-- ================================================================
-- the ieee8021STMaxSDUTable
-- ================================================================

ieee8021STMaxSDUTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021STMaxSDUEntry
```

```
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of max SDU
        parameters, one for each traffic class.
        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STMaxSDUSubtree 1 }

ieee8021STMaxSDUEntry OBJECT-TYPE
    SYNTAX      Ieee8021STMaxSDUEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing Max SDU size
        for each traffic class supported by the Port."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021STTrafficClass  }
    ::= { ieee8021STMaxSDUTable 1 }

Ieee8021STMaxSDUEntry ::=
    SEQUENCE {
        ieee8021STTrafficClass
            IEEE8021STTrafficClassValue,
        ieee8021STMaxSDU
            Unsigned32,
        ieee8021TransmissionOverrun
            Counter64
        }

ieee8021STTrafficClass OBJECT-TYPE
    SYNTAX      IEEE8021STTrafficClassValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The traffic class number associated with the row of
        the table.

        A row in this table is created for each traffic class
        that is supported by the Port"
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STMaxSDUEntry 1 }


ieee8021STMaxSDU OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "octets"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value of the MaxSDU parameter for the traffic class.
        This value is represented as an unsigned integer. A value
        of 0 is interpreted as the max SDU size supported by
        the underlying MAC.

        The default value of the MaxSDU parameter is 0.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    DEFVAL { 0 }
    ::= { ieee8021STMaxSDUEntry 2}


ieee8021TransmissionOverrun OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A counter of transmission overrun events, where
```

```
        a PDU is still being transmitted by a MAC at the
        time when the transmission gate for the queue closed."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1, 12.29.1.1.2"
    DEFVAL { 0 }
    ::= { ieee8021STMaxSDUEntry 3}


-- ============================================================
-- The ieee8021STParameters subtree
-- This subtree defines the objects necessary for the management
-- of the traffic scheduling mechanism for IEEE Std 802.1Q.
-- ============================================================

-- ============================================================
-- the ieee8021STParametersTable
-- ============================================================

ieee8021STParametersTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021STParametersEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains the per-port manageable parameters for
        traffic scheduling.

        For a given Port, a row in the table exists.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParameters 1 }

ieee8021STParametersEntry OBJECT-TYPE
    SYNTAX      Ieee8021STParametersEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contains the manageable parameters for
        traffic scheduling for a port."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort
           }
    ::= { ieee8021STParametersTable 1 }

Ieee8021STParametersEntry ::=
    SEQUENCE {
        ieee8021STGateEnabled
            TruthValue,
        ieee8021STAdminGateStates
            OCTET STRING,
        ieee8021STOperGateStates
            OCTET STRING,
        ieee8021STAdminControlListLength
            Unsigned32,
        ieee8021STOperControlListLength
            Unsigned32,
        ieee8021STAdminControlList
            OCTET STRING,
        ieee8021STOperControlList
            OCTET STRING,
        ieee8021STAdminCycleTimeNumerator
            Unsigned32,
        ieee8021STAdminCycleTimeDenominator
            Unsigned32,
        ieee8021STOperCycleTimeNumerator
            Unsigned32,
        ieee8021STOperCycleTimeDenominator
            Unsigned32,
        ieee8021STAdminCycleTimeExtension
            Unsigned32,
        ieee8021STOperCycleTimeExtension
            Unsigned32,
```

```
        ieee8021STAdminBaseTime
            IEEE8021STPTPtimeValue,
        ieee8021STOperBaseTime
            IEEE8021STPTPtimeValue,
        ieee8021STConfigChange
            TruthValue,
        ieee8021STConfigChangeTime
            IEEE8021STPTPtimeValue,
        ieee8021STTickGranularity
            Unsigned32,
        ieee8021STCurrentTime
            IEEE8021STPTPtimeValue,
        ieee8021STConfigPending
            TruthValue,
        ieee8021STConfigChangeError
            Counter64,
        ieee8021STSupportedListMax
            Unsigned32
            }

ieee8021STGateEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The GateEnabled parameter determines whether traffic scheduling
        is active (true) or inactive (false).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    DEFVAL { false }
    ::= { ieee8021STParametersEntry 1 }

ieee8021STAdminGateStates OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(1))
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the GateStates parameter for the Port.
        The bits of the octet represent the gate states for the
        corresponding traffic classes; the MS bit corresponds to traffic class 7,
        the LS bit to traffic class 0. A bit value of 0 indicates closed; a
        bit value of 1 indicates open.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 2 }

ieee8021STOperGateStates OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(1))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the GateStates parameter for the Port.
        The bits of the octet represent the gate states for the
        corresponding traffic classes; the MS bit corresponds to traffic class 7,
        the LS bit to traffic class 0. A bit value of 0 indicates closed; a
        bit value of 1 indicates open."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 3 }

ieee8021STAdminControlListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the ListMax parameter for the Port.
        The integer value indicates the number of entries (TLVs) in the
        AdminControlList.
```

```
        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 4 }

ieee8021STOperControlListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the ListMax parameter for the Port.
        The integer value indicates the number of entries (TLVs) in the
        OperControlList."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 5 }

ieee8021STAdminControlList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the ControlList parameter for the Port.
        The octet string value represents the contents of the control list as
        an ordered list of entries, each encoded as a TLV, as follows.
        The first octet  of each TLV is interpreted as an
        unsigned integer representing a gate operation name:
            0: SetGateStates
            1: Set-And-Hold-MAC
            2: Set-And-Release-MAC
            3-255: Reserved for future gate operations

        The second octet of the TLV is the length field,
        interpreted as an unsigned integer, indicating the number of
        octets of the value that follows the length. A length of
        zero indicates that there is no value
        (i.e., the gate operation has no parameters).

        The third through (3 + length -1)th octets encode the
        parameters of the gate operation, in the order that they
        appear in the definition of the operation
        in Table 8-6. Two parameter types are currently defined:

        - GateState:
            A GateState parameter is encoded in a single octet.
            The bits of the octet represent the gate states for the
            corresponding traffic classes; the MS bit corresponds
            to traffic class 7,
            the LS bit to traffic class 0. A bit value of 0 indicates
            closed; a bit value of 1 indicates open.

        - TimeInterval:
            A TimeInterval is encoded in 4 octets as a 32-bit
            unsigned integer, representing a number of nanoseconds.
            The first octet encodes the most significant 8 bits of the
            integer, and the fourth octet encodes the least
            significant 8 bits.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 6 }

ieee8021STOperControlList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the ListMax parameter for the Port.
        The octet string value represents the contents of the control list as
        an ordered list of TLVs, as follows.
        The first octet  of each TLV is interpreted as a gate operation name:
            0: SetGateStates
```

```
            1: Set-And-Hold-MAC
            2: Set-And-Release-MAC
            3-255: Reserved for future gate operations

        The second octet of the TLV is the length field,
        interpreted as an unsigned integer,
        indicating the number of octets of the value that follows
        the length. A length of zero indicates that there is no value
        (i.e., the gate operation has no parameters).

        The third through (3 + length -1)th octets encode the
        parameters of the gate operation, in the order that they
        appear in the definition of the operation
        in Table 8-6. Two parameter types are currently defined:

        - GateState:
            A GateState parameter is encoded in a single octet.
            The bits of the octet represent the gate states for the
            corresponding traffic classes; the MS bit corresponds to
            traffic class 7, the LS bit to traffic class 0.
            A bit value of 0 indicates closed; a
            bit value of 1 indicates open.

        - TimeInterval:
            A TimeInterval is encoded in 4 octets as a 32-bit
            unsigned integer, representing
            a number of nanoseconds. The first octet encodes the
            most significant 8 bits of the integer, and the fourth
            octet encodes the least significant 8 bits."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 7 }

ieee8021STAdminCycleTimeNumerator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the numerator of the CycleTime
        parameter for the Port.
        The numerator and denominator together represent the cycle time as
        a rational number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 8 }

ieee8021STAdminCycleTimeDenominator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the denominator of the
        CycleTime parameter for the Port.
        The numerator and denominator together represent the cycle time as
        a rational number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 9 }

ieee8021STOperCycleTimeNumerator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the numerator of the
        CycleTime parameter for the Port.
        The numerator and denominator together represent the cycle
        time as a rational number of seconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
```

```
    ::= { ieee8021STParametersEntry 10 }

ieee8021STOperCycleTimeDenominator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the denominator of the
        CycleTime parameter for the Port.
        The numerator and denominator together represent the
        cycle time as a rational number of seconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 11 }

ieee8021STAdminCycleTimeExtension OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nanoseconds"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the CycleTimeExtension
        parameter for the Port.
        The value is an unsigned integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 12 }

ieee8021STOperCycleTimeExtension OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nanoseconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the CycleTimeExtension parameter for the Port.
        The value is an unsigned integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 13 }

ieee8021STAdminBaseTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The administrative value of the BaseTime parameter for the Port.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 14 }

ieee8021STOperBaseTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operationsl value of the BaseTime parameter for the Port.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 15 }

ieee8021STConfigChange OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
```

```
    STATUS      current
    DESCRIPTION
        "The ConfigChange parameter signals the start of a
        configuration change
        when it is set to TRUE. This should only be done
        when the various administrative parameters
        are all set to appropriate values."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 16 }

ieee8021STConfigChangeTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The PTPtime at which the next config change is scheduled to occur.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 17 }

    ieee8021STTickGranularity OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The granularity of the cycle time clock, represented as an
        unsigned number of tenths of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 18 }

 ieee8021STCurrentTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The current time, in PTPtime, as maintained by the local system.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 19 }

 ieee8021STConfigPending OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the ConfigPending state machine variable.
        The value is TRUE if a configuration change is in progress
        but has not yet completed."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.29.1"
    ::= { ieee8021STParametersEntry 20 }

 ieee8021STConfigChangeError OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A counter of the number of times that a re-configuration
        of the traffic schedule has been requested with the old
        schedule still running and the requested base time was
        in the past."
    REFERENCE   "8.6.8.4, 8.6.9.3, 12.29.1"
```

```
    ::= { ieee8021STParametersEntry 21 }

ieee8021STSupportedListMax OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The maximum value supported by this Port of the
        AdminControlListLength and OperControlListLength
        parameters."
    REFERENCE   "12.29.1.5"
    ::= { ieee8021STParametersEntry 22 }


-- ================================================================
-- IEEE8021 FQTSS MIB - Conformance Information
-- ================================================================

ieee8021STCompliances
    OBJECT IDENTIFIER ::= { ieee8021STConformance 1 }
ieee8021STGroups
    OBJECT IDENTIFIER ::= { ieee8021STConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021STObjectsGroup group
-- ================================================================

ieee8021STObjectsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021STMaxSDU,
        ieee8021TransmissionOverrun,
        ieee8021STGateEnabled,
        ieee8021STAdminGateStates,
        ieee8021STOperGateStates,
        ieee8021STAdminControlListLength,
        ieee8021STOperControlListLength,
        ieee8021STAdminControlList,
        ieee8021STOperControlList,
        ieee8021STAdminCycleTimeNumerator,
        ieee8021STAdminCycleTimeDenominator,
        ieee8021STOperCycleTimeNumerator,
        ieee8021STOperCycleTimeDenominator,
        ieee8021STAdminCycleTimeExtension,
        ieee8021STOperCycleTimeExtension,
        ieee8021STAdminBaseTime,
        ieee8021STOperBaseTime,
        ieee8021STConfigChange,
        ieee8021STConfigChangeTime,
        ieee8021STTickGranularity,
        ieee8021STCurrentTime,
        ieee8021STConfigPending,
        ieee8021STConfigChangeError,
        ieee8021STSupportedListMax
    }
    STATUS      current
    DESCRIPTION
        "Objects that allow management of scheduled traffic."
    ::= { ieee8021STGroups 1 }


-- ================================================================
-- compliance statements
-- ================================================================

ieee8021STCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
```

```
        scheduled traffic.

        Support of the objects defined in this MIB module
        also requires support of the IEEE8021-BRIDGE-MIB; the
        provisions of 17.3.2 apply to implementations claiming
        support of this MIB. "

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021STObjectsGroup
        }

    ::= { ieee8021STCompliances 1 }

END
```

17.7.23 Definitions for the IEEE8021-Preemption-MIB module

```
IEEE8021-Preemption-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for support of the frame preemption enhancements
-- for IEEE 802.1Q Bridges.
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32
        FROM SNMPv2-SMI
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee802dot1mibs,
    IEEE8021PriorityValue
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId,
    ieee8021BridgeBasePort
        FROM IEEE8021-BRIDGE-MIB
    ;

ieee8021PreemptionMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
           E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        the frame preemption enhancements
        for IEEE 802.1Q Bridges.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201608150000Z" -- August 15, 2016
    DESCRIPTION
            "Initial version published as part of IEEE Std 802.1Qbu."

       ::= { ieee802dot1mibs 29 }


-- ============================================================
-- subtrees in the Preemption MIB
-- ============================================================
```

```
ieee8021PreemptionNotifications
    OBJECT IDENTIFIER ::= { ieee8021PreemptionMib 0 }

ieee8021PreemptionObjects
    OBJECT IDENTIFIER ::= { ieee8021PreemptionMib 1 }

ieee8021PreemptionConformance
    OBJECT IDENTIFIER ::= { ieee8021PreemptionMib 2 }

ieee8021PreemptionParameters
    OBJECT IDENTIFIER ::= { ieee8021PreemptionObjects 1 }

-- ================================================================
-- The ieee8021PreemptionNotifications subtree
-- This subtree defines any notifications necessary for the management
-- of frame preemption on a Port. This subtree is currently unused,
-- but is retained as a place-holder for future standardization.
-- ================================================================


-- ================================================================
-- The ieee8021PreemptionParameters subtree
-- This subtree defines the objects necessary for the management
-- of the frame preemption parameters for each priority value
-- on a Port.
-- ================================================================

-- ================================================================
-- the ieee8021PreemptionParameterTable
-- ================================================================

ieee8021PreemptionParameterTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PreemptionParameterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of frame preemption
        parameters, one for each priority value.
        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "6.7.2, 12.30.1"
    ::= { ieee8021PreemptionParameters 1 }

ieee8021PreemptionParameterEntry OBJECT-TYPE
    SYNTAX      Ieee8021PreemptionParameterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing preemption parameters
        for each  priority value."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021PreemptionPriority  }
    ::= { ieee8021PreemptionParameterTable 1 }

Ieee8021PreemptionParameterEntry ::=
    SEQUENCE {
        ieee8021PreemptionPriority
            IEEE8021PriorityValue,
        ieee8021FramePreemptionAdminStatus
            INTEGER
        }

ieee8021PreemptionPriority OBJECT-TYPE
    SYNTAX      IEEE8021PriorityValue
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The priority number associated with the row of
        the table.

        A row in this table is created for each priority value."
```

```
    REFERENCE   "6.7.2, 12.30.1"
    ::= { ieee8021PreemptionParameterEntry 1 }


ieee8021FramePreemptionAdminStatus OBJECT-TYPE
    SYNTAX      INTEGER {express (1), preemptable (2)}
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "The value of the framePreemptionAdminStatus parameter
        for the traffic class.

        The default value of the framePreemptionAdminStatus parameter
        is express (1).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "6.7.2, 12.30.1"
    ::= { ieee8021PreemptionParameterEntry 2}


-- ============================================================
-- the ieee8021PreemptionConfigTable
-- ============================================================

ieee8021PreemptionConfigTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PreemptionConfigEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of frame preemption
        parameters, one for each Port.
        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "6.7.2, 12.30.1"
    ::= { ieee8021PreemptionParameters 2 }

ieee8021PreemptionConfigEntry OBJECT-TYPE
    SYNTAX      Ieee8021PreemptionConfigEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing preemption parameters
        for each Port."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort }
    ::= { ieee8021PreemptionConfigTable 1 }

Ieee8021PreemptionConfigEntry ::=
    SEQUENCE {
        ieee8021FramePreemptionHoldAdvance
            Unsigned32,
        ieee8021FramePreemptionReleaseAdvance
            Unsigned32,
        ieee8021FramePreemptionActive
            INTEGER,
        ieee8021FramePreemptionHoldRequest
            INTEGER
        }

ieee8021FramePreemptionHoldAdvance OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the holdAdvance parameter
        for the Port in nanoseconds.

        There is no default value; the holdAdvance is
        a property of the underlying MAC."
    REFERENCE   "6.7.2, 12.30.1.2"
    ::= { ieee8021PreemptionConfigEntry 1 }
```

```
ieee8021FramePreemptionReleaseAdvance OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the releaseAdvance parameter
        for the Port in nanoseconds.

        There is no default value; the releaseAdvance is
        a property of the underlying MAC."
    REFERENCE   "6.7.2, 12.30.1.3"
    ::= { ieee8021PreemptionConfigEntry 2}

ieee8021FramePreemptionActive OBJECT-TYPE
    SYNTAX      INTEGER {idle (1), active (2)}
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value is active (2) when preemption is operationally
        active for the Port, and idle (1) otherwise."
    REFERENCE   "6.7.2, 12.30.1.4"
    ::= { ieee8021PreemptionConfigEntry 3}

ieee8021FramePreemptionHoldRequest OBJECT-TYPE
    SYNTAX      INTEGER {hold (1), release (2)}
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value is hold (1) when the sequence of gate operations
        for the Port has executed a Set-And-Hold-MAC operation,
        and release (2) when the sequence of gate operations has
        executed a Set-And-Release-MAC operation. The
        value of this object is release (2) on system
        initialization."
    REFERENCE   "6.7.2, Table 8-7, 12.30.1.5"
    ::= { ieee8021PreemptionConfigEntry 4}


-- ================================================================
-- IEEE8021 Preemption MIB - Conformance Information
-- ================================================================

ieee8021PreemptionCompliances
    OBJECT IDENTIFIER ::= { ieee8021PreemptionConformance 1 }
ieee8021PreemptionGroups
    OBJECT IDENTIFIER ::= { ieee8021PreemptionConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021PreemptionGroup group
-- ================================================================

ieee8021PreemptionGroup OBJECT-GROUP
    OBJECTS {
        ieee8021FramePreemptionAdminStatus,
        ieee8021FramePreemptionHoldAdvance,
        ieee8021FramePreemptionReleaseAdvance,
        ieee8021FramePreemptionActive,
        ieee8021FramePreemptionHoldRequest
    }
    STATUS      current
    DESCRIPTION
        "Objects that allow management of frame preemption."
    ::= { ieee8021PreemptionGroups 1 }


-- ================================================================
```

```
-- compliance statements
-- ============================================================

ieee8021PreemptionCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        frame preemption.

        Support of the objects defined in this MIB module
        also requires support of the IEEE8021-BRIDGE-MIB; the
        provisions of 17.3.2 apply to implementations claiming
        support of this MIB. "

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021PreemptionGroup
        }

    ::= { ieee8021PreemptionCompliances 1 }

END
```

17.7.24 Definitions for the IEEE8021-PSFP-MIB module

```
IEEE8021-PSFP-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB for support of the Per-Stream Filtering and Policing
-- Enhancements for IEEE 802.1Q Bridges.
-- ============================================================

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32,
    Integer32,
    Counter64
        FROM SNMPv2-SMI
    TruthValue, RowStatus
        FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ieee802dot1mibs
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBaseComponentId
        FROM IEEE8021-BRIDGE-MIB
    IEEE8021STPTPtimeValue
        FROM IEEE8021-ST-MIB
    ;

ieee8021PSFPMib MODULE-IDENTITY
    LAST-UPDATED "202201130000Z" -- January 13, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
        "The Bridge MIB module for managing devices that support
        the Per-Stream Filtering and Policing enhancements
        for IEEE 802.1Q Bridges.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202201130000Z" -- January 13, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "202011060000Z" -- November 6, 2020
    DESCRIPTION
            "Published as part of IEEE Std 802.1Qcr-2020.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."

    REVISION "201709080000Z" -- September 29, 2017
    DESCRIPTION
```

```
            "Initial version published as part of IEEE Std 802.1Qci."

       ::= { ieee802dot1mibs 31 }


-- ================================================================
-- subtrees in the PSFP MIB
-- ================================================================

ieee8021PSFPNotifications
    OBJECT IDENTIFIER ::= { ieee8021PSFPMib 0 }

ieee8021PSFPObjects
    OBJECT IDENTIFIER ::= { ieee8021PSFPMib 1 }

ieee8021PSFPConformance
    OBJECT IDENTIFIER ::= { ieee8021PSFPMib 2 }

ieee8021PSFPStreamFilterParameters
    OBJECT IDENTIFIER ::= { ieee8021PSFPObjects 1 }

ieee8021PSFPStreamGateParameters
    OBJECT IDENTIFIER ::= { ieee8021PSFPObjects 2 }

ieee8021PSFPFlowMeterParameters
    OBJECT IDENTIFIER ::= { ieee8021PSFPObjects 3 }

ieee8021PSFPStreamParameters
    OBJECT IDENTIFIER ::= { ieee8021PSFPObjects 4 }


-- ================================================================
-- The ieee8021PSFPStreamFilterParameters subtree
-- This subtree defines the objects necessary for the management
-- of the stream filters for IEEE Std 802.1Q.
-- ================================================================

-- ================================================================
-- the ieee8021PSFPStreamFilterTable
-- ================================================================

ieee8021PSFPStreamFilterTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PSFPStreamFilterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains the per-filter instance
        manageable parameters for stream filters.

        A row in the table exists for each stream filter instance.
        associated with a Bridge component.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterParameters 1 }

ieee8021PSFPStreamFilterEntry OBJECT-TYPE
    SYNTAX      Ieee8021PSFPStreamFilterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contains the manageable parameters for
        stream filters for a Bridge component."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021PSFPStreamFilterInstance
           }
    ::= { ieee8021PSFPStreamFilterTable 1 }

Ieee8021PSFPStreamFilterEntry ::=
    SEQUENCE {
        ieee8021PSFPStreamFilterInstance
```

```
            Unsigned32,
        ieee8021PSFPStreamHandleSpec
            Integer32,
        ieee8021PSFPPrioritySpec
            Integer32,
        ieee8021PSFPStreamGateInstanceID
            Unsigned32,
        ieee8021PSFPFilterSpecificationList
            OCTET STRING,
        ieee8021PSFPMatchingFramesCount
            Counter64,
        ieee8021PSFPPassingFramesCount
            Counter64,
        ieee8021PSFPNotPassingFramesCount
            Counter64,
        ieee8021PSFPPassingSDUCount
            Counter64,
        ieee8021PSFPNotPassingSDUCount
            Counter64,
        ieee8021PSFPREDFramesCount
            Counter64,
        ieee8021PSFPStreamBlockedDueToOversizeFrameEnable
            TruthValue,
        ieee8021PSFPStreamBlockedDueToOversizeFrame
            TruthValue,
        ieee8021PSFPStreamFilterEntryRowStatus
            RowStatus
             }

ieee8021PSFPStreamFilterInstance OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The StreamFilterInstance parameter is an index into the
        StreamFilterTable.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 1}

ieee8021PSFPStreamHandleSpec OBJECT-TYPE
    SYNTAX      Integer32 (-1..2147483647)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The StreamHandleSpec parameter contains a stream identifier
        specification value. A value of -1 denotes the wild card value;
        all positive values denote stream identifier values.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 2}

ieee8021PSFPPrioritySpec OBJECT-TYPE
    SYNTAX      Integer32 (-1..2147483647)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PrioritySpec parameter contains a priority
        specification value. A value of -1 denotes the wild card value;
        zero or positive values denote priority values.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 3}

ieee8021PSFPStreamGateInstanceID OBJECT-TYPE
    SYNTAX      Unsigned32
```

```
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The StreamGateInstance parameter contains the index of an
        entry in the Stream Gate Table.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 4}

ieee8021PSFPFilterSpecificationList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FilterSpecificationList parameter contains a list of
        filter specifications associated with this stream filter.

        The octet string value represents the contents of the list as
        an ordered list of entries, each encoded as a TLV, as follows.

        The first octet  of each TLV is interpreted as an
        unsigned integer representing a filter specification type:
            0: Maximum SDU Size.
            1: Flow meter instance identifier.
            2-255: Reserved for future filter specification types

        The second and third octets of the TLV are the length field,
        interpreted as an unsigned integer, indicating the number of
        octets of the value that follows the length. A length of
        zero indicates that there is no value
        (i.e., the filter specification has no parameters).

        The fourth through (4 + length -1)th octets encode the
        parameters of the filter specification, as defined for each
        filter specification type.

        - Maximum SDU Size:
            A single SDU size parameter is encoded in four octets, and
            is interpreted as an unsigned integer value.

        - Flow meter instance identifier:
            A single flow meter instance identifier is encoded in
            four octets, and is interpreted as an unsigned integer value.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 5}

ieee8021PSFPMatchingFramesCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The MatchingFramesCount counter counts received frames that
        match this stream filter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 6}

ieee8021PSFPPassingFramesCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The PassingFramesCount counter counts received frames that
        pass the gate associated with this stream filter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 7}
```

```
ieee8021PSFPNotPassingFramesCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The NotPassingFramesCount counter counts received frames that
        do not pass the gate associated
        with this stream filter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 8}

ieee8021PSFPPassingSDUCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The  PassingSDUCount counter counts received frames that
        pass the maximum SDU size filter specification associated
        with this stream filter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 9}

ieee8021PSFPNotPassingSDUCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The  NotPassingSDUCount counter counts received frames that
        do not pass the maximum SDU size filter specification associated
        with this stream filter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 10}

ieee8021PSFPREDFramesCount OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The REDFramesCount counter counts received
         frames that were discarded as a result of the
         operation of the flow meter.
        "
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamFilterEntry 11}

ieee8021PSFPStreamBlockedDueToOversizeFrameEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The ieee8021PSFPStreamBlockedDueToOversizeFrameEnable object
        contains a Boolean value that indicates whether the
        StreamBlockedDueToOversizeFrame function is
        enabled (TRUE) or disabled (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamFilterEntry 12 }

ieee8021PSFPStreamBlockedDueToOversizeFrame OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The ieee8021PSFPStreamBlockedDueToOversizeFrame object
        contains a Boolean value that indicates whether, if the
```

```
        StreamBlockedDueToOversizeFrame function is
        enabled, all frames are to be discarded (TRUE)
        or not (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.3, 12.31.2"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamFilterEntry 13 }

ieee8021PSFPStreamFilterEntryRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of the row.

         The writable columns in a row cannot be changed if the row
         is active. All columns MUST have a valid value before a row
         can be activated.
        "
    ::= { ieee8021PSFPStreamFilterEntry 14 }


-- ================================================================
-- The ieee8021PSFPStreamGateParameters subtree
-- This subtree defines the objects necessary for the management
-- of the stream gate scheduling mechanism for IEEE Std 802.1Q.
-- ================================================================

-- ================================================================
-- the ieee8021PSFPStreamGateTable
-- ================================================================

ieee8021PSFPStreamGateTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PSFPStreamGateEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains the per-gate instance
        manageable parameters for stream gate scheduling.

        For a given Bridge component, a row in the table exists for
        each stream gate instance.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateParameters 1 }

ieee8021PSFPStreamGateEntry OBJECT-TYPE
    SYNTAX      Ieee8021PSFPStreamGateEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contains the manageable parameters for
        stream gate scheduling for a Bridge component."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021PSFPStreamGateInstance
           }
    ::= { ieee8021PSFPStreamGateTable 1 }

Ieee8021PSFPStreamGateEntry ::=
    SEQUENCE {
        ieee8021PSFPStreamGateInstance
            Unsigned32,
        ieee8021PSFPGateEnabled
            TruthValue,
        ieee8021PSFPAdminGateStates
            INTEGER,
        ieee8021PSFPOperGateStates
            INTEGER,
```

```
        ieee8021PSFPAdminControlListLength
            Unsigned32,
        ieee8021PSFPOperControlListLength
            Unsigned32,
        ieee8021PSFPAdminControlList
            OCTET STRING,
        ieee8021PSFPOperControlList
            OCTET STRING,
        ieee8021PSFPAdminCycleTimeNumerator
            Unsigned32,
        ieee8021PSFPAdminCycleTimeDenominator
            Unsigned32,
        ieee8021PSFPOperCycleTimeNumerator
            Unsigned32,
        ieee8021PSFPOperCycleTimeDenominator
            Unsigned32,
        ieee8021PSFPAdminCycleTimeExtension
            Unsigned32,
        ieee8021PSFPOperCycleTimeExtension
            Unsigned32,
        ieee8021PSFPAdminBaseTime
            IEEE8021STPTPtimeValue,
        ieee8021PSFPOperBaseTime
            IEEE8021STPTPtimeValue,
        ieee8021PSFPConfigChange
            TruthValue,
        ieee8021PSFPConfigChangeTime
            IEEE8021STPTPtimeValue,
        ieee8021PSFPTickGranularity
            Unsigned32,
        ieee8021PSFPCurrentTime
            IEEE8021STPTPtimeValue,
        ieee8021PSFPConfigPending
            TruthValue,
        ieee8021PSFPConfigChangeError
            Counter64,
        ieee8021PSFPAdminIPV
            Integer32,
        ieee8021PSFPOperIPV
            Integer32,
        ieee8021PSFPGateClosedDueToInvalidRxEnable
            TruthValue,
        ieee8021PSFPGateClosedDueToInvalidRx
            TruthValue,
        ieee8021PSFPGateClosedDueToOctetsExceededEnable
            TruthValue,
        ieee8021PSFPGateClosedDueToOctetsExceeded
            TruthValue,
ieee8021PSFPStreamGateEntryRowStatus
            RowStatus
            }

ieee8021PSFPStreamGateInstance OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The StreamGateInstance parameter is an index into the
        StreamGateTable.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.2.1, 8.6.5.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 1}

ieee8021PSFPGateEnabled OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The GateEnabled parameter determines whether the stream gate
        is active (true) or inactive (false).
```

```
        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamGateEntry 2}

ieee8021PSFPAdminGateStates OBJECT-TYPE
    SYNTAX      INTEGER { open(1), closed(2) }
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the GateStates parameter for the
        stream gate.
        The open value indicates that the gate is open,
        the closed value indicates that the gate is closed.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 3 }

ieee8021PSFPOperGateStates OBJECT-TYPE
    SYNTAX      INTEGER { open(1), closed(2) }
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the GateStates parameter for the
        stream gate.
        The open value indicates that the gate is open,
        the closed value indicates that the gate is closed.
"
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 4 }

ieee8021PSFPAdminControlListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the ListMax parameter for the gate.
        The integer value indicates the number of entries (TLVs) in the
        AdminControlList.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 5 }

ieee8021PSFPOperControlListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the ListMax parameter for the gate.
        The integer value indicates the number of entries (TLVs) in the
        OperControlList."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 6 }

ieee8021PSFPAdminControlList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the ControlList parameter for the gate.
        The octet string value represents the contents of the control list as
        an ordered list of entries, each encoded as a TLV, as follows.
        The first octet  of each TLV is interpreted as an
        unsigned integer representing a gate operation name:
            0: SetGateAndIPV
            1-255: Reserved for future gate operations
```

```
        The second octet of the TLV is the length field,
        interpreted as an unsigned integer, indicating the number of
        octets of the value that follows the length. A length of
        zero indicates that there is no value
        (i.e., the gate operation has no parameters).

        The third through (3 + length -1)th octets encode the
        parameters of the gate operation, in the order that they
        appear in the definition of the operation
        in Table 8-4. Three parameter types are defined:

        - StreamGateState:
            A GateState parameter is encoded in a single octet, and
            is interpreted as an integer value.
            The value 1 indicates open; the value 2 indicates closed.

        - IPV:
            An IPV is encoded in four octets as a 32-bit
            signed integer. A negative denotes the null value;
            zero or positive values denote internal priority values.

        - TimeInterval:
            A TimeInterval is encoded in 4 octets as a 32-bit
            unsigned integer, representing a number of nanoseconds.
            The first octet encodes the most significant 8 bits of the
            integer, and the fourth octet encodes the least
            significant 8 bits.
        - IntervalOctetMax:
            An integer representing the maximum number of MSDU octets
            that are permitted to pas the gate during the specified
            TimeInterval. If this parameter is omitted, there is
            no maximum.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 7 }

ieee8021PSFPOperControlList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the ControlList parameter for the gate.
        The octet string value represents the contents of the control list as
        an ordered list of entries, each encoded as a TLV, as follows.
        The first octet  of each TLV is interpreted as an
        unsigned integer representing a gate operation name:
            0: SetGateAndIPV
            1-255: Reserved for future gate operations

        The second octet of the TLV is the length field,
        interpreted as an unsigned integer, indicating the number of
        octets of the value that follows the length. A length of
        zero indicates that there is no value
        (i.e., the gate operation has no parameters).

        The third through (3 + length -1)th octets encode the
        parameters of the gate operation, in the order that they
        appear in the definition of the operation
        in Table 8-4. Three parameter types are defined:

        - StreamGateState:
            A GateState parameter is encoded in a single octet, and
            is interpreted as an integer value.
            The value 1 indicates open; the value 2 indicates closed.

        - IPV:
            An IPV is encoded in four octets as a 32-bit
            signed integer. A negative value denotes the null value;
            zero and positive values denote internal priority values.
```

```
        - TimeInterval:
            A TimeInterval is encoded in 4 octets as a 32-bit
            unsigned integer, representing
            a number of nanoseconds. The first octet encodes the
            most significant 8 bits of the integer, and the fourth
            octet encodes the least significant 8 bits.
        - IntervalOctetMax:
            An integer representing the maximum number of MSDU octets
            that are permitted to pas the gate during the specified
            TimeInterval. If this parameter is omitted, there is
            no maximum.
        "
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 8 }

ieee8021PSFPAdminCycleTimeNumerator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the numerator of the CycleTime
        parameter for the gate.
        The numerator and denominator together represent the cycle time as
        a rational number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 9 }

ieee8021PSFPAdminCycleTimeDenominator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the denominator of the
        CycleTime parameter for the gate.
        The numerator and denominator together represent the cycle time as
        a rational number of seconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 10 }

ieee8021PSFPOperCycleTimeNumerator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the numerator of the
        CycleTime parameter for the gate.
        The numerator and denominator together represent the cycle
        time as a rational number of seconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 11 }

ieee8021PSFPOperCycleTimeDenominator OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the denominator of the
        CycleTime parameter for the gate.
        The numerator and denominator together represent the
        cycle time as a rational number of seconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 12 }

ieee8021PSFPAdminCycleTimeExtension OBJECT-TYPE
    SYNTAX      Unsigned32
```

```
    UNITS       "nanoseconds"
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the CycleTimeExtension
        parameter for the gate.
        The value is an unsigned integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 13 }

ieee8021PSFPOperCycleTimeExtension OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "nanoseconds"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operational value of the CycleTimeExtension
        parameter for the gate.
        The value is an unsigned integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 14 }

ieee8021PSFPAdminBaseTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the BaseTime parameter for the gate.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 15 }

ieee8021PSFPOperBaseTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The operationsl value of the BaseTime parameter for the gate.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 16 }

ieee8021PSFPConfigChange OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The ConfigChange parameter signals the start of a
        configuration change for the gate
        when it is set to TRUE. This should only be done
        when the various administrative parameters
        are all set to appropriate values."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 17 }

ieee8021PSFPConfigChangeTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    UNITS       "PTP time"
    MAX-ACCESS  read-only
    STATUS      current
```

```
    DESCRIPTION
        "The PTPtime at which the next config change is scheduled to occur.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 18 }

    ieee8021PSFPTickGranularity OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The granularity of the cycle time clock, represented as an
        unsigned number of tenths of nanoseconds.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 19 }

 ieee8021PSFPCurrentTime OBJECT-TYPE
    SYNTAX      IEEE8021STPTPtimeValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The current time, in PTPtime, as maintained by the local system.
        The value is a representation of a PTPtime value,
        consisting of a 48-bit integer
        number of seconds and a 32-bit integer number of nanoseconds."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 20 }

 ieee8021PSFPConfigPending OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The value of the ConfigPending state machine variable.
        The value is TRUE if a configuration change is in progress
        but has not yet completed."
    REFERENCE   "8.6.8.4, 8.6.9.4, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 21 }

 ieee8021PSFPConfigChangeError OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "A counter of the number of times that a re-configuration
        of the traffic schedule has been requested with the old
        schedule still running and the requested base time was
        in the past."
    REFERENCE   "8.6.8.4, 8.6.9.3, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 23 }

ieee8021PSFPAdminIPV OBJECT-TYPE
    SYNTAX      Integer32 (-1..2147483647)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The administrative value of the IPV parameter for the gate.
        A value of -1 denotes the null value.
        "
    REFERENCE   "8.6.5.4, 8.6.10, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 24 }

ieee8021PSFPOperIPV OBJECT-TYPE
    SYNTAX      Integer32 (-1..2147483647)
```

```
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The operational value of the IPV parameter for the gate.
        A value of -1 denotes the null value.
        "
    REFERENCE   "8.6.5.4, 8.6.10, 12.31.3"
    ::= { ieee8021PSFPStreamGateEntry 25 }

ieee8021PSFPGateClosedDueToInvalidRxEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PSFPGateClosedDueToInvalidRxEnable object contains
        a Boolean value that indicates whether the
        GateClosedDueToInvalidRx function is enabled (TRUE) or
        disabled (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.4, 12.31.3"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamGateEntry 26}

ieee8021PSFPGateClosedDueToInvalidRx OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PSFPGateClosedDueToInvalidRx object contains
        a Boolean value that indicates whether, if the
        GateClosedDueToInvalidRx function is enabled,
        all frames are to be discarded (TRUE) or not (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.4, 12.31.3"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamGateEntry 27}

ieee8021PSFPGateClosedDueToOctetsExceededEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PSFPGateClosedDueToOctetsExceededEnable object contains
        a Boolean value that indicates whether the
        GateClosedDueToOctetsExceeded function is enabled (TRUE)
        or disabled (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.4, 12.31.3"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamGateEntry 28}

ieee8021PSFPGateClosedDueToOctetsExceeded OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The PSFPGateClosedDueToOctetsExceeded parameter contains
        a Boolean value that indicates whether, if the
        GateClosedDueToOctetsExceeded function is enabled, all
        frames are to be discarded (TRUE) or not (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.4, 12.31.3"
    DEFVAL { false }
    ::= { ieee8021PSFPStreamGateEntry 29}
```

```
ieee8021PSFPStreamGateEntryRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of the row.

         The writable columns in a row cannot be changed if the row
         is active. All columns MUST have a valid value before a row
         can be activated.
        "
    ::= { ieee8021PSFPStreamGateEntry 30 }



-- ================================================================
-- The ieee8021PSFPFlowMeterParameters subtree
-- This subtree defines the objects necessary for the management
-- of the flow meters for IEEE Std 802.1Q.
-- ================================================================

-- ================================================================
-- the ieee8021PSFPFlowMeterTable
-- ================================================================

ieee8021PSFPFlowMeterTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PSFPFlowMeterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains the per-meter instance
        manageable parameters for flow meters.

        For a given Bridge component, a row in the table exists for
        each flow meter instance.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterParameters 1 }

ieee8021PSFPFlowMeterEntry OBJECT-TYPE
    SYNTAX      Ieee8021PSFPFlowMeterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contains the manageable parameters for
        flow meters for a Bridge component."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021PSFPFlowMeterInstance
           }
    ::= { ieee8021PSFPFlowMeterTable 1 }

Ieee8021PSFPFlowMeterEntry ::=
    SEQUENCE {
        ieee8021PSFPFlowMeterInstance
            Unsigned32,
        ieee8021PSFPFlowMeterCIR
            Unsigned32,
        ieee8021PSFPFlowMeterCBS
            Unsigned32,
        ieee8021PSFPFlowMeterEIR
            Unsigned32,
        ieee8021PSFPFlowMeterEBS
            Unsigned32,
        ieee8021PSFPFlowMeterCF
            Integer32,
        ieee8021PSFPFlowMeterCM
            INTEGER,
        ieee8021PSFPFlowMeterDropOnYellow
```

```
            TruthValue,
        ieee8021PSFPFlowMeterMarkAllFramesRedEnable
            TruthValue,
        ieee8021PSFPFlowMeterMarkAllFramesRed
            TruthValue,
        ieee8021PSFPFlowMeterEntryRowStatus
            RowStatus
             }

ieee8021PSFPFlowMeterInstance OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The FlowMeterInstance parameter is an index into the
        FlowMeterTable.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 1}

ieee8021PSFPFlowMeterCIR OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterCIR parameter contains an integer value that
        represents the CIR value for the flow meter, in bit/second.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 2}

ieee8021PSFPFlowMeterCBS OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterCBS parameter contains an integer value that
        represents the CBS value for the flow meter, in octets.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 3}

ieee8021PSFPFlowMeterEIR OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterEIR parameter contains an integer value that
        represents the EIR value for the flow meter, in bit/second.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 4}

ieee8021PSFPFlowMeterEBS OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterEBS parameter contains an integer value that
        represents the EBS value for the flow meter, in octets.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
```

```
    ::= { ieee8021PSFPFlowMeterEntry 5}

ieee8021PSFPFlowMeterCF OBJECT-TYPE
    SYNTAX      Integer32 (0..1)
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterCF parameter contains an integer value that
        represents the CF value for the flow meter, as an integer
        value 0 or 1.

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 6}

ieee8021PSFPFlowMeterCM OBJECT-TYPE
    SYNTAX      INTEGER  {colorBlind(1), colorAware(2)}
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterCM parameter contains an integer value that
        represents the CM value for the flow meter, as an enumerated
        value indicating colorBlind(1) or colorAware(2).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 7}

ieee8021PSFPFlowMeterDropOnYellow OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterDropOnYellow parameter contains a Boolean value that
        indicates whether yellow frames are dropped (TRUE) or
        have drop_eligible set to TRUE (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPFlowMeterEntry 8}

ieee8021PSFPFlowMeterMarkAllFramesRedEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterMarkAllFramesRedEnable parameter contains
        a Boolean value that indicates whether the MarkAllFramesRed
        function is enabled (TRUE) or disabled (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
    DEFVAL { false }
    ::= { ieee8021PSFPFlowMeterEntry 9}

ieee8021PSFPFlowMeterMarkAllFramesRed OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The FlowMeterMarkAllFramesRed parameter contains
        a Boolean value that indicates whether, if the
        MarkAllFramesRed function is enabled, all frames are to
        be discarded (TRUE) or not (FALSE).

        The value of this object MUST be retained across
        reinitializations of the management system."
    REFERENCE   "8.6.5.5, 12.31.4"
```

```
    DEFVAL { false }
    ::= { ieee8021PSFPFlowMeterEntry 10}

ieee8021PSFPFlowMeterEntryRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "The status of the row.

         The writable columns in a row cannot be changed if the row
         is active. All columns MUST have a valid value before a row
         can be activated.
        "
    ::= { ieee8021PSFPFlowMeterEntry 11 }




-- ================================================================
-- The ieee8021PSFPStreamParameters subtree
-- This subtree defines the objects necessary for the management
-- of the flow meters for IEEE Std 802.1Q.
-- ================================================================

-- ================================================================
-- the ieee8021PSFPStreamParameterTable
-- ================================================================

ieee8021PSFPStreamParameterTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021PSFPStreamParameterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table that contains per-Bridge component
        manageable parameters for PSFP.

        A row in the table exists for each Bridge component.

        All writable objects in this table must be
        persistent over power up restart/reboot."
    REFERENCE   "8.6.5.2, 12.31.1"
    ::= { ieee8021PSFPStreamParameters 1 }

ieee8021PSFPStreamParameterEntry OBJECT-TYPE
    SYNTAX      Ieee8021PSFPStreamParameterEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects that contains the manageable parameters for
        flow meters for a Bridge component."
    INDEX  { ieee8021BridgeBaseComponentId
           }
    ::= { ieee8021PSFPStreamParameterTable 1 }

Ieee8021PSFPStreamParameterEntry ::=
    SEQUENCE {
        ieee8021PSFPMaxStreamFilterInstances
            Unsigned32,
        ieee8021PSFPMaxStreamGateInstances
            Unsigned32,
        ieee8021PSFPMaxFlowMeterInstances
            Unsigned32,
        ieee8021PSFPSupportedListMax
            Unsigned32
             }

ieee8021PSFPMaxStreamFilterInstances OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
```

```
        "The MaxStreamFilterInstances parameter defines the
        maximum number of stream filter instances that are
        supported by this Bridge component."
    REFERENCE   "8.6.5.3, 12.31.2"
    ::= { ieee8021PSFPStreamParameterEntry 1}

ieee8021PSFPMaxStreamGateInstances OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The MaxStreamGateInstances parameter defines the
        maximum number of stream gate instances that are
        supported by this Bridge component."
    REFERENCE   "8.6.5.4, 12.31.3"
    ::= { ieee8021PSFPStreamParameterEntry 2}

ieee8021PSFPMaxFlowMeterInstances OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The MaxFlowMeterInstances parameter defines the
        maximum number of flow meter instances that are
        supported by this Bridge component."
    REFERENCE   "8.6.5.5, 12.31.4"
    ::= { ieee8021PSFPStreamParameterEntry 3}

ieee8021PSFPSupportedListMax OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "The SupportedListMax parameter defines the
        The maximum value supported by this Bridge component of
        the AdminControlListLength and
        OperControlListLength parameters."
    REFERENCE   "8.6.5.4, 12.31.3"
    ::= { ieee8021PSFPStreamParameterEntry 4}


-- ================================================================
-- IEEE8021 PSFP MIB - Conformance Information
-- ================================================================

ieee8021PSFPCompliances
    OBJECT IDENTIFIER ::= { ieee8021PSFPConformance 1 }
ieee8021PSFPGroups
    OBJECT IDENTIFIER ::= { ieee8021PSFPConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021PSFPObjectsGroup group
-- ================================================================

ieee8021PSFPObjectsGroup OBJECT-GROUP
    OBJECTS {
        ieee8021PSFPStreamHandleSpec,
        ieee8021PSFPPrioritySpec,
        ieee8021PSFPStreamGateInstanceID,
        ieee8021PSFPFilterSpecificationList,
        ieee8021PSFPMatchingFramesCount,
        ieee8021PSFPPassingFramesCount,
        ieee8021PSFPNotPassingFramesCount,
        ieee8021PSFPPassingSDUCount,
        ieee8021PSFPNotPassingSDUCount,
        ieee8021PSFPREDFramesCount,
        ieee8021PSFPStreamBlockedDueToOversizeFrameEnable,
        ieee8021PSFPStreamBlockedDueToOversizeFrame,
```

```
        ieee8021PSFPStreamFilterEntryRowStatus,
        ieee8021PSFPGateEnabled,
        ieee8021PSFPAdminGateStates,
        ieee8021PSFPOperGateStates,
        ieee8021PSFPAdminControlListLength,
        ieee8021PSFPOperControlListLength,
        ieee8021PSFPAdminControlList,
        ieee8021PSFPOperControlList,
        ieee8021PSFPAdminCycleTimeNumerator,
        ieee8021PSFPAdminCycleTimeDenominator,
        ieee8021PSFPOperCycleTimeNumerator,
        ieee8021PSFPOperCycleTimeDenominator,
        ieee8021PSFPAdminCycleTimeExtension,
        ieee8021PSFPOperCycleTimeExtension,
        ieee8021PSFPAdminBaseTime,
        ieee8021PSFPOperBaseTime,
        ieee8021PSFPConfigChange,
        ieee8021PSFPConfigChangeTime,
        ieee8021PSFPTickGranularity,
        ieee8021PSFPCurrentTime,
        ieee8021PSFPConfigPending,
        ieee8021PSFPConfigChangeError,
        ieee8021PSFPAdminIPV,
        ieee8021PSFPOperIPV,
        ieee8021PSFPGateClosedDueToInvalidRxEnable,
        ieee8021PSFPGateClosedDueToInvalidRx,
        ieee8021PSFPGateClosedDueToOctetsExceededEnable,
        ieee8021PSFPGateClosedDueToOctetsExceeded,
        ieee8021PSFPStreamGateEntryRowStatus,
        ieee8021PSFPFlowMeterCIR,
        ieee8021PSFPFlowMeterCBS,
        ieee8021PSFPFlowMeterEIR,
        ieee8021PSFPFlowMeterEBS,
        ieee8021PSFPFlowMeterCF,
        ieee8021PSFPFlowMeterCM,
        ieee8021PSFPFlowMeterDropOnYellow,
        ieee8021PSFPFlowMeterMarkAllFramesRedEnable,
        ieee8021PSFPFlowMeterMarkAllFramesRed,
        ieee8021PSFPFlowMeterEntryRowStatus,
        ieee8021PSFPMaxStreamFilterInstances,
        ieee8021PSFPMaxStreamGateInstances,
        ieee8021PSFPMaxFlowMeterInstances,
        ieee8021PSFPSupportedListMax
        }

    STATUS      current
    DESCRIPTION
        "Objects that allow management of PSFP."
    ::= { ieee8021PSFPGroups 1 }


-- ============================================================
-- compliance statements
-- ============================================================

ieee8021PSFPCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        PSFP.

        Support of the objects defined in this MIB module
        also requires support of the IEEE8021-BRIDGE-MIB; the
        provisions of 17.3.2 apply to implementations claiming
        support of this MIB. "

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021PSFPObjectsGroup
        }

    ::= { ieee8021PSFPCompliances 1 }
```

```
END
```

17.7.25 Definitions for the IEEE8021-TSN-REMOTE-MANAGEMENT-MIB module

```
IEEE8021-TSN-REMOTE-MANAGEMENT-MIB DEFINITIONS ::= BEGIN

-- ============================================================
-- MIB module supporting TSN stream reservations
-- in IEEE 802.1Q Bridges.
-- ============================================================

IMPORTS
       OBJECT-GROUP,
       MODULE-COMPLIANCE
             FROM SNMPv2-CONF
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Counter64,
    Unsigned32
        FROM SNMPv2-SMI
    TEXTUAL-CONVENTION,
    TruthValue,
    RowStatus
        FROM SNMPv2-TC
    IEEE8021BridgePortNumber,
    ieee802dot1mibs
        FROM IEEE8021-TC-MIB
    ieee8021BridgeBasePort,
    ieee8021BridgeBaseComponentId,
    ieee8021BridgeTrafficClass
        FROM IEEE8021-BRIDGE-MIB
    ieee8021QBridgeVlanIndex
        FROM IEEE8021-Q-BRIDGE-MIB
    ;

ieee8021TsnRemoteMgmtMib MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
       "IEEE 802.1Q Bridge MIB module supporting
        TSN stream reservations.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201810040000Z" -- October 4, 2018
    DESCRIPTION
        "Initial revision, included in IEEE 802.1Qcc-2018"
    ::= { ieee802dot1mibs 32 }

-- ============================================================
-- subtrees in the TSN Remote Management MIB
-- ============================================================
```

```
ieee8021TsnRemoteMgmtNotifications
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtMib 0 }

ieee8021TsnRemoteMgmtObjects
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtMib 1 }

ieee8021TsnRemoteMgmtConformance
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtMib 2 }

ieee8021TsnRemoteMgmtBridgeDelay
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtObjects 1 }

ieee8021TsnRemoteMgmtPropagationDelay
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtObjects 2 }

ieee8021TsnRemoteMgmtStaticTrees
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtObjects 3 }

ieee8021TsnRemoteMgmtMrpExternalControl
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtObjects 4 }

-- ============================================================
-- the ieee8021TsnRemoteBridgeDelayTable
-- ============================================================

ieee8021TsnRemoteMgmtBridgeDelayTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021TsnRemoteMgmtBridgeDelayEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of parameters necessary to
        determine the delay of frames as they pass through the
        Bridge's relay.
        There is one Bridge Delay managed object per Port pair of
        a Bridge component. The Port pair consists of three indices,
        an ingress Port followed by an egress Port and a traffic
        class associated with the Port pair."
    REFERENCE   "12.32.1"
    ::= { ieee8021TsnRemoteMgmtBridgeDelay 1 }

ieee8021TsnRemoteMgmtBridgeDelayEntry OBJECT-TYPE
    SYNTAX      Ieee8021TsnRemoteMgmtBridgeDelayEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information necessary to
        determine the delay of frames as they pass through the
        Bridge's relay."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeTrafficClass,
             ieee8021TsnRemoteMgmtBridgeIngressPort,
             ieee8021TsnRemoteMgmtBridgeEgressPort
           }
    ::= { ieee8021TsnRemoteMgmtBridgeDelayTable 1 }

Ieee8021TsnRemoteMgmtBridgeDelayEntry ::=
    SEQUENCE {
        ieee8021TsnRemoteMgmtBridgeIngressPort
            IEEE8021BridgePortNumber,
        ieee8021TsnRemoteMgmtBridgeEgressPort
            IEEE8021BridgePortNumber,
        ieee8021TsnRemoteMgmtIndependentDelayMin
            Unsigned32,
        ieee8021TsnRemoteMgmtIndependentDelayMax
            Unsigned32,
       ieee8021TsnRemoteMgmtDependentDelayMin
            Unsigned32,
        ieee8021TsnRemoteMgmtDependentDelayMax
            Unsigned32
    }

ieee8021TsnRemoteMgmtBridgeIngressPort OBJECT-TYPE
```

```
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The ingress port of the port pair for which the bridge delay is being provided."
    REFERENCE   "12.32.1"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 1 }

ieee8021TsnRemoteMgmtBridgeEgressPort OBJECT-TYPE
    SYNTAX      IEEE8021BridgePortNumber
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The egress port of the port pair for which the bridge delay is being provided."
    REFERENCE   "12.32.1"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 2 }

ieee8021TsnRemoteMgmtIndependentDelayMin OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the minimum delay independent
        from frame length for a frame to forward from ingress
        port to egress port.

        The delay begins when the message timestamp point of the
        ingress frame passes the reference plane marking the
        boundary between the network media and PHY. The delay
        ends when the message timestamp point of the egress
        frame passes the reference plane marking the boundary
        between the network media and PHY. The message timestamp
        point is specified by IEEE Std 802.1AS for various media,
        near the start of the frame.

        Note: This delay includes all aspects of length-independent
        delay for a frame that is forwarded, including handling of
        error conditions."
    REFERENCE   "12.32.1.1"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 3 }

ieee8021TsnRemoteMgmtIndependentDelayMax OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the maximum delay independent
        from frame length for a frame to forward from ingress
        port to egress port.

        The delay begins when the message timestamp point of
        the ingress frame passes the reference plane marking
        the boundary between the network media and PHY. The delay
        ends when the message timestamp point of the egress frame
        passes the reference plane marking the boundary between
        the network media and PHY. The message timestamp point is
        specified by IEEE Std 802.1AS for various media, near the
        start of the frame."
    REFERENCE   "12.32.1.1"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 4 }

ieee8021TsnRemoteMgmtDependentDelayMin OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the minimum length-dependent
        delay from ingress port to egress port.

        It provides the portion of delay that is dependent on
        frame length, where frame length is the number of octets
        that transfer across the MAC Service interfaces. Each
```

```
        length-dependent delay attribute specifies the time for
        a single octet of the frame to transfer from ingress
        to egress."
    REFERENCE   "12.32.1.2"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 5 }

ieee8021TsnRemoteMgmtDependentDelayMax OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the maximum length-dependent
        delay from ingress port to egress port.

        It provides the portion of delay that is dependent on
        frame length, where frame length is the number of octets
        that transfer across the MAC Service interfaces. Each
        length-dependent delay attribute specifies the time for
        a single octet of the frame to transfer from ingress
        to egress."
    REFERENCE   "12.32.1.2"
    ::= { ieee8021TsnRemoteMgmtBridgeDelayEntry 6 }

-- ============================================================
-- the ieee8021TsnRemoteMgmtPropagationDelayTable
-- ============================================================

ieee8021TsnRemoteMgmtPropagationDelayTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021TsnRemoteMgmtPropagationDelayEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of parameters necessary to
        determine the delay along the network media (e.g. cable)
        for a frame transmitted from the specified Port of this
        Bridge to the neighboring Port on a different Bridge.
        There is one Propagation Delay managed object per
        egress Port of a Bridge."
    REFERENCE   "12.32.2"
    ::= { ieee8021TsnRemoteMgmtPropagationDelay 1 }

ieee8021TsnRemoteMgmtPropagationDelayEntry OBJECT-TYPE
    SYNTAX      Ieee8021TsnRemoteMgmtPropagationDelayEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects containing information necessary to
            determine the delay along the network media (e.g. cable)
            for a frame transmitted from the specified Port of this
            Bridge to the neighboring Port on a different Bridge."
    INDEX  { ieee8021BridgeBasePort }
    ::= { ieee8021TsnRemoteMgmtPropagationDelayTable 1 }

Ieee8021TsnRemoteMgmtPropagationDelayEntry ::=
    SEQUENCE {
        ieee8021TsnRemoteMgmtTxPropagationDelay
            Unsigned32
        }

ieee8021TsnRemoteMgmtTxPropagationDelay OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute provides the transmission propagation delay.

        The propagation delay begins when the message timestamp
        point of an egress frame passes the reference plane marking
        the boundary between the network media and PHY. It ends
        when the message timestamp point of an ingress frame on the
        neighboring Bridge's Port passes the reference plane marking
        the boundary between the network media and PHY. The message
```

```
        timestamp point is specified by IEEE Std 802.1AS for
        various media."
    REFERENCE   "12.32.2.1"
    ::= { ieee8021TsnRemoteMgmtPropagationDelayEntry 1 }


-- ================================================================
-- The Static Tree subtree
-- This subtree defines the objects necessary to determine if
-- the static trees feature is supported by the Bridge.
-- ================================================================

ieee8021TsnRemoteMgmtStaticTreesSupported OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used by the TSN CNC to determine that
        TE-MSTID is supported by the Bridge."
    REFERENCE   "12.32.3.1"
    ::= { ieee8021TsnRemoteMgmtStaticTrees 1 }

-- ================================================================
-- the ieee8021TsnRemoteMgmtMsrpMrpExternalControlTable
-- ================================================================

ieee8021TsnRemoteMgmtMsrpMrpExternalControlTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF Ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A table containing a set of parameters necessary for
        a network manager to 1) disable MRP attribute propagation (MAP)
        for the MRP Participant of a bridge port, 2) read MRP attribute
        registrations that the MRP Participant receives, and 3) write
        MRP attribute values for the MRP Participant to declare."
    REFERENCE   "12.32.4"
    ::= { ieee8021TsnRemoteMgmtMrpExternalControl 1 }

ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry OBJECT-TYPE
    SYNTAX      Ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "A list of objects necessary for a network manager to
        1) disable MRP attribute propagation (MAP) for the
        MRP Participant of a bridge port, 2) read MRP attribute
        registrations that the MRP Participant receives, and 3) write
        MRP attribute values for the MRP Participant to declare."
    INDEX  { ieee8021BridgeBaseComponentId,
             ieee8021BridgeBasePort,
             ieee8021QBridgeVlanIndex }
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlTable 1 }

Ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry ::=
    SEQUENCE {
        ieee8021TsnRemoteMgmtMsrpMrpExternalControl
            TruthValue,
        ieee8021TsnRemoteMgmtMrpIndicationList
            OCTET STRING,
        ieee8021TsnRemoteMgmtMrpIndicationListLength
            Unsigned32,
        ieee8021TsnRemoteMgmtMrpIndicationChangeCounter
            Counter64,
        ieee8021TsnRemoteMgmtMrpAdminRequestList
            OCTET STRING,
        ieee8021TsnRemoteMgmtMrpAdminRequestListLength
            Unsigned32,
        ieee8021TsnRemoteMgmtMrpOperRequestList
            OCTET STRING,
        ieee8021TsnRemoteMgmtMrpOperRequestListLength
            Unsigned32
```

```
        }

ieee8021TsnRemoteMgmtMsrpMrpExternalControl OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
        "This attribute is used to indicate, whether MRP
        attributes are propagated on the MRP Participant,
        according to the specifications for MRP Attribute
        Propagation (MAP) and specifications of the
        MRP Application. When true(1), the MRP Participant is
        removed from the MRP Application's MAP Context. The
        MRP Participant performs all other aspects of MRP,
        including MRP operation, MRP specifications, and
        MRPDU encodings. The application component stores MAD
        indications for registration received on the Port,
        and invokes MAD requests for declarations on the Port.
        When false(2), MRP attributes propagate on the
        MRP Participant according to the specifications for
        MRP Attribute Propagation (MAP) and specifications of
        the MRP Application. Ports with the externalControl
        attribute false(2) are considered as candidates for
        the MRP Application's MAP Context. The remaining
        attributes of this subtree are ignored by Ports with
        the externalControl attribute false(2).
        This managed object applies to the MSRP application.
        A table is provided for each MAP Context (VLAN ID)."
    REFERENCE   "12.32.4.1"
    DEFVAL { false }
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 1 }

ieee8021TsnRemoteMgmtMrpIndicationList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to store the list of all joined
        MRP attributes for the MRP Participant when the
        ieee8021TsnRemoteMgmtMrpExternalControl attribute is
        true(1). When the ieee8021TsnRemoteMgmtMrpExternalControl
        attribute is false(2), this attribute is ignored by the
        MRP Participant, and returns the empty octet string."
    REFERENCE   "12.32.4.2"
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 2 }

ieee8021TsnRemoteMgmtMrpIndicationListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the number of octets
        in the ieee8021TsnRemoteMgmtMrpIndicationListLength
        attribute. When the ieee8021TsnRemoteMgmtMrpExternalControl
        attribute is false(2), this attribute returns zero."
    REFERENCE   "12.32.4.3"
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 3 }

ieee8021TsnRemoteMgmtMrpIndicationChangeCounter OBJECT-TYPE
    SYNTAX      Counter64
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the number of changes
        done to the ieee8021TsnRemoteMgmtMrpIndicationList. When
        the ieee8021TsnRemoteMgmtMrpExternalControl attribute is
        false(2), this attribute returns zero."
    REFERENCE   "12.32.4.4"
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 4 }

ieee8021TsnRemoteMgmtMrpAdminRequestList OBJECT-TYPE
    SYNTAX      OCTET STRING
```

```
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the administrative
        value of the current list of MAD requests for the
        MRP Participant (operRequestList). Each entry in this
        attribute is encoded as the attribute_type parameter as
        a single octet, followed by the length of the
        attribute_value parameter as a single octet, followed
        by a sequence of octets for the attribute_value parameter.
        When the ieee8021TsnRemoteMgmtMrpExternalControl attribute
        is true(1), this attribute is copied to the
        ieee8021TsnRemoteMgmtMrpOperRequestList attribute as soon
        as possible according to the implementation. When the
        ieee8021TsnRemoteMgmtMrpExternalControl attribute is
        false(2), this attribute is ignored by the MRP Participant,
        but it retains its value."
    REFERENCE   "12.32.4.5"
    DEFVAL { "" }
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 5 }

ieee8021TsnRemoteMgmtMrpAdminRequestListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the administrative
        value for the number of octets in the
        ieee8021TsnRemoteMgmtMrpAdminRequestList attribute.
        When the ieee8021TsnRemoteMgmtMrpExternalControl attribute
        is true(1), this attribute is copied to the
        ieee8021TsnRemoteMgmtMrpOperRequestListLength attribute at
        the same time that the ieee8021TsnRemoteMgmtMrpAdminRequestList
        attribute is copied to the ieee8021TsnRemoteMgmtMrpOperRequestList
        attribute. When the ieee8021TsnRemoteMgmtMrpExternalControl
        attribute is false(2), this attribute is ignored by the
        MRP Participant, but it retains its value."
    REFERENCE   "12.32.4.6"
    DEFVAL { 0 }
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 6 }

ieee8021TsnRemoteMgmtMrpOperRequestList OBJECT-TYPE
    SYNTAX      OCTET STRING
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the operational value
        of the current list of MAD requests for the MRP Participant."
    REFERENCE   "12.32.4.7"
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 7 }

ieee8021TsnRemoteMgmtMrpOperRequestListLength OBJECT-TYPE
    SYNTAX      Unsigned32
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "This attribute is used to provide the operational value
        of the ieee8021TsnRemoteMgmtMrpAdminRequestListLength
        attribute, and it is copied at the same time that
        ieee8021TsnRemoteMgmtMrpAdminRequestList attribute is
        copied to ieee8021TsnRemoteMgmtMrpOperRequestList."
    REFERENCE   "12.32.4.8"
    ::= { ieee8021TsnRemoteMgmtMsrpMrpExternalControlEntry 8 }


-- ============================================================
-- IEEE802 TSN REMOTE MANAGEMENT MIB - Conformance Information
-- ============================================================

ieee8021TsnRemoteMgmtCompliances
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtConformance 1 }
ieee8021TsnRemoteMgmtGroups
```

```
    OBJECT IDENTIFIER ::= { ieee8021TsnRemoteMgmtConformance 2 }

-- ================================================================
-- units of conformance
-- ================================================================

-- ================================================================
-- the ieee8021TsnRemoteMgmtBridgeDelay group
-- ================================================================

ieee8021TsnRemoteMgmtBridgeDelayGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TsnRemoteMgmtIndependentDelayMin,
        ieee8021TsnRemoteMgmtIndependentDelayMax,
        ieee8021TsnRemoteMgmtDependentDelayMin,
        ieee8021TsnRemoteMgmtDependentDelayMax
    }
    STATUS      current
    DESCRIPTION
        "Objects that define the delay of frames as they pass
        through the Bridge's relay."
    ::= { ieee8021TsnRemoteMgmtGroups 1 }


-- ================================================================
-- the ieee8021TsnRemoteMgmtPropagationDelay group
-- ================================================================

ieee8021TsnRemoteMgmtPropagationDelayGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TsnRemoteMgmtTxPropagationDelay
    }
    STATUS      current
    DESCRIPTION
        "Objects that define delay of frames along the network
        media (e.g. cable)."
    ::= { ieee8021TsnRemoteMgmtGroups 2 }


-- ================================================================
-- the ieee8021TsnRemoteMgmtStaticTrees group
-- ================================================================

ieee8021TsnRemoteMgmtStaticTreesGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TsnRemoteMgmtStaticTreesSupported
    }
    STATUS      current
    DESCRIPTION
        "Objects that define static tree support."
    ::= { ieee8021TsnRemoteMgmtGroups 3 }


-- ================================================================
-- the ieee8021TsnRemoteMgmtMrpExternalControl group
-- ================================================================

ieee8021TsnRemoteMgmtMrpExternalControlGroup OBJECT-GROUP
    OBJECTS {
        ieee8021TsnRemoteMgmtMsrpMrpExternalControl,
        ieee8021TsnRemoteMgmtMrpIndicationList,
        ieee8021TsnRemoteMgmtMrpIndicationListLength,
        ieee8021TsnRemoteMgmtMrpIndicationChangeCounter,
        ieee8021TsnRemoteMgmtMrpAdminRequestList,
        ieee8021TsnRemoteMgmtMrpAdminRequestListLength,
        ieee8021TsnRemoteMgmtMrpOperRequestList,
        ieee8021TsnRemoteMgmtMrpOperRequestListLength
    }
    STATUS      current
    DESCRIPTION
        "Objects that define configuration of MRP External control."
    ::= { ieee8021TsnRemoteMgmtGroups 4 }
```

```
-- ============================================================
-- compliance statements
-- ============================================================

ieee8021TsnRemoteMgmtCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for devices supporting
        TSN Remote management.

        Support of the objects defined in the IEEE8021-TSN REMOTE
        MANAGEMENT MIB also requires support of the IEEE8021-BRIDGE-MIB;
        the provisions of 17.3.2 apply to implementations claiming
        support of the IEEE8021-TSN REMOTE  MANAGEMENT MIB."

    MODULE -- this module
        MANDATORY-GROUPS {
            ieee8021TsnRemoteMgmtBridgeDelayGroup,
            ieee8021TsnRemoteMgmtPropagationDelayGroup,
            ieee8021TsnRemoteMgmtStaticTreesGroup,
            ieee8021TsnRemoteMgmtMrpExternalControlGroup
        }

    ::= { ieee8021TsnRemoteMgmtCompliances 1 }

END
```

18. Principles of Connectivity Fault Management operation

Connectivity Fault Management (CFM) comprises capabilities for detecting, verifying, and isolating connectivity failures in Virtual Bridged Networks. These capabilities can be used in networks operated by multiple independent organizations, each with restricted management access to each other's equipment.

CFM is designed to be transparent to the customer data transported by a network and to be capable of providing maximum fault coverage. Accordingly, CFM Entities (Clause 19) are specified as shims that make use of and provide the ISS or EISS (IEEE Std 802.1AC, 6.8, 6.17) at SAPs within the network. They can, in principle, be added between any of the other media-independent protocol entities that compose a Bridge Port, without requiring changes to those entities. Customer data is forwarded transparently by CFM Entities while CFM PDUs are generated and processed as specified in Clause 20. The formats of the various CFM PDUs are described in Clause 21, and the creation and placement of CFM Entities in Bridges are specified in Clause 22.

This clause provides the context necessary to understand each of the CFM protocols, and how CFM Entities in Bridges are selected and configured as Maintenance Points (MPs, 19.1) to participate in and operate those protocols.

CFM introduces the following concepts to support multiple independent operators, each supporting service instances for multiple independent customers:

a) A Maintenance Domain (18.1) is a part of a network that is controlled by a single operator and used to support connectivity between the Domain Service Access Points (DoSAPs, 18.1) that bound the Maintenance Domain.
b) A Maintenance Domain Level (MD Level, 18.3), carried in CFM PDUs, allows each of an operator's customers also to use CFM and to function as an operator if desired, multiplexing provided service instances over its own connectivity.
c) A Maintenance Association (MA, 18.2) is created by configuring CFM Entities that support an individual service instance's DoSAPs as MA Endpoints (MEPs), and is used to monitor connectivity provided by that instance through the Maintenance Domain.

MP (19.1) configuration of CFM Entities supports the hierarchical nesting of Maintenance Domains. The DoSAPs for a given service instance are Intermediate Service Access Points (ISAPs) for MAs monitoring connectivity through an enclosing Maintenance Domain. When a MEP is configured, a MA Intermediate Point (MIP) can also be configured at the appropriate level for its immediately enclosing Maintenance Domain. Below the innermost Maintenance Domain, every physical LAN can serve as an implied Maintenance Domain, and every Bridge Port as an implied MEP. In the innermost Maintenance Domain, every Bridge Port is an ISAP and can be configured with a MIP.

Maintenance Domains are nested, not overlapped. That is, if a given DoSAP for service instance 1 in Maintenance Domain *x* is an ISAP for Maintenance Domain *y*, then all DoSAPs for service instance 1 in Maintenance Domain *x* are either ISAPs or DoSAPs for Maintenance Domain *y*, and no other Maintenance Domain. Conformance to this rule is not a condition for the correct operation of CFM. Rather, if this rule is violated, then CFM will detect the violation as an error condition, whatever the intentions of the administrators.

The information about individual service instances that is configured and recorded within a network to support CFM is entirely associated with MEPs, and thus scales linearly with the number of SAPs provided to customers. The transmission of CFM PDUs is stimulated by state machines associated with MEPs as are actions taken that require recording information from received PDUs. MIPs can add, check, and respond to information in received PDUs, thus supporting discovery of paths among MEPs and location of faults along those paths. MIPs can be configured per Maintenance Domain, thus allowing the amount of MIP configuration information to scale linearly with the size of the network, and is thus a constant function of the

ability of the network to support those MIPs, rather than being a product of the number of service instances supported. In contrast each MEP is associated with a SAP that provides access to a single service instance.

CFM functions are partitioned as follows:

— Path discovery
— Fault detection
— Fault verification and isolation
— Fault notification
— Fault recovery

Path discovery uses the Linktrace protocol (20.3) to determine the path taken to a target MAC address, MIP by MIP, from one MEP to another MP across an MA. This target MAC address can be that of a MIP, a MEP, or any other individual MAC address. A Linktrace Message (LTM, 20.3.1) is transmitted from a MEP to its neighboring MIPs, and from MIP to MIP, to the MP terminating the path. Each MIP along the path and the terminating MP return unicast Linktrace Replies (LTR, 20.3.2) to the originating MEP. LTMs are triggered by administrative action. The replies are cataloged by the originating MEP for examination by the administrator.

Fault detection uses the Continuity Check protocol (20.1) to detect both connectivity failures and unintended connectivity between service instances. Each MEP can periodically transmit a Continuity Check Message (CCM) announcing the identity of the MEP and its MA, and tracks the CCMs received from the other MEPs. All connectivity faults that can misdirect a CCM show up as differences between the CCMs received and the MEP's configured expectations. The state of the tracked CCMs is available to the administrator for examination.

Fault verification and fault isolation are administrative actions, typically performed after fault detection. Fault verification can also confirm successful initiation or restoration of connectivity. The administrator uses the Loopback protocol (20.2) to perform fault verification. A MEP can be ordered to transmit a Loopback Message (LBM, 20.2.1) to a MEP or MIP in the MA, whose MAC address can be discovered from CCMs (MEPs only) or LTMs/LTRs (MEPs or MIPs). The receiving MP responds by transforming the LBM into a unicast Loopback Reply (LBR, 20.2.2) sent back to the originating MEP. That MEP records the responses for examination by the administrator.

Fault notification is provided by a MEP that has detected a connectivity fault in its MA, because expected CCMs were not received, because unexpected or invalid CCMs were received, or because a CCM carried a notification of the failure of its associated Bridge Port. A single fault may be detected by multiple MEPs and may result in the generation of multiple Fault Alarms. In the absence of alarm suppression mechanisms in CFM, network management systems receiving such Fault Alarms can deploy other means to identify if a Fault Alarm identifies the primary fault for which a fault corrective action can be initiated, or represents a secondary fault for which no corrective action can be taken.

For VLANs, fault recovery is provided by the active topology protocols of Clause 13 while fault recovery for TESIs is provided by the Protection Switching mechanisms of 26.10. Fault recovery actions performed by the network administrator, such as the correction of configuration errors or replacement of failed components, are outside the scope of this standard.

18.1 Maintenance Domains and DoSAPs

A "domain" may be defined as a network or part of a network that is capable of offering connectivity to systems outside this region. It comprises a set of DoSAPs at which the domain is capable of or intended to offer connectivity to systems outside the domain. Each DoSAP is an instance either of the EISS or of the

ISS. A Maintenance Domain is then a domain or part of a domain for which faults in connectivity are to be managed.

A Maintenance Domain is, or is intended to be, fully connected internally. That is, a DoSAP associated with a Maintenance Domain has connectivity to every other DoSAP in the Maintenance Domain, in the absence of faults. It is, in principle at least, capable of connecting (i.e., supporting service between) any of its DoSAPs. The factors (apart from faults) that can prevent desired connectivity are second-order, e.g., exhaustion of resources that would support a proposed connection, an administrative decision to limit multipoint services, misconfiguration of security parameters, unwillingness of customers or attached Maintenance Domains to use a particular connection configuration. The purpose of CFM is to monitor and diagnose the ability of a Maintenance Domain to meet its operators' intentions for connectivity, as expressed in the configuration of CFM.

Figure 18-1 illustrates a single Maintenance Domain, consisting of five Bridges, from the point of view of an operator. The operator has six DoSAPs to offer to customers.

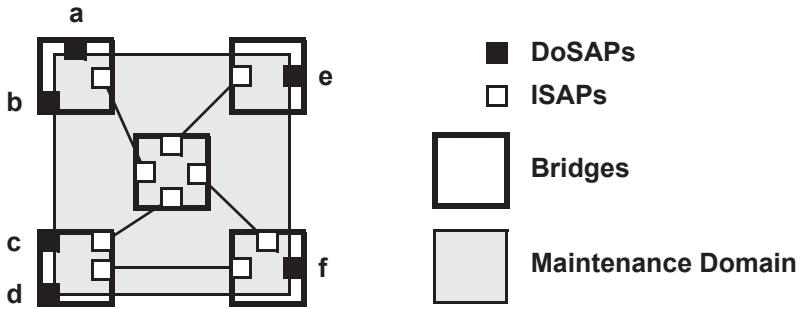


Figure 18-1—One Maintenance Domain: operator's view

Each Maintenance Domain can be separately administered. Each Maintenance Domain is assigned a Maintenance Domain Name. This should be chosen to be unique among all those used or available to an operator, and to facilitate easy identification of administrative responsibility for the Maintenance Domain. CFM PDU formats support the creation of Maintenance Domain Names that are unique over the domain for which CFM is to protect against accidental concatenation of service instances. Ideally, these names are globally unique.

There are a number of methods to fulfill the requirements to both maintain connectivity within, and control access to, a Maintenance Domain. A Maintenance Domain can be, for example,

a) An MST Region, identified and kept separate from other Maintenance Domains, by its MST Configuration Name (8.9.2, 13.8).
b) A number of such MST Regions (13.5.3), interconnected via the CIST (13.5.2), and kept separate from other Maintenance Domains by configuring the managed objects controlling the CIST topology.
c) An entire Virtual Bridged Network, and kept separate from other Maintenance Domains by means not specified in this standard.
d) A subset of the DoSAPs of a VLAN Bridged Network, assigned to the use of a particular higher-level provider among many.
e) A subset of the DoSAPs of the concatenated network in item c).
f) A single physical link between two providers or between a provider and a customer.
g) A single VLAN on a single physical link between two providers or between a provider and a customer.

18.2 Service instances and MAs

When a network administrator configures a service instance for a customer, the network administrator configures some number of the DoSAPs to be accessible by that customer, assigning whatever identifiers the systems require to segregate that service instance from others supported by that Maintenance Domain (e.g., VIDs), as well as configuring other service properties (such as bandwidth profiles) for the DoSAPs. Creation of a service instance establishes a connectionless connectivity (IEEE Std 802.1AC) among the selected DoSAPs.

Configuring a MEP at each of the DoSAPs of a service instance creates an MA to monitor that connectionless connectivity. The MA is identified by a Short MA Name that is unique within the Maintenance Domain. Together, the Maintenance Domain Name and the Short MA Name form the Maintenance Association Identifier (MAID) that is carried in CFM PDUs to identify inadvertent connections among MEPs. A small integer, the MA Endpoint Identifier (MEPID) uniquely identifies each MEP among those configured on a single MA.

NOTE 1—In order to accommodate the requirements of service providers as expressed in ITU-T G.8013/Y.1731, the Maintenance Domain Name can be configured to be null, in which case the Short MA Name needs to be globally unique, in order to provide complete protection against the accidental concatenation of service instances. Suitable choices for globally unique Short MA Names are defined in ITU-T G.8013/Y.1731.

Figure 18-2 illustrates a single service instance created from the Maintenance Domain of Figure 18-1, again from the point of view of an operator. It offers four DoSAPs to a customer (C1). Each DoSAP is marked with its MEPID.

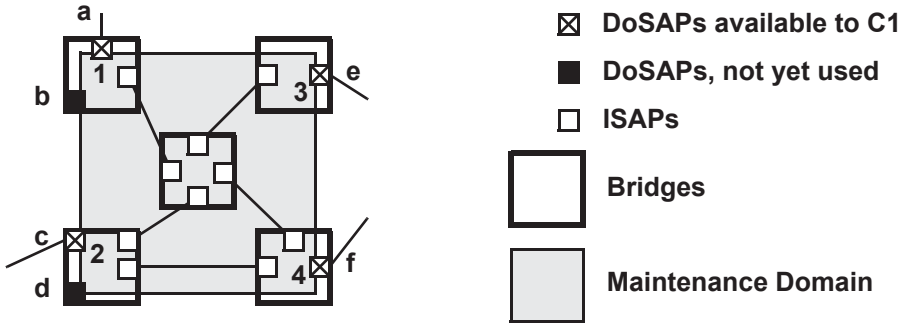


Figure 18-2—One service instance: operator's view

Figure 18-3 illustrates that same service instance from the point of view of customer C1. The customer has four items of customer equipment attached to the four DoSAPs 1–4. The means by which the operator connects the four DoSAPs to create the service instance are invisible to the customer.

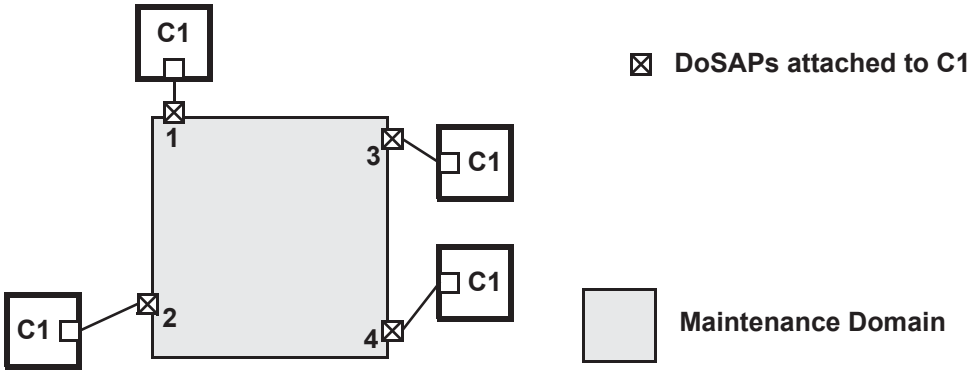


Figure 18-3—One service instance: customer's view

NOTE 2—The term “service instance” has been used to mean an “end-to-end service supplied to a customer.” One cannot predict whether an apparently end-to-end service instance will be used by a customer to create another service instance at a still higher level to yet another customer. Therefore, no specific term is provided by this standard to label an “end-to-end” service instance.

The CFM protocol state machines and variables (see Clause 20) are used by MEPs to conduct protocol exchanges within a Maintenance Domain. Each MIP functions symmetrically with respect to the SAPs of its containing MA and service instance, and is modeled as comprising two MIP Half Functions (MHFs). Figure 18-4 specifies the symbols used for MEPs, MHFs, and MIPs in this standard, e.g., in Figure 18-7.

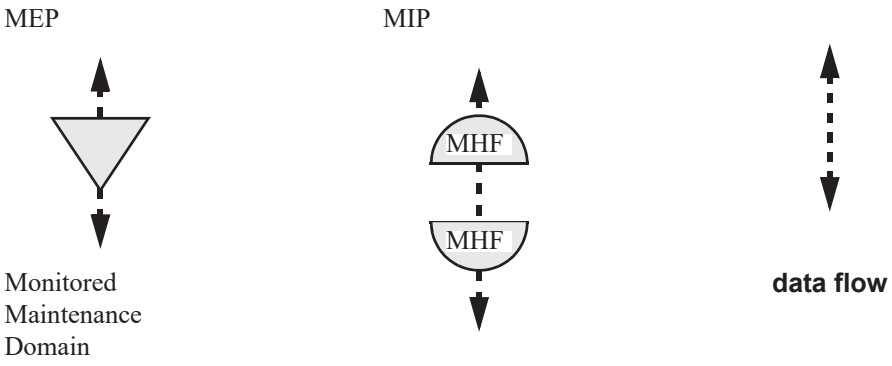


Figure 18-4—MEP and MIP Symbols

18.3 Maintenance Domain Levels

A Maintenance Domain can provide service instances to an enclosing Maintenance Domain or utilize service instances provided by an enclosed Maintenance Domain. An explicit Maintenance Domain Level (MD Level) is included in CFM PDUs to indicate the nesting relationships among Maintenance Domains, because systems can be organized into Maintenance Domains as administrative needs dictate, without necessarily adding headers to data frames to enforce a layered organization.

As part of the nested decomposition facility provided by Maintenance Domains, the CFM protocols hide information. The components of a given Maintenance Domain interior to the DoSAPs presented to the enclosing Maintenance Domain are invisible, through the CFM protocols and managed objects, to the Maintenance Domains enclosing that given Maintenance Domain, except for configured points of visibility. No part of a Maintenance Domain lower than (nested within) a given Maintenance Domain is unintentionally visible to any higher Maintenance Domain. No part of a Maintenance Domain is ever visible to any Maintenance Domain except its immediately higher (enclosing) Maintenance Domain. This enables the separation of responsibility for network administration. The administrator of an end-to-end service on the largest scale can be insulated from the administration of the networks comprising that service, and so on, in principle, down to the administration of individual LANs. This prevents, for example, a customer from learning the internal topology of an operator’s network.

In order to facilitate the diagnosis of connectivity failures, an administrator can make a DoSAP visible as an ISAP to the immediately enclosing Maintenance Domain by configuring it as a MIP. The diagnostic functions provided by CFM detect connectivity failures between any pair of MEPs in an MA. The MIPs allow these failures to be isolated to smaller segments of the network; loss of connectivity between a pair of MIPs corresponds to a MEP connectivity failure at a lower MD Level. In the lowest Maintenance Domains, the MIPs can be configured on individual Bridge Ports.

Figure 18-5 illustrates the nesting of Maintenance Domains, service instances, and MAs. It illustrates nested service instances, each configured with one MA in a Maintenance Domain. There are seven Maintenance Domains, and hence seven service instances illustrated. At the (white) "provider" MD Level, the service instance is offered to a single "customer" C1. That customer creates a (gray) service instance of his own, configured with an MA that verifies the integrity of the service instance offered by the provider. Several levels of nested Maintenance Domains are shown:

a) Covering the widest physical extent, a Maintenance Domain (and MA and service instance) at the customer MD Level has a MEP in each of four devices labeled C1 in Figure 18-5. The four DoSAPs a, b, g, and h can be configured as MIPs for this MA.

b) Covering the physical range corresponding to the limits of the end-to-end provider's network are the MEPs a, b, g, and h belonging to the provider MD Level. The four DoSAPs c, d, e, and f can be configured as MIPs for this MA.

c) Each of the two operator networks has a Maintenance Domain at the operator MD Level. These DoSAPs are marked a through h. The unlabeled SAPs in both operators' Maintenance Domains can be configured as MIPs for their respective MAs.

d) Three "physical" layer Maintenance Domains are shown as well. (Two are labeled "PMDL," for "physical MD Level.") Note that not all physical links are given Maintenance Domains.

   1) A network of devices is being used, in some unspecified fashion, to offer the operators' Bridges an emulated shared-medium LAN with four DoSAPs. A Maintenance Domain has been created to verify the connectivity of that LAN.

NOTE—This central emulated LAN could equally be a network of Bridges that are separated via nonstandard configuration from the operator clouds on either side, a network of PBBs, a network of Ethernet over SONET circuits with a central interconnect device, or an ATM Emulated LAN.[33]

   2) Physical-level Maintenance Domains have been created at the edge of the network (on the left side) to monitor two LANs, perhaps because they include Repeaters or are otherwise unreliable.

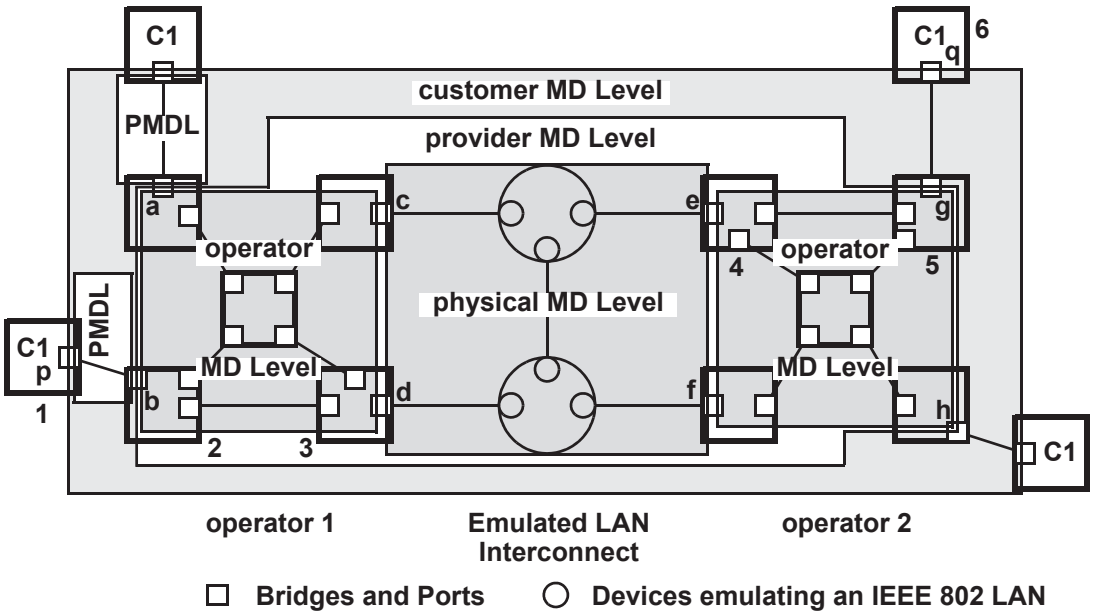


Figure 18-5—MAs: one service instance in a provider network

[33] See ATM Forum af-lane-0021.000; "LAN Emulation over ATM 1.0"; https://www.broadband-forum.org/ftp/pub/approved-specs/af-lane-0021.000.pdf.

Figure 18-6 expands the upper right corner of Figure 18-5, including Bridges 4 and 5 and device 6. Examining device 6 (C1), readers can see that the highest MA, at the "customer" MD Level, requires a MEP in its Port q. The side of the DoSAP of this service instance that offers access to the service instance faces the center of device 6, just like the service offered by a LAN. On the other hand, in Port g, there are two service instances, each with a MEP: the white service instance at the provider MD Level, and the gray service instance at the operator MD Level. Neither of these service instances include the wire attached to Port g. Thus, ensuring the proper operation of the LAN connecting Port q to Port g is the responsibility of the MA at the customer MD Level, and not the other MAs. Port e has two MEPs, one facing in each direction.

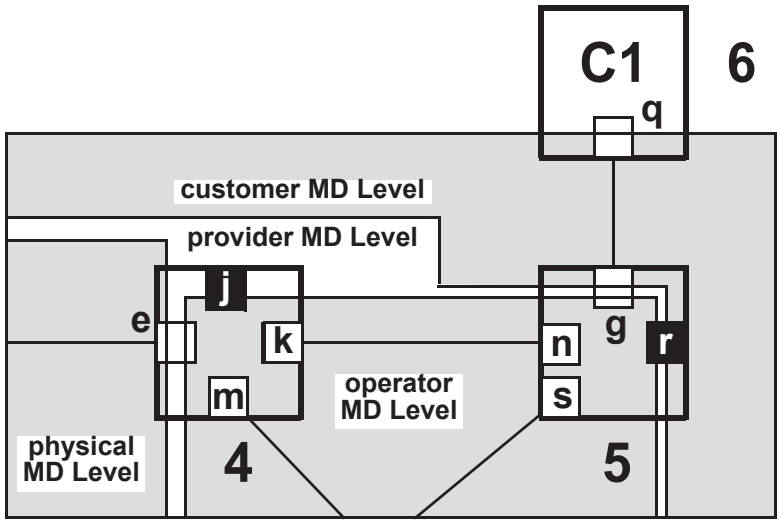


Figure 18-6—MAs: Expansion of Figure 18-5

Port g in Figure 18-6 also is an example of the fact that only the MD Level distinguishes the provider and operator Level Maintenance Domains at Port g. The single service instance in the example network shown in Figure 18-5 and Figure 18-6 is carried on a single VLAN with a single VID through the right-hand operator's Maintenance Domain. Within that Maintenance Domain, it cannot be distinguished whether a data frame on that VID belongs to the operator, provider, or customer Maintenance Domain; it belongs to all of them. However, the MD Level permits CFM PDUs to be associated with different Maintenance Domains even when they share the same VID.

Port j and Port r have been added to Figure 18-6; they are not present in Figure 18-5. Both represent DoSAPs that have not been configured to support either a service instance or an MA. For the integrity of the network to be ensured by CFM, these DoSAPs should be configured to be Disabled.

Ports k, m, n, and s can be configured as ISAPs for the gray service instance, providing a MIP at the operator MD Level. Port e can be configured with a MIP for the provider MD Level, and Port g with a MIP for the customer MD Level.

Figure 18-7 illustrates the use of MD Levels to allow the use of CFM by a user of connectivity provided by two bridged Maintenance Domains and by the operators of each of those Maintenance Domains. It illustrates a vertical slice through Figure 18-5, including two of the customer's devices, and the path through the network connecting them. One can see from Figure 18-7 why MD Levels are required to identify CFM PDUs; there would otherwise be no way for Bridge Port b, for example, to tell whether a given CFM PDU is to be sunk (MD Levels 2 or 3) or passed (MD Level 5).

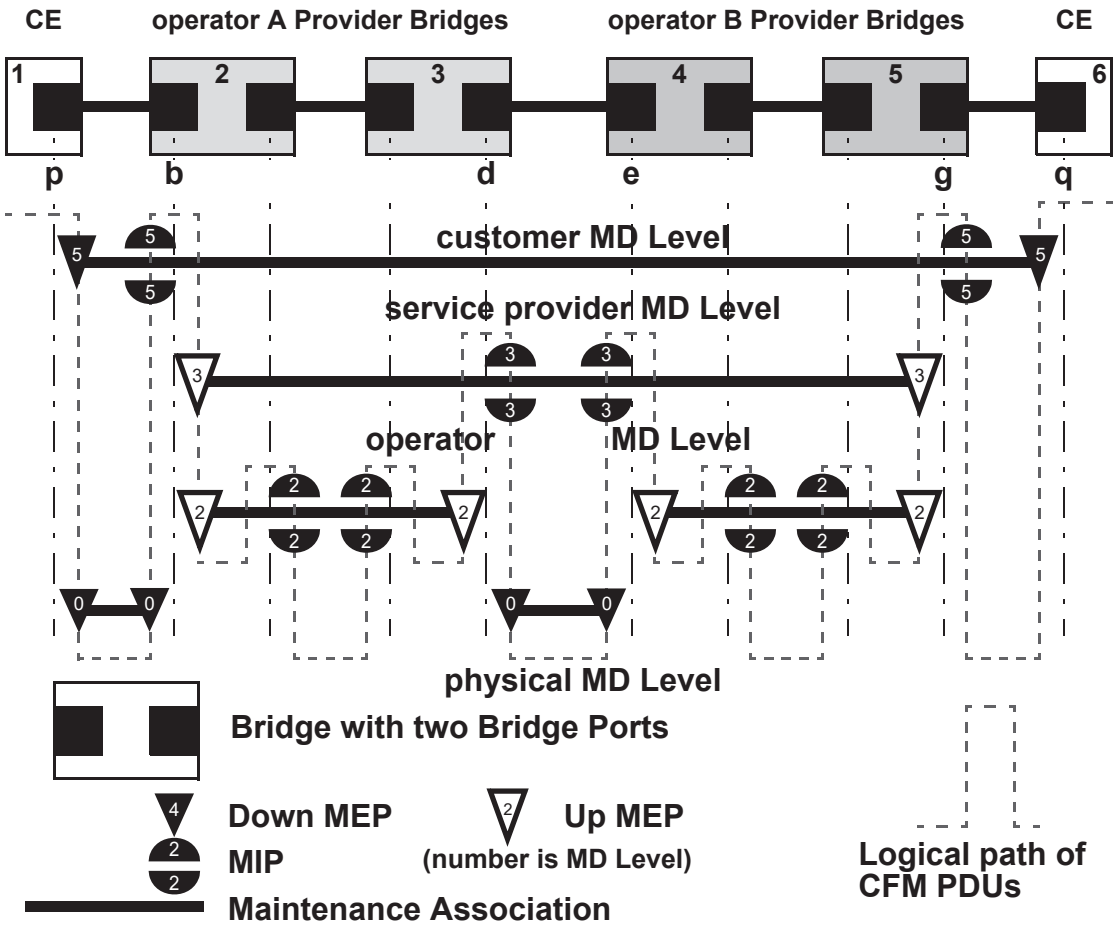


Figure 18-7—MEPs, MIPs, and MD Levels

Assignment of numerical MD Levels to the “customer” role, the “service provider” role, or the “operator” MD Levels is somewhat arbitrary, since those terms imply business relationships that cannot be standardized. See J.3 for a more detailed discussion of the assignment of MD Levels.

19. CFM entity operation

This clause specifies:

a) How the MPs that instantiate a CFM MA attach to ISS-SAPs or EISS-SAPs (19.1).
b) How MPs are addressed in networks (19.4).
c) The architecture of MEPs (19.2), MIPs (19.3), MHFs (19.3), Linktrace Output Multiplexers (LOMs, 19.5), and Linktrace Responders (19.6), including their identification, addressing, and decomposition into components that provide the CFM functions.

NOTE—Clause 18 introduces the principles of CFM operation and the network architectural concepts that support it. Clause 20 specifies the protocols operated by the components of each MP, and Clause 21 specifies the PDU formats used by those protocols. The use of CFM within systems and networks is further described in Clause 22.

The models of operation in this clause provide a basis for specifying the externally observable behavior of MEPs and MIPs, and are not intended to place additional constraints on implementations; these can adopt any internal model of operation compatible with the externally observable behavior specified. Conformance of equipment to this standard is purely in respect of observable protocol.

19.1 Maintenance Points (MPs)

The primary CFM protocol shims are called Maintenance Points (MPs). (See 19.6 for the other CFM protocol shim.) An MP can be either a MEP or an MHF. (See also 19.5 for a third type of CFM shim.) A MEP or an MHF each have two principle SAPs, an Active SAP, through which CFM PDUs produced and consumed by the MP are exchanged, and a Passive SAP, through which data frames and unprocessed CFM PDUs pass. Figure 19-1 illustrates the principle SAPs, and the symbols used for MEPs, MIPs, and MHFs in other figures, e.g., Figure 22-1. Note that an MP can be a Down MP or an Up MP, depending on whether the Passive SAP is above or below the Active SAP, respectively, in a shim diagram.

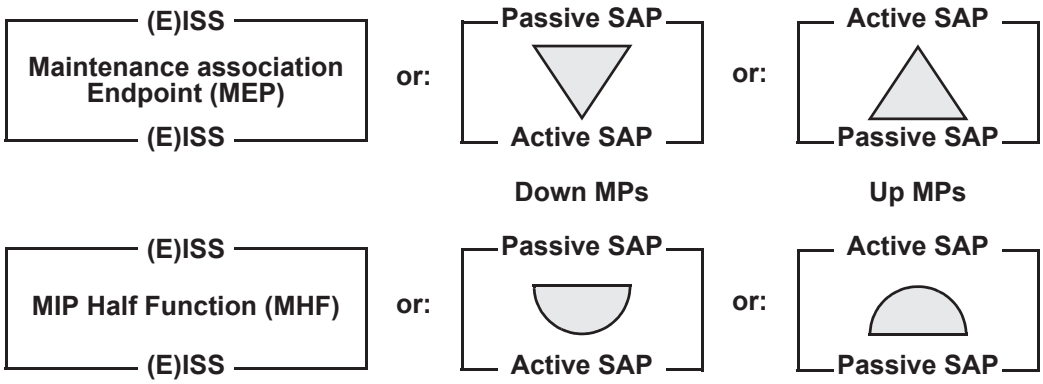


Figure 19-1—CFM Protocol shims

NOTE—The difference between Up MPs and Down MPs is explained more fully in 19.2.3 and 22.1.1.

19.2 MA Endpoints (MEPs)

A MEP can be created in either a Bridge Port (22.2) or an end station attachment to a LAN.

19.2.1 MEP identification

A MEP is associated with exactly one MA. It is identified for management purposes by two parameters, although other, additional parameters are used to manage the MEP:

a) The MAID, identifying the MA
b) A MEPID specific to this MEP

The MEP is identified for data forwarding purposes by:

c) A set of VIDs, including a Primary VID, inherited from the MA; or
d) An I-SID in the case of a Backbone Service Instance MA; or
e) A set of 3-tuples <ESP-DA, ESP-SA, ESP-VID> inherited from the MA when the MA is associated with a TESI; or
f) A SEG-ID inherited from the MA when the MA is associated with an Infrastructure Segment.

From the MA, the MEP inherits a Maintenance Domain, and from this it inherits:

g) A Maintenance Domain Level (MD Level), inherited from its Maintenance Domain and
h) One of the following inherited from its MA:
    1) A Primary VID or
    2) an I-SID in the case of a backbone service instance or
    3) a TE-SID in the case of a TESI or
    4) a SEG-ID in the case of an Infrastructure Segment

A MEP is associated with two Bridge Ports. For a Down MEP, both associations are with the same Bridge Port. For an Up MEP, the two associations can be with either the same, or with different, Bridge Ports (see 19.4, J.6). The two Bridge Ports are:

i) The Bridge Port on which the MEP is configured.
j) The Bridge Port on which the MEP is implemented, and from which it inherits its individual MAC address.

The set of MEPs configured with identical values for MAID define an MA. Thus, one can say that the MA, and not the MEPs, possesses this parameter. However, an MA is a diffuse entity that can be spread among a number of geographically separated Bridges. Each Bridge has its own Maintenance Association managed object for an MA, from which its MEP's MAID, MD Level, and Primary VID, I-SID, series of <ESP-DA, ESP-SA, ESP-VID> 3-tuples, or SEG-ID are derived. In the case of a VLAN-associated MA, the selection of which of the MA's VIDs is the Primary VID can be overridden for a specific MEP. Although this information can be incorrectly configured (i.e., configured differently than some other Bridge), the Maintenance Association managed object ensures the uniform configuration of MEPs in a single Bridge.

Each individual MEP is configured with a MEPID that is unique within that MA. Again, the Maintenance Association managed object helps to maintain uniqueness, as it ties together the configuration parameters of the MEPs in a single Bridge and the same MA and ensures the uniqueness of the MEPIDs, at least in that Bridge.

The MAID can take a number of forms (see 21.6.5.1), including a Domain Name-based string. To prevent incorrect operation in the face of unanticipated connections among systems, the MAID is unique over the domain for which CFM is to provide such protection. If the MAID is globally unique, then that domain is global. CFM can detect connectivity errors only over a set of MEPs in which MAIDs are unique.

The MEPID is an integer in the range 1–8191. It provides each MEP with the unique identity required for the MEPs to verify the correct connectivity of the MA.

NOTE—The range of the MEPID has been chosen to be large enough to accommodate most network needs, but small enough to be used as an index into a table of remote MEPs, and not require a table lookup, in a MEP Continuity Check Receiver (19.2.8) implemented in hardware.

19.2.2 MEP functions

The MEP:

a) Periodically transmits CCMs according to the managed objects defined in item e) in 12.14.6.1.3.
b) Validates received CFM PDUs as specified in 20.1, 20.2, 20.3, and 20.51.
c) Discards those CFM PDUs at a lower MD Level to that configured in the MEP (20.7.1).
d) Transmits LBMs and receives LBRs as defined in 20.2, according to the managed objects defined in 12.14.7.3.
e) Transmits LTMs, and transmits and receives LTRs as defined in 20.3, according to the managed objects defined in 12.14.7.4.
f) Responds to LBMs with LBRs as defined in 20.2.2.
g) Responds to LTMs with LTRs as defined in 20.3.2.
h) Maintains the MEP CCM Database as defined in 20.1.3.
i) May maintain the MIP CCM Database as defined in 20.1.3.
j) Maintains the variables in 20.9.

a) May decapsulate and transmit the payload of received Send Frame Messages (SFMs) (29.2.6).
b) May pass the received Reflected Frame Messages (RFMs) to RFM-Receiver (29.2.4).

Although defined as having either ISS or EISS interfaces, a MEP is highly constrained in its use of the EISS. Specifically,

c) Every frame passing through the MEP, in either direction, is emitted with its vlan_identifier and drop_eligible parameters unchanged from the value received.
d) All PDUs generated by the MEP, namely CCMs, LBMs, LBRs, LTMs, and LTRs, use the MEP's configured Primary VID as the vlan_identifier parameter.

19.2.3 MEP architecture

Figure 19-2 illustrates the component entities of a MEP. Entities that simply pass, redirect, or filter frames without altering them, and that have no internal state, are shown with dashed outlines; those that generate or transform frames, or that have an internal state, are shown with continuous outlines. State machines describing the latter entities are specified in Clause 20. Figure 19-2 shows that the two enclosing SAPs are not equivalent. The upper SAP in the figure is the Passive SAP. It lies closer to the DoSAP of the monitored service instance. The lower SAP in the figure is the Active SAP, the one that faces the monitored service instance. Thus, Figure 19-2 illustrates one of the Down MEPs shown in Figure 22-1. To illustrate one of the Up MEPs of Figure 22-1, Figure 19-2 would have to be inverted. Note also in the diagram that there are two paths, one of which is present only in the Up MEP, and one of which is present only in the Down MEP.

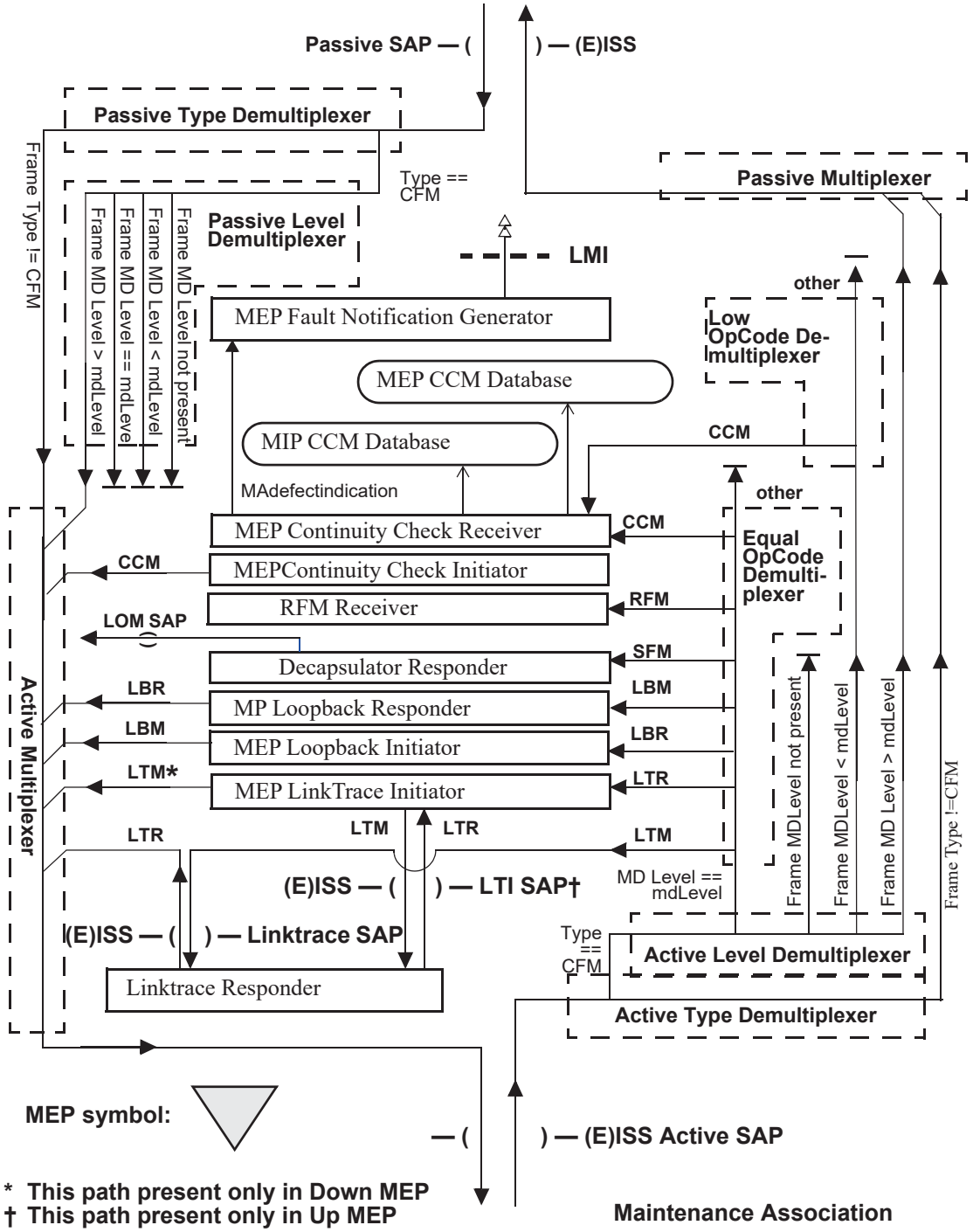


Figure 19-2—MA Endpoint (MEP)

19.2.4 MP Type Demultiplexer

There are two MP Type Demultiplexers in a MEP, the Active and the Passive Type Demultiplexers, and one in an MHF. All have the same purpose: to separate the data frames from those carrying CFM PDUs using the CFM encapsulation (21.2), output non-CFM frames to one output, and output the CFM frames to a second output. Frames containing CFM PDUs are sent to the Level Demultiplexer, and non-CFM frames are passed through the MEP intact.

NOTE—The model used for functional entities in this standard assumes that the operations of the components shown in Figure 19-2 and Figure 19-3 are atomic with respect to each other, so that the demultiplexing and multiplexing of frames, e.g., of CFM and non-CFM frames, cannot change the order of delivery of these frames. Although such reordering has no adverse consequences on this standard, and although it would not normally violate the frame ordering requirements of 6.5.3 (because CFM and non-CFM frames would seldom have the same source and destination MAC address pairs), this reordering could cause the frame loss measurement operations of ITU-T G.8013/Y.1731 to fail to operate correctly. IEEE Std 802.1AX also can disrupt the operation of ITU-T G.8013/Y.1731 frame loss measurement operations.

19.2.5 MP Multiplexer

There are two MP Multiplexers in a MEP or in an MHF, the Active and the Passive Multiplexers. An MP Multiplexer merges frames from multiple inputs and outputs them to a single output. No frame queuing is specified or implied by this standard.

19.2.6 MP Level Demultiplexer

There are two MP Level Demultiplexers in a MEP, the Active and Passive Level Demultiplexers. Both separate CFM PDUs according to the MD Level contained within the PDU, and the MD Level configured in the MEP, and output them to different outputs. Specifically,

a) Any CFM PDU received that is too short to contain an MD Level header field shall be discarded.

b) Otherwise, the MD Level header field of the CFM PDU is compared to the MD Level configured for the MP [item b) in 12.14.5.1.3, item b) in 12.14.3.2.2, 20.7.1], and the CFM PDU is directed to one of the three outputs of the MP Level Demultiplexer, according to whether the CFM PDU's MD Level is less than, equal to, or greater than the MP's MD Level.

19.2.7 MP OpCode Demultiplexer

There are two MP OpCode Demultiplexers in a MEP, the Equal and the Low OpCode Demultiplexers, and one in an MHF. Each MP OpCode Demultiplexer separates CFM PDUs that carry different values in their OpCode fields (see 21.4.3), and either discards them or passes them to the appropriate state machine. Those PDUs that do not match any of the OpCodes recognized by an MP OpCode Demultiplexer, or that are too short to contain an OpCode, are discarded by either of a MEP's MP OpCode Demultiplexers, and passed to the Passive MHF Multiplexer by an MHF's MP OpCode Demultiplexer. Those PDUs that do match a recognized OpCode are stored in a variable and cause another Boolean variable to be set, according to Table 19-1. These variables, in turn, trigger state machine actions. The three MP OpCode Demultiplexers separate different sets of OpCodes; see Figure 19-2 (in 19.2.3) and Figure 19-3 (in 19.3.3).

19.2.8 MEP Continuity Check Receiver

The MEP Continuity Check Receiver receives CCMs whose MD Levels are equal to or less than the MD Level of the MEP. The MEP Continuity Check Receiver processes those at or lower than its own MD Level, to update the MEP CCM Database. The MEP Continuity Check Receiver maintains one instance of the Remote MEP state machine (20.20) for each active remote MEP configured for this MA. In addition, the MEP Continuity Check Receiver maintains a single instance each of the Remote MEP Error state machine (20.22) and the MEP Cross Connect state machine (20.24).

Table 19-1—Actions taken by MP OpCode Demultiplexers

OpCode	MEP Equal OpCode Demultiplexer	MEP Low OpCode Demultiplexer	MHF OpCode Demultiplexer
CCM	Sets CCMreceivedEqual and CCMequalPDU for 20.18	Sets CCMreceivedLow and CCMlowPDU for 20.18	Sets MHFrecvdCCM and MHFCCMPDU for 20.15 and transfers CCM to Passive MHF Multiplexer
LBM	Sets LBMreceived and LBMPDU for 20.29	Discards PDU	Sets LBMreceived and LBMPDU for 20.29 and in non-PBB-TE MHFs transfers LBM to Passive MHF Multiplexer
LBR	Sets LBRreceived and LBRPDU for 20.34	Discards PDU	Transfers LBR to Passive MHF Multiplexer
LTM	Transfers LTM to MEP Linktrace SAP	Discards PDU	Transfers LTM to MHF Linktrace SAP
LTR	Sets LTRreceived and LTRPDU for 20.45	Discards PDU	Transfers LTR to Passive MHF Multiplexer
Other	Discards PDU	Discards PDU	Transfers PDU to Passive MHF Multiplexer
SFM	Sets SFMreceived (29.3.8.5) and SFMPDU (29.3.8.3)	Discards PDU	Sets SFMreceived (29.3.8.5) and SFMPDU (29.3.8.3). Transfers the SFM to Passive MHF Multiplexer
RFM	Sets RFMreceived (29.3.6.1) and RFMPDU (29.3.6.2)	Discards PDU	Sets RFMreceived (29.3.6.1) and RFMPDU (29.3.6.2). Transfers the RFM to Passive MHF Multiplexer

If a MEP's Continuity Check Receiver state machine's allRMEPsDead variable (20.9.4) is set, and if the MEP is not associated with any VID or I-SID and is a Down MEP (i.e., in position 5 in Figure 22-9), then the MAC_Operational parameter presented to the Passive SAP by the MEP is false, whatever the state of the MAC_Operational parameter received from the Active SAP. Thus, a completely failed MA causes the attached Bridge Port to appear as a failed link.

Optionally, the MEP Continuity Check Receiver may maintain the MIP CCM Database as described in 19.3.10.

Various error conditions, including the receipt of CCMs at a lower MD Level than that of the MEP, cause the Remote MEP state machine to detect a defect that can in turn generate a Fault Alarm.

19.2.9 MEP Continuity Check Initiator

The Continuity Check Initiator transmits CCMs at the MD Level of the MEP only. The state machine for the Continuity Check Initiator is described in 20.12.

19.2.10 MP Loopback Responder

The Loopback Responder receives LBMs at the MD Level of the MP only, validates and filters them according to destination_address (19.4) and the PBB-TE MIP TLV (21.7.5) in the case of a PBB-TE MA and transmits LBRs in response. The state machine for the MP Loopback Responder is described in 20.29.

19.2.11 MEP Loopback Initiator

The Loopback Initiator transmits LBMs at the MD Level of the MEP only, and validates, filters according to destination_address (19.4), and counts the LBRs returned by other MPs' Loopback Responders. The state machine for the Loopback Initiator is described in 20.32.

19.2.12 MEP Linktrace Initiator

The Linktrace Initiator transmits LTMs at the MD Level of the MEP only, and validates, filters according to destination_address (19.4), and catalogs the LTRs returned by other Bridges' Linktrace Responders. The state machine for the Linktrace Initiator is described in 20.45. In an Up MEP the Linktrace Initiator transmits its LTMs to the Bridge's Linktrace Responder. In a Down MEP, the Linktrace Initiator transmits its LTMs through the MEP's own Active Multiplexer toward the MEP's Active SAP.

19.2.13 MEP LTI SAP

An Up MEP, but not a Down MEP, has a MEP LTI SAP, an instance of the ISS or EISS. This SAP is used to:

a) Transmit LTMs originated by the MEP's Linktrace Initiator.
b) Receive LTRs from the Linktrace Responder.

19.2.14 MEP Linktrace SAP

Every MEP has a MEP Linktrace SAP, an instance of the ISS or EISS. This SAP is used to relay received LTMs to the Linktrace Responder.

NOTE—Both the MEP LTI SAP and MEP Linktrace SAP are required so that the MEP knows, when an LTR is returned to it by the Linktrace Responder, whether the LTR is a response to an LTM generated by the MEP and thus to direct it to the MEP Linktrace Initiator, or whether the LTR is a response to an LTM previously received by the MEP and thus to forward it out the Active SAP.

19.2.15 MEP CCM Database

The MEP CCM Database is maintained by the Remote MEP state machines (20.20), one entry for each of the other MEPs configured in the MA. In addition to the Remote MEP variables (20.19) used by the Remote MEP state machine, each entry holds information obtained from the remote MEP's CCMs as listed in 12.14.7.6.3. See also 20.1.3.

19.2.16 MEP Fault Notification Generator

The Fault Notification Generator uses the MAdefectIndication variable (see 20.9.3) in order to generate a Fault Alarm to the administrator of the Maintenance Domain to which the MA is attached. This can be accomplished by sending an SNMP Notification. The state machine for the Fault Notification Generator is described in 20.37.

19.2.17 MEP Decapsulator Responder (DR)

The MEP DR is an optional component entity within an MEP shim required only by DDCFM. Its position relative to other MP component entities is shown in Figure 19-2. When the destination_address of the SFM matches with the MEP's MAC address, the MEP DR (29.2.6) will decapsulate the SFM, change the source_address field of the decapsulated data frame if it is required, and send the frame to the LOM SAP of selected port(s) (29.3.9.1).

19.2.18 MEP RFM Receiver

The MEP RFM Receiver is an optional component entity within a MEP shim required only by DDCFM. It is placed next to the OpCode Demultiplexer functions receiving RFM frames. When the destination_address of the RFM matches with the MP's MAC address, the MEP RFM Receiver will pass the received RFM to the corresponding, nonstandardized RFM Analyzer.

19.3 MIP Half Function

A MIP consists of two MIP Half Functions (MHFs) on a single Bridge Port, an Up MHF and a Down MHF. (See J.6 for a more detailed explanation.) An MHF may maintain a MIP CCM Database, separate from the MEP CCM Databases.

19.3.1 MHF identification

Every MHF is characterized by one configuration parameter for management purpose, and all of the MHFs of a MIP have identical values for that configuration parameter:

a) The Maintenance Domain to which the MHF is assigned.

For data flow purposes, the MHF is characterized by:

b) A Maintenance Domain Level (MD Level), inherited from its Maintenance Domain or from the Default MD Level managed object.

c) A set of Primary VIDs, one from each MA associated with the MHF's Maintenance Domain; or a set of I-SIDs, one for each MA associated with the MHF's Maintenance Domain.

NOTE—When multiple VIDs are used for a single service instance, an MHF is aware of each MA's VID set and Primary VID. Unlike the MEP, however, the MHF has no occasion to use a MAID, so is not identified by a MAID.

An MHF is associated with two Bridge Ports. For a Down MHF, both associations are with the same Bridge Port; for an Up MHF, the two associations can be with either the same, or with different, Bridge Ports (see 19.4, J.6). The two Bridge Ports are:

d) The Bridge Port on which the MHF is configured.

e) The Bridge Port on which the MHF is implemented and from which it inherits its individual MAC address.

19.3.2 MHF functions

Each MHF:

a) Validates received LTMs as specified in 20.1, 20.2, 20.3, and 20.51.

b) Optionally, validates received CCMs and builds the MIP CCM Database.

c) Responds to LBMs with LBRs as defined in 20.2.2.

d) Responds to LTMs by forwarding them and responding with LTRs as defined in 20.3.2.

e) May decapsulate and transmit the payload of the received SFM (29.4.3).

f) May pass the received RFM (29.4.2).

Although defined as having either ISS or EISS interfaces, an MHF is highly constrained in its use of the EISS. Specifically,

g) Every frame passing through the MHF, in either direction, is emitted with its vlan_identifier and drop_eligible parameters unchanged from the value received.

h) All LBMs forwarded by the MHF carry the same vlan_identifier and drop_eligible parameters as the received LBM.

i) All PDUs generated by the MHF, namely LBRs, and LTRs, are transmitted with a vlan_identifier equal to the Primary VID of the MA to which the vlan_identifier of the received LBM or LTM belongs, or to the Reverse VID field of the PBB-TE MIP TLV if the received LBM or LTM carries such a TLV.

19.3.3 MHF architecture

Figure 19-3 illustrates a single MHF. Entities that simply pass, redirect, or filter frames without altering them, and that have no internal state, are shown with dashed outlines; those that generate or transform frames, or that have an internal state, are shown with continuous outlines. State machines describing the latter entities are specified in Clause 20. Figure 19-3 shows that the two enclosing SAPs are not equivalent. The upper SAP in the figure is the Passive SAP. This lies nearer an ISAP for the monitored service instance. The lower SAP in the figure is the Active SAP, the one through which CFM PDUs are actively transmitted and received. Thus, Figure 19-3 illustrates one of the Down MHFs shown in Figure 22-1. To illustrate one of the Up MHFs of Figure 22-1, Figure 19-3 would have to be inverted.

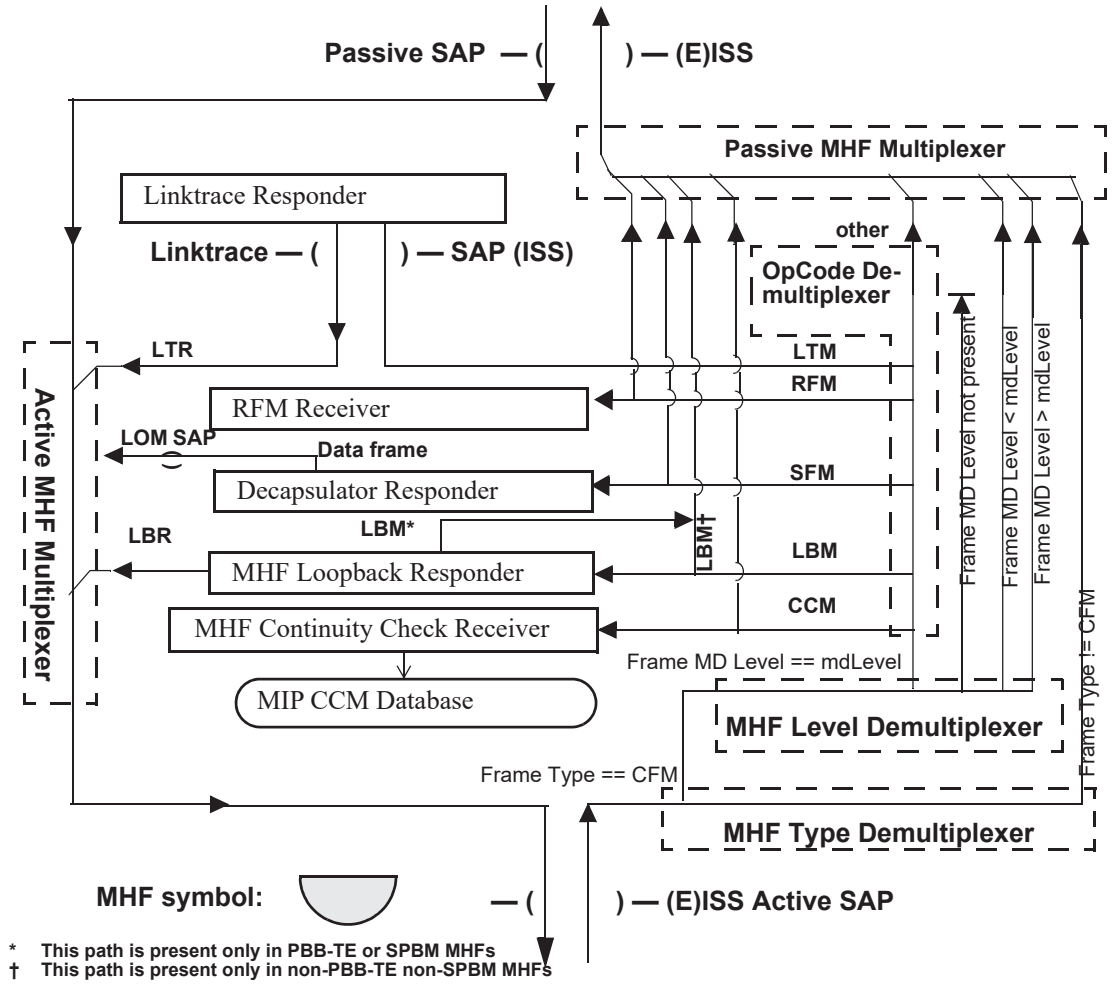


Figure 19-3—MIP Half Function (MHF)

19.3.4 MHF Level Demultiplexer

The MHF Level Demultiplexer is identical to the MP Level Demultiplexer described in 19.2.6.

19.3.5 MHF Type Demultiplexer

The MHF Type Demultiplexer is identical to the MP Type Demultiplexer described in 19.2.4.

19.3.6 MHF OpCode Demultiplexer

An example of the MP OpCode Demultiplexer described in 19.2.7. The MHF OpCode Demultiplexer is fully described in that subclause.

NOTE—As indicated by the split arrows labeled “CCM” and “LBM” in Figure 19-3, some of the frames output from the MHF OpCode Demultiplexer are supplied to two other entities, and not just one.

19.3.7 MHF Multiplexer

The MHF Multiplexer is identical to the MP Multiplexer described in 19.2.5. There are two MHF Multiplexers in an MHF, the Active MHF Multiplexer and the Passive MHF Multiplexer.

19.3.8 MHF Loopback Responder

The MHF Loopback Responder is identical to the MP Loopback Responder described in 19.2.10.

19.3.9 MHF Continuity Check Receiver

The optional MHF Continuity Check Receiver receives CCMs, validates them, filters them by destination_address parameter (19.4), and contributes to the MIP CCM Database. From Figure 19-3, readers can see that all CCMs at the same MD Level as the MHF are presented to the MHF Continuity Check Receiver. No other information in the received CCMs is examined. In particular, the MAID in the CCM is not compared to the MHF’s MAID.

The MHF Continuity Check Receiver, and the MIP CCM Database it maintains, are not required for conformance to this standard.

19.3.10 MIP CCM Database

The MIP CCM Database is optionally maintained by an MHF or MEP. It is a list of every distinct {FID, source_address, Port number} triple from all of the CCMs presented to all of the Bridge’s MPs’ Continuity Check Receivers since the Bridge was last reset. Entries in the MIP CCM Database are timed out very slowly, on the order of one day, so that their information is available for fault isolation long after the information is no longer used for frame forwarding.

19.3.11 MHF Linktrace SAP

Every MHF has an MHF Linktrace SAP, an instance of the ISS or EISS. This SAP is used to relay received LTMs to the Linktrace Responder, and to pass LTRs from Linktrace Responder to the MHF’s Active SAP.

19.3.12 MHF DR

The MHF DR is identical to the MEP DR described in 19.2.17.

19.3.13 MHF RFM Receiver

The MHF RFM Receiver is identical to the MEP RFM Receiver described in 19.2.18.

19.4 MP addressing

The CFM entities within an MP use the Group addresses for CCM and LTM PDUs listed in Table 8-18 and Table 8-19 and in the case of PBB-TE, SPBM, and ECMP path MAs, the individual MAC addresses or the group MAC addresses that are associated with the monitored services (20.1, 20.2, 20.3). In addition, they recognize and in the case of PBB-TE, SPBM, and ECMP path MEPs use the individual MAC address of the port on which the MP is operating. This is the port on which the MP is configured, if the Bridge created the MP using the Individual MP address model (J.6.1), and is a CFM Port, if the Bridge created the MP using the Shared MP address model (J.6.2). CFM entities associated with a TESI may also use the ESP-SA parameter in the tuple identifying the corresponding ESP.

A Down MP shall not be assigned an individual MAC address [item i) in 12.14.7.1.3] that is the same as the individual MAC address configured for an MP on any other Bridge Port, because if two Bridge Ports are connected to the same LAN, but have the same MAC address, then both would respond to an LBM sent to that MAC address. The CFM protocol is specifically designed to allow an Up MP to be assigned an individual MAC address that is the same as the individual MAC address configured for an Up MP on some other Bridge Port, because it is impossible to tell, from outside the Bridge, from which Up MP a given CFM PDU was actually transmitted, or to which physical entity a given CFM PDU was delivered. See J.6 for a discussion of the assignment of individual MAC addresses to MPs.

All the CFM entities within one MP use the same CCM and LTM addresses, and individual MAC address. The various multiplexing and demultiplexing entities pay no attention to the destination_address parameter of a received CFM PDU. Only the entities responsible for processing received CFM PDUs check a received frame's destination_address parameter. Each of these entities recognizes frames whose destination_address parameters match the individual MAC address of the MP or are a group address. Each of these entities (except the MEP Continuity Check Receiver) filters and does not process frames whose destination_address parameters are not a group address and do not match the individual MAC address of the MP.

NOTE—Even though in the original version of IEEE Std 802.1ag-2007, the MEP Continuity Check Initiator could only transmit multicast CCMs, the MEP Continuity Check Receiver recognized unicast CCMs. In general the definitions of the various CFM receiving entities were more liberal in recognizing certain Individual or group MAC addresses than the corresponding definitions of the CFM transmitting entities a property that allows for the PBB-TE enhancements of CFM, and for improved compatibility with ITU-T G.8013/Y.1731.

19.5 Linktrace Output Multiplexer (LOM)

The third type of CFM protocol shim is the LOM. An LOM has two principle SAPs, an Active SAP, through which CFM PDUs are transmitted, and a Passive SAP, through which pass data frames and unprocessed CFM PDUs. Figure 19-4 illustrates these SAPs and the symbol used for the LOM in other figures, e.g., Figure 22-1. An LOM can be only a Down LOM; its Passive SAP is always above the Active SAP in a shim diagram.

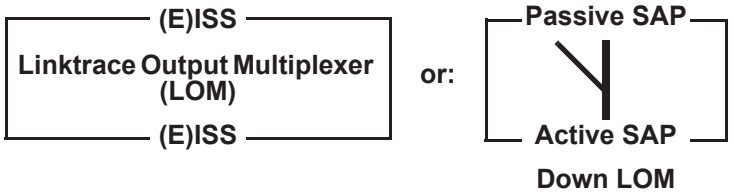


Figure 19-4—LOM shim

As illustrated in Figure 19-5, the LOM has only a single active entity, the LOM Multiplexer. It injects LTMs from the Linktrace Responder among the frames passing from the LOM's Passive SAP to its Active SAP. Frames received from the LOM's Linktrace SAP are transmitted through only the Active SAP, and not

through the Passive SAP. All frames received on either the Active or Passive SAP are passed through the LOM unchanged, and only to the Passive or Active SAP, respectively.

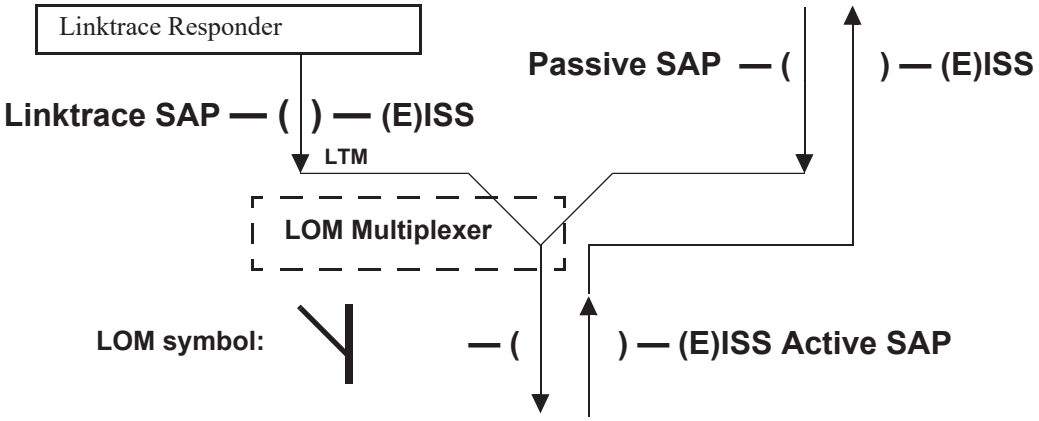


Figure 19-5—LOM architecture

NOTE 1—An LOM is not an MP, but an entity that assists the Linktrace Responder (19.6), also not an MP.

NOTE 2—The LOM exists on every Bridge Port in order to allow the Linktrace Responder to transmit an LTM on a particular Bridge Port without the possibility of that LTM being reflected back toward the Bridge's Forwarding process. However, the LOM has no constituent entity that differentiates CFM frames from any other frames.

19.6 Linktrace Responder

A single Linktrace Responder serves all of the MHFs and MEPs in a Bridge. It is connected to every MP and LOM in the Bridge, via the Linktrace SAPs and LTI SAPs in those MPs and LOMs.

NOTE—A Linktrace Responder is not an MP, but an entity that assists the MPs (MEP and MHF, 19.2 and 19.3) in performing their functions.

In order to minimize the possibility of generating an unbounded number of responses to an LTM, an LTM is always transmitted from a Bridge on a single Bridge Port (20.3). If the LLC entity of a Bridge Port (see Figure 22-1) were used to transmit an LTM on a particular Bridge Port, the Bridge Port connectivity entity (8.5.1) would direct the LTM to the LAN, but it would also pass that frame up toward the Frame filtering entity (8.6.3), as it does for BPDUs. BPDUs are never transmitted to other Bridge Ports, however, because the Frame filtering entity filters them, based on their destination MAC addresses. The placement of MHFs at different MD Levels on different Bridge Ports, all for the same VID, precludes filtering LTMs in this manner. Therefore, the Linktrace Responder filters incoming LTMs by the destination_address parameter (19.4), and a path is required that will direct an LTM only down the Bridge Port, toward the LAN, and not toward the Frame filtering entity.

This path is provided by the Linktrace SAPs in the MEP (Figure 19-2), the MHF (Figure 19-3), and the LOM (Figure 19-5). The Linktrace SAPs are also used to direct a received LTM to the Linktrace Responder when the LTM first encounters an MP at the appropriate MD Level.

Referring to Figure 22-1, readers can see that an LTM originated by a Down MEP Linktrace Initiator is directed out to the LAN and is thus output on a single Bridge Port, as desired. The situation is different for an LTM originated by an Up MEP. The Bridge in which an Up MEP resides is, in effect, the first hop of the Linktrace protocol. The MEP LTI SAP is required in order to provide a path through which the MEP can direct its originated LTM to the Linktrace Responder. This path can also be used by the Linktrace Responder to return the resultant LTR to the MEP Linktrace Initiator. See Figure 20-16 for a diagrammatic explanation of these paths.

Table 19-2 summarizes the SAP connections between the MPs and LOM on the one hand, and the Linktrace Responder, on the other.

Table 19-2—SAP use for LTMs and LTRs

Entity taking action		Sends originated LTM to	Relays received LTM to	Sends to Active SAP an LTR received on	Sends to Active SAP an LTM received on
Up	MEP	MEP LTI SAP	MEP Linktrace SAP	MEP Linktrace SAP	Not applicable [a]
	MHF	Not applicable [b]	MHF Linktrace SAP	MHF Linktrace SAP	Not applicable [a]
Down	MEP	Not applicable [c]	MEP Linktrace SAP	MEP Linktrace SAP	Not applicable [a]
	MHF	Not applicable [b]	MHF Linktrace SAP	MHF Linktrace SAP	Not applicable
LOM		Not applicable [b]	Not applicable [d]	Not applicable [a]	LOM Linktrace SAP

[a] The Linktrace Responder only forwards LTMs through an LOM.
[b] The MHF and LOM have no MEP Linktrace Initiator, so cannot originate LTMs.
[c] The Down MEP transmits the LTMs it originates through its Active SAP.
[d] The LOM is not an MP; it cannot detect received LTMs.

A single instance of the LTR Transmitter state machine is instantiated by the Linktrace Responder. It is described in 20.50.

20. CFM protocols

MEPs and MIPs can participate in the following CFM protocols:

a) Continuity Check protocol (20.1)
b) Loopback protocol (20.2)
c) Linktrace protocol (20.3)
d) DDCFM protocol (29.3)

The detailed operation of these protocols by the MEP (19.2) and MHF (19.3) components introduced in Clause 19 is specified in terms of a number of state machines, and the variables and procedures associated with each machine. The state machines defined adhere to the conventions in Annex E and Figure 13-14.

This clause specifies the following:

e) Relationships among the various CFM state machines and their variables (20.4).
f) Requirements for decrementing the timer counters used by a number of CFM state machines (20.5).
g) Maintenance Domain variables (20.7) that control all MAs belonging to the Maintenance Domain.
h) MA variables (20.8) that control all MEPs and MHFs belonging to the MA.
i) MEP variables (20.9) that control the MEP's overall operation, and either apply to the majority of state machines or facilitate communication of information between the individual MEP state machines.
j) MEP Continuity Check Initiator (19.2.9) variables (20.10), procedures (20.11), and state machine (20.12).
k) (optional) MHF Continuity Check Receiver (19.3.9) variables (20.13), procedures (20.14), and state machine (20.15).
l) MEP Continuity Check Receiver (19.2.8) variables (20.16), procedures (20.17), and state machine (20.18).
m) Remote MEP variables (20.19) and state machines (20.20) used by the MEP Continuity Check Receiver to track each active Remote MEP [item ae) in 12.14.7.1.3].
n) Remote MEP Error variables (20.21) and the Remote MEP Error state machine (20.22) used by MEP Continuity Check Receiver to track received invalid CCMs.
o) MEP Cross Connect variables (20.23) and state machine (20.24) used by the MEP Continuity Check Receiver to track received CCMs that could indicate a cross connect defect.
p) MP Loopback Responder (19.2.10) variables, (20.27), procedures (20.28), and state machine (20.29).
q) MEP Loopback Initiator (19.2.11) variables (20.30), transmit procedures (20.31) and state machine (20.32), and receive procedures (20.33) and state machine (20.34).
r) MEP Fault Notification Generator (19.2.16) variables (20.35), procedures (20.36), and state machine (20.37).
s) MEP Linktrace Initiator (19.2.12) variables (20.41) and transmit procedures (20.42), and receive variables (20.43), procedures (20.44), and state machine (20.45).
t) Linktrace Responder variables (20.46), procedures (20.47), and state machine (20.48), used by the Linktrace Responder (19.6).
u) LTR Transmitter state machine (20.50) used only by the Linktrace Responder.

To facilitate extension of this standard while maximizing interoperability, this clause further specifies:

v) Rules for CFM PDU validation and versioning (20.51) that support specific goals for extensibility and interoperability (20.51.1).
w) Rules for the identification of incoming CFM PDUs (20.52).
x) Rules for the use of transaction identifier and sequence number fields (20.53).

The models of operation in this clause provide a basis for specifying the externally observable behavior of MHFs and MIPs, and are not intended to place additional constraints on implementations; these can adopt any internal model of operation compatible with the externally observable behavior specified. Conformance of equipment to this standard is purely in respect of observable protocol.

NOTE—Clause 18 introduces the principles of CFM operation and the network architectural concepts that support it. Clause 19 breaks down the CFM protocol entities into their components. Clause 21 specifies the PDU formats used by the CFM protocols. The use of CFM within systems and networks is further described in Clause 22.

20.1 Continuity Check protocol

The Continuity Check protocol is performed by the MEP Continuity Check Initiator (19.2.9), the MEP Continuity Check Receiver (19.2.8) of the MEP, and optionally, in the MHF Continuity Check Receiver (19.3.9) of the MHF.

For the purposes of Fault detection and the Continuity Check protocol, readers can define an MA as "a set of MEPs, all of which are configured with the same MAID and MD Level, each of which is configured with a MEPID unique within that MAID and MD Level, and all of which are configured with the complete list of MEPIDs." The CCM (21.6) provides a means to detect connectivity failures in an MA. Each MEP can be configured to periodically transmit a CCM. A connectivity failure is then defined as one of the following:

a) Inability of a MEP to receive three consecutive CCMs from any one of the other MEPs in its MA, indicating either a MEP failure or a network failure.
b) Reception by a MEP of a CCM with an incorrect transmission interval, indicating a configuration error.
c) Reception by a MEP of a CCM with an incorrect MEPID or MAID, indicating a configuration error or a cross connect error.
d) Reception by a MEP of a CCM with an MD Level lower than that of the MEP, indicating a configuration error or a cross connect error.
e) Reception by a MEP of a CCM containing a Port Status TLV or Interface Status TLV indicating a failed Bridge Port or aggregated port.
f) Reception by a PBB-TE MEP implementing the Traffic field, over a period of time that is 4.75 times the CCM interval or equal to 50 ms, whichever is larger, of CCMs with Traffic fields not matching the local Traffic field declaration, indicating a mismatch on the presence or absence of Backbone Service Instance entries on the CBPs that are associated with the monitored TESI.

In order to take the fullest advantage of CFM, the operator defines "correct connectivity" as being the configuration of the MEPs. If an MA is defined for every service instance, then the Continuity Check protocol can detect 100% of all connectivity faults, cross connection errors, or misconfigurations that occur within the boundaries of the configured MAs.

The transmission rate for CCMs is configurable, to accommodate different needs for error reporting, and different capabilities of network devices. The loss of three CCMs can be detected in as little as 10.8 ms (see Table 21-15). The reception of a cross connected CCM is an instantaneous occurrence.

A MEP uses its own configured timer to detect the loss of CCMs, rather than using the transmission rate of the sender (signaled in the CCM), in order to minimize the complexity of a MEP tracking hundreds of other MEPs. The timer is reset when a valid CCM is received, and a defect declared if the timer expires. The timer value is chosen such that the loss of three consecutive CCMs from a given remote MEP triggers a defect for that remote MEP, and the timer accuracy chosen to ensure against a premature defect indication. In addition, state machines in the MEP track the receipt of CCMs from remote MEPs with unexpected information, CCMs from remote MEPs not configured in the receiving MEP, CFM PDUs from a lower MD Level, or CCMs from MEPs in another MA.

Depending on the associated MA, a CCM is carried:

g) In a multicast frame, with a destination_address parameter chosen according to the transmitting MEP's MD Level, according to Table 8-18; or

h) In the case of a PBB-TE, SPBM, or ECMP associated MA, in a unicast or multicast frame with a destination_address identified by the monitored MA.

The CCM does not generate a response. Therefore, in an MA with *n* MEPs, *n* CCMs need to be transmitted periodically, one from each MEP. Compared to a full mesh of point-to-point messages in terms of frames carried on wires, multicast CCMs require less bandwidth than the point-to-point messages, except of course for MAs with only two MEPs. And for each MEP, only one transmission and $n - 1$ receptions are required, instead of $n - 1$ of each. In addition, even in MAs with only two MEPs, using multicast instead of unicasts for CCMs obviates the need for configuration or discovery of those MEPs' MAC addresses.

Of more importance than frame count is the fact that making the CCM a multicast frame enables the detection of a cross connect error when MEPs from two different service instances are accidentally connected. This type of error can result from a wiring error or a misconfiguration of VID mapping parameters at the boundary between two Maintenance Domains. Were CCMs unicast to specific MAC addresses, then a merging of two service instances, e.g., the accidental concatenation of two point-to-point services into a 4-SAP LAN service, would go undetected; unicast CCMs would still be delivered properly. This scenario also points out why globally unique MAIDs are important.

NOTE—The TESI Multiplex Entity (6.19) helps PBB-TE associated MEPs to avoid this type of cross connect problem for unicast CCMs by checking the source_address to determine CCMs destined to PBB-TE MAs. Correspondingly the assignment of globally unique MAIDs is not as important for PBB-TE MAs as it is for other types of MAs but in general a globally unique MAID will provide guaranties for full coverage on all possible misconfiguration errors.

Cataloging the receipt of CCMs ensures that a MEP, say, MEP 1, knows that it is receiving them from exactly the correct set of remote MEPs; it does not ensure that the CCMs transmitted by that same MEP are being received by the remote MEPs. For example, suppose that in a 10-MEP MA, all of MEP 1's CCMs are being lost. All of the other MEPs in the MA would know about MEP 1's problem, because they would not be receiving 1's CCMs. But, MEP 1 itself would be unaware of the problem. In order for the operator to decide whether an MA is working properly, every MEP in the MA would have to be inspected.

For this reason, the Remote Defect Indication (RDI), a single bit, is carried by the CCM. The absence of RDI in a CCM indicates that the transmitting MEP is receiving CCMs from all configured MEPs. In the case of MEP 1's unidirectional connectivity, MEP 1 would receive the RDI in the CCM from each remote MEP that is not receiving MEP 1's (or any other MEP's) CCMs. Thus, every MEP, including the receive-only MEP 1, is aware that a problem exists. The presence of RDI enables a system administrator to inspect any single MEP belonging to an MA, and discover whether there is any MEP in the MA that is detecting a defect, as well as which particular MEPs have defects.

A sequence number should be transmitted in every CCM. The receiver may use this sequence number to detect and count CCM losses. Detection of occasional CCM losses can enable a network administrator to notice suboptimal network conditions such as overloaded links, and correct them before connectivity defects and their consequent Fault Alarms occur.

An ECMP path MA is used to test multiple paths between a pair of endpoints. This type of MA has only two MEPs, at two SPT Region boundary ports. An ECMP path MEP cycles through a set of flow hash values intended to direct the CCM frames along (and thus test) different paths to the other MEP in the MA. The path taken by CCM frames with a given flow hash depends on the current state of the network (i.e., paths are subject to rerouting triggered by topology changes). Each flow hash is used in at least three consecutive CCM frames so that a fault on a particular path will be detected and reported back via an RDI signal. To avoid false positive or false negative detections of a loss of connectivity, the rate of CCM transmission should be greater than the maximum difference in latency between any pair of paths.

20.1.1 MAC status reporting in the CCM

The CCM can carry information about the status of the port on which the transmitting MEP is configured in the Port Status TLV (21.5.4) and Interface Status TLV (21.5.5). This information is not strictly within the scope of the MA bounded by the MEPs transmitting and receiving the CCM. But, by providing port status information in an Up MEP's CCMs, this TLV allows the detection of an error immediately outboard of the MA. This in turn supports fault isolation where a problem has arisen at the point of connection to a service instance, rather than within the equipment supporting the service instance. The Port Status TLV and Interface Status TLV are particularly useful where the boundary between the equipment used by two operators to support a service instance is a link or connection that could fail. Use of the Port Status TLV and Interface Status TLV allows monitoring to be uninterrupted from end to end, without requiring management access by both operators to a single item of interface equipment, or relying on monitoring by the user of the concatenated service. The Port Status TLV and Interface Status TLV allow errors that are immediately outboard of the MA to be distinguished easily from those properly attributed to the MA itself.

Figure 18-7 provides an example. Consider a failure of the access link that connects the customer equipment (1) directly to Port b of Provider Bridge 2. Without the Interface Status TLV, none of the MEPs at the operator or service provider MD Level would be notified of the error. The Interface Status TLV allows the failure to be signaled in CCMs transmitted by the Port b service provider and operator MD Level MEPs.

20.1.2 Defects and Fault Alarms

Defects are separated from Fault Alarms (19.2.16), as is standard practice for service providers.[34] The loss of CCMs or the reception of a cross connected CCM is a defect. A Fault Alarm is a Management operation (12.14.7.7), an unsolicited announcement by a Bridge. If the CFM MIB module (17.5) is implemented and is operating, an SNMP Notification is sent. If the CFM YANG module (Clause 48) is implemented and is operating, a YANG Notification is sent. Notifications are sent when the MEP Fault Notification Generator state machine (20.37), or the MEP Mismatch Fault Notification Generator state machine (20.40), detects that a configured time period (default, 2.5 s) has passed with one or more defects indicated, and Fault Alarms are enabled. Each of these state machine can transmit no further Fault Alarms until it is reset by the passage of a configured time period (default, 10 s) during which no defect indication is present. The normal operator procedure upon receiving a Fault Alarm is to inspect the reporting MEP's managed objects, diagnose the fault, correct the fault, examine the MEP's managed objects to see whether the state machine has reset, and repeat those steps until the Fault Alarm has cleared.

A number of separate defects are maintained by a MEP, as shown in Table 20-1. The defects are ranked by priority. If a higher priority defect occurs after a lower priority defect has triggered a Fault Alarm, but before the Fault Alarm has reset, then the MEP will immediately issue another Fault Alarm. This enables the operator to reliably prioritize Fault Alarms. For example, cross connect errors are typically of greater concern in a service provider environment than loss of connectivity errors.

Only the highest priority defect is reported in the Fault Alarm. Table 20-1 shows the relationships between the variables that indicate defects, the priorities of these defects, and the enumerated value reported in the Fault Alarm for each defect. The mmdefectIndication (20.38.2) is independent from the other CFM defects and is reported independently by the operation of the MEP Mismatch Fault Notification Generator state machine (20.40).

20.1.3 CCM reception

Every active MEP receives and catalogs CCMs in its MEP CCM Database. Every CCM shall be examined to be sure that its MAID matches that configured in the receiving MP. This check is optional for CCMs associated with PBB-TE MAs. A receiving MEP checks to ensure that its own MEPID does *not* match that

[34] See, for example, ITU-T G.806 (2006) [B47].

Table 20-1—Fault Alarm defects and priorities

Defect		Priority	
Variable	**highestDefect (20.35.9)**	**highestDefectPri (20.35.8)**	**Importance**
xconCCMdefect (20.23.3)	DefXconCCM	5	Most
errorCCMdefect (20.21.3)	DefErrorCCM	4	
someRMEPCCMdefect (20.35.5)	DefRemoteCCM	3	
someMACstatusDefect (20.35.6)	DefMACstatus	2	
someRDIdefect (20.35.7)	DefRDICCM	1	Least

in the received CCM. (This could indicate either a duplicate MEPID or a network forwarding loop.) The information in the CCM is cataloged in the MEP CCM Database, indexed by the received MEPID. The information kept in the MEP CCM Database is listed in 12.14.7.6.3.

The MIP CCM Database is optionally maintained by a MEP Continuity Check Receiver or an MHF Continuity Check Receiver. It is a list of every distinct {FID, source_address, Port number} triple from all of the CCMs presented to all of the Bridge's Down MHFs' MHF Continuity Check Receivers since the Bridge was last reset. (See 8.8.8 for a discussion of VIDs and FIDs.) An entry in the CCM Database is retained for at least 24 h after the last CCM with its triple is received and is removed from the MIP CCM Database after, at most, 48 h. If the resources allocated for the MIP CCM Database are not sufficient to maintain all of the entries for the required time, then the least-recently updated entries should preferentially be removed to make room for new entries. See 20.3.2 for a description of the use of the MIP CCM Database.

20.2 Loopback protocol

The Loopback protocol is used for Fault verification and isolation. To verify the connectivity between MEPs and MIPs, a MEP can be instructed by a system administrator to issue one or more LBMs. The LBM is initiated by a MEP with specified destination_address, priority, and drop_eligible parameters, the destination_address being the individual MAC address of another MP within the same MA as the transmitting MEP. In the case of PBB-TE and SPBM VID MAs, the destination_address parameter for an LBM is always a MAC address associated with the terminating CBP(s). In order to identify intermediate MHFs in PBB-TE and SPBM VID MAs, an additional TLV, the PBB-TE MIP TLV (21.7.5), is carried as the first TLV in an LBM, with the receiving MHF's MAC address in its MIP MAC address field (21.7.5.1). The receiving MP responds to the LBM with an LBR.

The Loopback protocol is performed by the MEP Loopback Initiator (19.2.11) and the MP Loopback Responder (19.2.10), the latter residing in either a MEP or an MHF.

20.2.1 LBM transmission

LBMs are transmitted by operator command as specified in 12.14.7.3. Each LBM transmitted contains a Loopback Transaction Identifier field (21.7.3) that is incremented with each transmission. That enables the transmitting MEP to correlate the returned LBRs with the transmitted LBMs. In a PBB-TE or SPBM VID

MA, a PBB-TE MIP TLV is carried by the transmitted LBM as the first TLV if the targeted MP is a MIP. The MIP MAC address field (21.7.5.1) in the TLV is set to the destination_address parameter of the appropriate managed object [item b) in 12.14.7.3.2]. The PBB-TE MIP TLV provides also the Reverse VID field [21.7.5.2, item f) in 12.14.7.3.2] to be used in the VID field by a MIP transmitted LBR, and, when the LBM is to be sent on a point-to-multipoint TESI, the Reverse MAC field (21.7.5.3) associated with MAC addresses to be used by the LBR. The LBM can carry an arbitrary amount of data to help diagnose faults that are sensitive to the amount or pattern of data in a frame [item d) in 12.14.7.3.2]. It can be sent with any priority or drop_eligible parameters [item e) in 12.14.7.3.2].

No means for specifying the rate at which the LBMs are to be sent is provided. A Bridge shall not transmit LBMs at a rate that would cause the queues serving that Bridge Port to overflow and drop LBMs, were there no other traffic being inserted into those queues.

20.2.2 LBM reception and LBR transmission

When an LBM is received by an MP Loopback Responder (19.2.10), it may be examined for validity and discarded if invalid. Regardless of whether the LBM is examined for validity, it shall be discarded if the source_address is a Group and not an individual MAC address. Also, if the destination_address does not match the MAC address of the receiving MP, and the MP Loopback Responder does not reside in a PBB-TE or SPBM VID MHF, the MP shall discard the LBM. If the receiving MP Loopback Responder resides in a non-PBB-TE and non-SPBM VID associated MHF and the destination_address is a group MAC address, the MHF shall discard the LBM. If the MP Loopback Responder state machine resides in a PBB-TE MEP and the received LBM carries a PBB-TE MIP TLV, the MEP shall discard the LBM. If the MP Loopback Responder state machine resides in an SPBM VID MEP and the received LBM carries a PBB-TE MIP TLV, the MEP may process the LBM if the MIP MAC address field matches the MEP's address and shall otherwise discard the LBM. PBB-TE and SPBM VID MHFs forward all received LBMs and only stop and process those that carry a PBB-TE MIP TLV containing in their MIP MAC address field the MAC address of the receiving MIP [item f) in 20.8.1]. If the frame passes these tests, the receiving MP generates an LBR and transmits it to the originating MEP. Every M_UNITDATA.indication (or EM_UNITDATA.indication) parameter and octet in the mac_service_data_unit in the LBM is copied to the LBR's M_UNITDATA.request (or EM_UNITDATA.request) with the following exceptions:

a) The source_address parameter of the received LBM is used as the destination_address parameter for the transmitted LBR. In the case of a PBB-TE MHF, this destination_address value will be overwritten by the value of the group MAC address in the Reverse MAC field of the PBB-TE MIP TLV, if this is present. In the case of a PBB-TE MEP, the destination_address parameter for the transmitted LBR is the value of the ESP-DA of the MA's ESP that has the replying MEP's MAC address [item i) in 12.14.7.1.3] in its ESP-SA field.
b) The source_address parameter for the LBR is the MAC address of the replying MP. If the MP is associated with a PBB-TE MHF, the source_address is set to the destination_address of the received LBM if this is an individual MAC address or otherwise to the value carried in the Reverse MAC field, contained in the PBB-TE MIP TLV.
c) If the LBM was received at a PBB-TE MHF and contains a PBB-TE MIP TLV, then the vlan_identifier in the LBR is set to the value in the Reverse VID field; otherwise, the vlan_identifier in the LBR is set to the value of the Primary VID associated with the replying MP [item d) in 12.14.7.1.3, item a) in 12.14.3.2.2, item c) in 12.14.5.3.2].
d) The OpCode field is changed from LBM to LBR.
e) (Only in PBB-TE MAs) The vlan_identifier for the LBR is the Primary VID [item d) in 12.14.7.1.3] associated with the replying PBB-TE MEP; otherwise, if the received LBM contained a PBB-TE MIP TLV, the value in the Reverse VID field is used as the vlan_identifier parameter.

The receiver of an LBM shall not interpret any of the other fields or TLVs in the LBM. The contents of any TLVs that do not violate the validation criteria of 20.51, but are not specified in this standard, and any valid

Organization-Specific TLV not known to the receiving MP, shall be ignored, and not interpreted, by the receiver, except that their contents shall be copied to the LBR.

NOTE—This standard provides no means for transmitting an LBM with a group MAC address. The MP Loopback Responder responds to LBMs sent to the CCM Group address because ITU-T G.8013/Y.1731 provides for transmitting such messages. See J.4.

20.2.3 LBR reception

When an LBR is received by a MEP Loopback Initiator (19.2.11), it is checked to see whether the destination_address parameter matches the MAC address of the receiving MEP, and discarded if not. Next it is checked to see whether its Loopback Transaction Identifier field matches that of a recently transmitted LBM, and the appropriate counter incremented, either the in-sequence counter [item y) in 12.14.7.1.3] or the out-of-sequence counter [item z) in 12.14.7.1.3].

If the Shared MP address model for implementing CFM is used by a particular Bridge, then as mentioned in 20.52, there is an ambiguity in the identification of the particular Up MP to which an LBR is destined. Therefore, a Bridge using this model uses a single variable for managing the Loopback Transaction Identifier fields for all MPs sharing the same MAC address, MAID, and MD Level.

The receiver of an LBR may compare its contents bit-for-bit with the remembered contents of the corresponding LBM, and increment a variable [item aa) in 12.14.7.1.3] if they do not match.

20.3 Linktrace protocol

The Linktrace protocol is performed by the MEP Linktrace Initiator (19.2.12), associated with a single MEP, and the Linktrace Responder (19.6) associated with a Bridge.

A Linktrace Message (LTM) is transmitted by a MEP Linktrace Initiator in order to perform path discovery and fault isolation. The LTM carries a target MAC address. It is carried in a frame, with a destination_address taken from Table 8-19 according to the MD Level of the transmitting MEP, or the ESP-DA field of the appropriate ESP in the case of a PBB-TE MA (20.31.1), or an individual or group address in the case of an SPBM VID MA, and is relayed as such through the bridged network until it reaches an MP at the appropriate MD Level. That MP intercepts the LTM and deflects it to a Bridge's Linktrace Responder. The Linktrace Responder determines whether its Bridge's MAC Relay Entity would forward an ordinary data frame with the specified target MAC address and vlan_identifier to an egress Bridge Port, or would filter or flood it. If the single egress port is found, or if the receiving MP is the terminating MP, or if the MP is associated with a PBB-TE MA or an SPBM VID MA, the Linktrace Responder sends a unicast Linktrace Reply (LTR) to the originator of the LTM, whose MAC address was also carried as payload in the LTM. The LTR is sent after a random delay in the range $0 < \text{delay} \leq 1$ s, to mitigate the load on the originating MEP. In addition, if the MP through which the LTM was received was an MHF, the Linktrace Responder forwards an altered version of the LTM in the direction of the target MAC address. The MEP Linktrace Initiator that originated the initial LTM collects the LTRs. These provide sufficient information to construct the sequence of MPs that would be traversed by a data frame sent to the target MAC address.

Path discovery in a connectionless environment is more challenging than a connection-oriented environment. In Bridged Networks, it can be especially challenging, since the MAC address of the target of an LTM can be deleted from the FDB by a TCN immediately after a network topology change, and ages out and is deleted a few minutes (Max Age) after last being learned when a fault results in isolating the target from the MEP originating the LTM.

CFM offers three ways to address the problem of ageing out MAC addresses:

a) Launching the Linktrace protocol automatically, immediately following the detection of a fault, such that it gets exercised within the Max Age window.

b) Maintaining information about the destination MP at the intermediate points along the path by using the optional MIP CCM Database, 19.3.9 and 20.1.3.

c) Maintaining normal path information by issuing periodic LTMs during normal operations.

NOTE—Periodic LTMs allow a system administrator to determine the MIPs along the paths among MEPs during normal operations, thus establishing a baseline for subsequent fault isolation. However, triggering LTMs at rates approaching the CCM transmission interval could overwhelm the Bridges' ability to process CFM PDUs. See also 22.5.

20.3.1 LTM origination

LTMs are transmitted by a MEP Linktrace Initiator in response to an operator command (12.14.7.4). The nextLTMtransID [item b) in 12.14.7.4.3, 20.41.1] of each LTM transmitted is retained for at least 5 s after the LTM is transmitted. The LTM Transaction Identifier values transmitted by a given MEP are unique over this time period in order to match LTRs returned by slow MPs to the LTM that triggered the slow LTR. Initializing the nextLTMtransID to a random value[35] and incrementing it once per LTM transmitted satisfies this criterion. For each LTM transmitted, the MEP Linktrace Initiator creates an entry in a Linktrace database (20.41.2). This entry is indexed by nextLTMtransID for retrieval when a corresponding LTR is received.

The transmitting Bridge can maintain a separate sequence of LTM Transaction Identifiers per MEP if multiple MEPs in the same service instance and at the same MD Level have different MAC addresses, but uses a common sequence of LTM Transaction Identifiers for MEPs that share both of these characteristics.

In the case of a VID-based MA, the destination_address of an LTM is the group MAC address reserved for LTMs and appropriate to the MD Level of the originating MEP according to Table 8-19. In the case of a PBB-TE MEP, the destination_address of an LTM is the entry in the ESP-DA field of the 3-tuple of the MA's ESP that has the MEP's MAC address in its ESP-SA field. In the case of an SPBM VID MEP, the destination_address of an LTM is the individual B-MAC address of a remote system or the SPBM group MAC address (27.15) associated with an I-SID associated with the source MEP.

The Target MAC Address field [item c) in 12.14.7.4.2, 21.8.6] in the LTM can be any individual MAC address. However, since MEPs are required to periodically transmit CCMs, a MEP's MAC address is likely to be known to the MIPs along the path. Conversely, a MIP's MAC address, because the MIP does not initiate any CFM PDUs, can be unknown to intermediate Bridges unless it has recently replied to an LBM or LTM.

In the case of a PBB-TE MA, a PBB-TE MIP TLV is carried by the LTM, containing the Reverse VID [21.7.5.2, item e) in 12.14.7.4.2], to be used in the VID field by a MIP transmitted LTR, and, when the LTM is to be sent on a point-to-multipoint TESI, the Reverse MAC field (21.7.5.3) associated with MAC addresses to be used by the corresponding LTRs. The MIP MAC address field (21.7.5.1) in a PBB-TE MIP TLV associated with an LTM is null.

The MEP Linktrace Initiator in a Down MEP transmits the LTM through its Active SAP, toward the LAN attached to its Bridge Port. The MEP Linktrace Initiator in an Up MEP transmits the LTM through its MEP LTI SAP to its own Bridge's Linktrace Responder. That Linktrace Responder handles the LTM as described in 20.3.2. The Linktrace Responder can forward the LTM through the LOM Linktrace SAP and can respond through the MEP LTI SAP with an LTR. Thus, when an LTM is initiated in an Up MEP, the originating Bridge is the first hop.

[35] For this purpose, a pseudo-random value is sufficient, provided that the same value is not produced each time a system is reinitialized.

20.3.2 LTM reception, forwarding, and replying

An LTM at a particular MD Level is forwarded as an ordinary data frame until it encounters a MEP at an equal or higher MD Level, or an MHF at an equal MD Level. A MEP at a higher MD Level discards the LTM without further processing. An MP at an equal MD Level directs the LTM to its Bridge's Linktrace Responder. Since, for a given MD Level, different Bridge Ports on a given Bridge can be configured with MHFs, MEPs, both, or neither, an LTM can be both forwarded as ordinary data and processed by the Bridge's Linktrace Responder. An LTM that is originated by an Up MEP is forwarded directly to its Bridge's Linktrace Responder and not through the MEP's Active SAP toward the Frame filtering process.

The Linktrace Responder is responsible for processing and forwarding LTMs, and for replying to them with LTRs. All LTMs are subject to the validation criteria of 20.51.4; invalid or incorrectly addressed LTMs are discarded without further processing. After processing the LTM, the Linktrace Responder can return an LTR through the SAP on which the LTM was received and can forward at most one altered copy of the received LTM through an LOM on a different Bridge Port. It never forwards an LTM past a MEP at the LTM's own MD Level or higher, i.e., a MEP that bounds the LTM's MA. An LTM carries an LTM TTL field (21.8.4) that is decremented each time the LTM passes through a Linktrace Responder. The LTM is not forwarded if this field is 0 or 1 when the LTM is received.

The Linktrace Responder replies to the LTM if:

a) An ordinary data frame, with the same vlan_identifier as the LTM, a destination_address equal to the Target MAC Address field (21.8.6) of the LTM and received on the same Bridge Port as the LTM, would be forwarded through exactly one other Bridge Port (or to just the Management Port); or
b) The UseFDBonly bit of the Flags field of the LTM is 0, the Target MAC Address field (21.8.6) of the LTM is found in the Bridge's MIP CCM Database (19.3.10), and that entry in the MIP CCM Database identifies a Bridge Port (or the Management Port), other than the one on which the LTM was received; or
c) The MAC address of the MP that received the LTM equals the Target MAC Address field of the LTM;

and

d) LTM TTL field is nonzero when the LTM is received.

The single output Port identified in the preceding item a) or item b) is called the Egress Port. The Linktrace Responder forwards a copy of the LTM through the LOM on the Egress Port, with a new source_address parameter and the LTM TTL field decremented by 1, only if all of the following conditions are met:

e) An LTR was generated for the reasons specified in the preceding item a) or item b), but not item c);
f) The LTM was received via an MHF Linktrace SAP or a MEP LTI SAP, and not a MEP Linktrace SAP;
g) The Egress Port does not have a MEP at or above the LTM's MD Level; and
h) The received LTM TTL field was greater than 1.

The source_address parameter in the forwarded LTM does not change if the MA is associated to a TESI.

NOTE 1—When tracing the path to a known MAC address, all of the Bridges on a shared medium will receive the LTM. Making transmission of the LTR and forwarding of the LTM conditional on the FDB query ensures that at most one of those Bridges will reply. Similarly an LTM can be flooded, through a region of the network that has not yet learned the target MAC address, without provoking a storm of LTRs.

LTMs are forwarded immediately in order to minimize the time required to complete a Linktrace operation. LTRs are enqueued for delivery at a later time. If the LTM was received by a Down MEP or a Down MHF, the LTR includes a Reply Ingress TLV (21.9.8) describing that MP. If not received by a Down MEP, and if the Egress Port has an Up MEP or Up MHF configured for the LTM's MA, the LTR includes a Reply Egress

TLV (21.9.9). These TLVs report, to the originating MEP, the MIPs and/or the MEP along the path to the targeted MAC address.

If an LTM is forwarded to a shared medium LAN, and if one or more of the other Bridges attached to that LAN have only two Bridge Ports forwarding data for the LTM's vlan_identifier (including that shared medium), and if the MAC address in the LTM's Target MAC Address field (21.8.6) is not present in those Bridge's FDBs (or if the targeted MAC address is present in more than one Bridge's MIP CCM Database), then more than one of those receiving Bridges can respond to the LTM with an LTR. Also, an anomaly in the operation of Bridge or LAN, e.g., an FDB is recording its information incorrectly, can cause LTR responses along multiple paths.

The Reply TTL field in the LTR is sufficient for the originating MEP Linktrace Initiator to order the LTRs returned along a single path. The LTMs (21.8) also include the LTM Egress Identifier TLV (21.8.8). The LTRs (21.9) also include the LTR Egress Identifier TLV (21.9.7). The information in these TLVs allows the originating MEP to unambiguously construct the tree of paths taken by the LTM, if LTRs are returned along multiple paths.

NOTE 2—If an MA cannot be configured to transmit CCMs more quickly than Max Age causes MAC addresses to be removed from the Bridges' FDBs, then the best practice for the system administrator is to trigger an LTM transmission only after triggering a few LBMs to the target MAC address. This helps to ensure that the target MAC address is known to the intermediate Bridges, so that the LBM will return a result, and so that LTRs will be returned only along a single path.

NOTE 3—If unusual conditions prompt responses along multiple paths, the delay in transmitting the LTR reduces the chance that the originating MEP's receiving capabilities will be overwhelmed by the returned LTRs.

NOTE 4—The forwarded LTM uses, as its source address, the address of the MP through which the LTM is forwarded, not the source address of the original LTM. This means that a Bridge's Linktrace Responder need not be fully synchronized with its Relay Entity, as the latter can change the active topology rapidly without the risk of an adjacent Bridge learning the wrong direction for the source MAC address from an LTM. However, in the case of TESIs, the forwarded LTM simply uses the source address of the original LTM since the previous considerations do not apply in a PBB-TE Region. The LTM TTL field ensures that an LTM that is being processed while the active topology is changing will not be forwarded in a persistent loop.

The MEP Linktrace Initiator ignores any TLVs received in an LTR that do not violate the validation criteria of 20.51, but are not specified in this standard, and it ignores any valid Organization-Specific TLV not known to it. Except as otherwise specified in 20.47.3 and 20.47.4, all TLVs, whether known or ignored by the Linktrace Responder, are copied from the received LTM to the forwarded LTM, and from the received LTM to the LTR.

NOTE 5—Forwarding all unknown TLVs in both the LTM and the LTR enables future revisions of this standard, and designers of Organization-Specific TLVs, to add new capabilities.

20.3.3 LTR reception

LTRs are transmitted by a Linktrace Responder in response to a received LTM and returned in a unicast frame to the MEP Linktrace Initiator that originated the LTM. The MEP Linktrace Initiator validates the received LTR, discarding it if invalid, if the destination_address parameter does not match the MAC address of the Bridge Port on which the MEP resides, or if the LTR Transaction Identifier field does not match any of those stored in the MEP's Linktrace database (20.41.2), created when the LTM was originated.

Each validated LTR triggers the creation of a new entry in the Linktrace database, accessible as a managed object through the Read Linktrace Reply command (12.14.7.5). If no entry exists in the Linktrace database for this MEP, corresponding to the LTR Transaction Identifier field, the MEP Linktrace Initiator creates a new entry, with an index value [item c) in 12.14.7.5.2] of 1. If an entry does exist matching that field, it creates a new entry, with an index value one greater than the last matching LTR. In either case, the MEP Linktrace Initiator stores the contents of the LTR in this new entry.

See J.5 for a description of a method to reconstruct the path(s) taken by an LTM, based on the information in the Linktrace database.

20.4 CFM state machines

The relationships among a MEP's state machines are illustrated in Figure 20-1. That figure uses conventions similar to those of 13.24 and of Figure 13-13: open arrows denote variables that are set by one state machine and both read and set by another; closed arrows denote variables that are set by the owning state machine, and only read by other state machines. Not included in Figure 20-1 are the MEP Continuity Check Initiator state machine, the MP Loopback Responder state machine used in the MEP, and all of the MHF and Linktrace Responder state machines, because they operate independently.

20.5 CFM state machine timers

The timer variables declared in this subclause are part of the specification of the operation of CFM. The accompanying descriptions of their meaning and use are provided to aid in the comprehension of the protocol only and are not part of the specification.

One instance of the following shall be implemented:

a) LTFwhile (20.5.1)

One instance of the following shall be implemented per MEP:

b) CCIwhile (20.5.2)
c) errorCCMwhile (20.5.3)
d) xconCCMwhile (20.5.4)
e) LBIwhile (20.5.5)
f) FNGwhile (20.5.6)

One instance of the following shall be implemented per PBB-TE MEP implementing the Traffic field (21.6.1.4):

g) mmCCMwhile (20.5.7)
h) mmLocwhile (20.5.8)
i) mmFNGwhile (20.5.9)

One instance per MEP of the following shall be implemented for each remote MEP in the MEP's MA (those MEPs in the MA other than the MEP, itself):

j) rMEPwhile (20.5.10)

The "granularity" of a timer variable is the periodicity with which it is decremented.

20.5.1 LTFwhile

A timer variable used by the LTR Transmitter state machine to time out the expected transmission of LTRs.

20.5.2 CCIwhile

Timer counter for transmitting CCMs. CCIwhile has a granularity finer than or equal to 1/4 of the time represented by the CCMinterval variable.

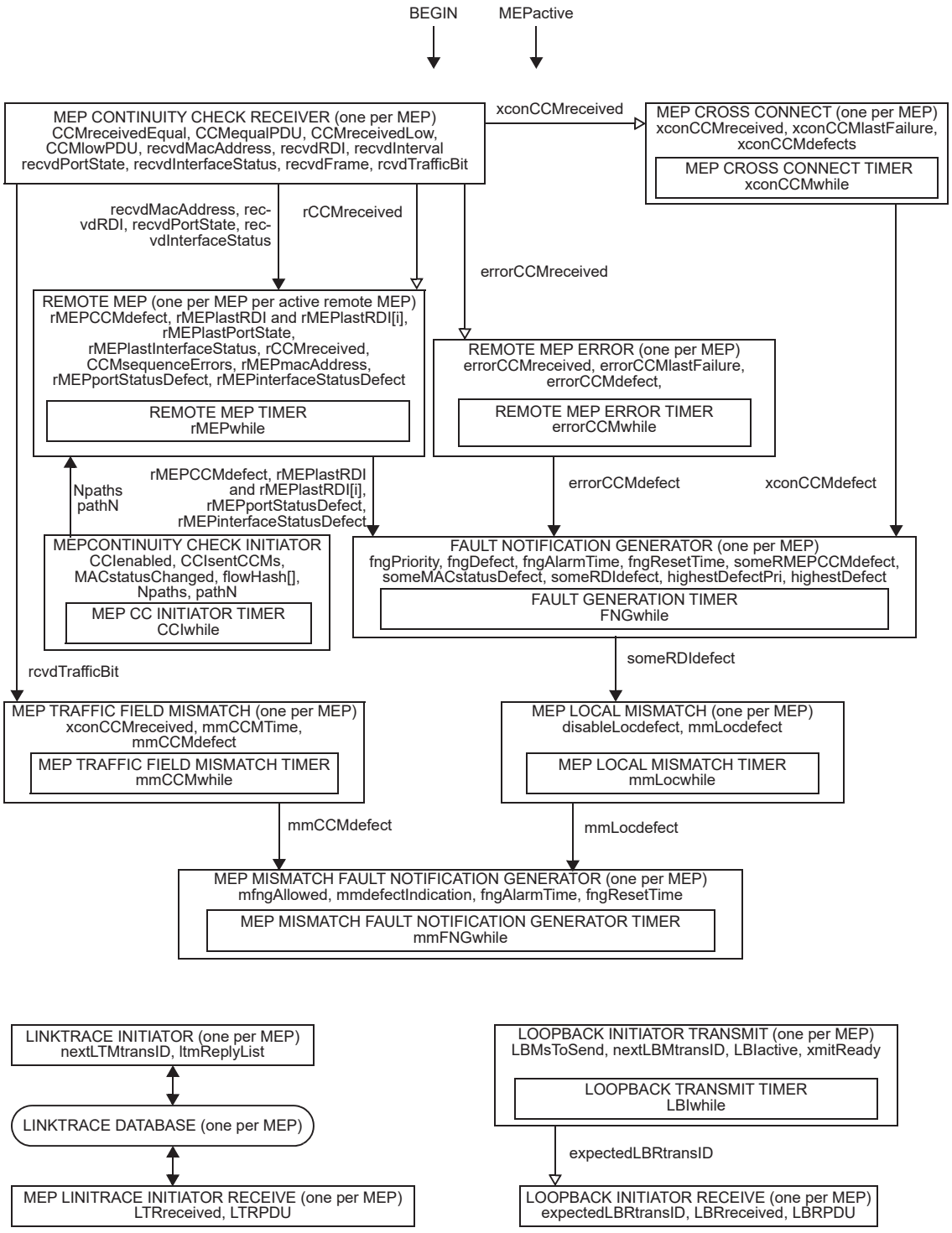


Figure 20-1—MEP state machines—overview and relationships

20.5.3 errorCCMwhile

Timer counter for timing out invalid CCMs. errorCCMwhile has a granularity finer than or equal to 1 ms.

20.5.4 xconCCMwhile

Timer counter for timing out cross connect CCMs. xconCCMwhile has a granularity finer than or equal to 1 ms.

20.5.5 LBIwhile

A timer variable used by the MEP Loopback Initiator transmit state machine to time out the expected reception of LBRs.

20.5.6 FNGwhile

A timer variable used by the MEP Fault Notification Generator state machine to wait for defects to stabilize and disappear.

20.5.7 mmCCMwhile

Timer counter for declaring mismatch defects based on the received Traffic field. mmCCMwhile has a granularity finer than or equal to 1 ms.

20.5.8 mmLocwhile

Timer counter for declaring mismatch defects based on inconsistencies in locally declared values (20.9.9). mmLocwhile has a granularity finer than or equal to 1 ms.

20.5.9 mmFNGwhile

A timer variable used by the MEP Mismatch Fault Notification Generator state machine (20.40) to wait for defects to stabilize and disappear.

20.5.10 rMEPwhile

Timer counter for timing out CCMs. rMEPwhile has a granularity finer than or equal to 1/4 of the time represented by the CCMinterval variable. A Bridge shall not set rMEPCCMdefect within (3.25 × CCMtime(CCMinterval)) seconds of the receipt of a CCM, and shall set rMEPCCMdefect within (3.5 × CCMtime(CCMinterval)) seconds after the receipt of the last CCM. This variable is readable as a managed object [item c) in 12.14.7.6.3].

NOTE—In order to generate a Defect upon the loss of three CCMs, but not generate a Defect when only two CCMs have been lost, a minimum resolution is required for rMEPwhile. The granularity specified for rMEPwhile, when used with the state machine in Figure 20-5, generates a Defect in a maximum of (3.5 × CCMtime(CCMinterval)) seconds, and a minimum of (3.25 × CCMtime(CCMinterval)) seconds.

20.6 CFM procedures

The following procedure is global to the system:

a) CCMtime() (20.6.1)

20.6.1 CCMtime()

CCMtime() takes, as a parameter, a value of the form used in the CCMinterval variable (20.8.1) and the CCM Interval field in a CCM PDU (21.6.1.3). It returns, as a value, the corresponding time interval, in the form used by the CCIwhile or rMEPwhile timer, as appropriate (20.5.2, 20.5.10).

20.7 Maintenance Domain variable

The following variable is local to a single Maintenance Domain and is accessible by more than one state machine:

a) mdLevel (20.7.1)

20.7.1 mdLevel

The integer MD Level of the Maintenance Domain. This variable is available as a managed object [item b) in 12.14.5.1.3].

20.8 MA variables

The following variable is local to a single MA and is accessible by more than one state machine:

a) CCMinterval (20.8.1)

20.8.1 CCMinterval

The configured time between CCM transmissions. The value configured for this variable shall be one of the nonzero values in Table 21-15. This variable is available as a managed object [item e) in 12.14.6.1.3].

20.9 MEP variables

The following variables are local to a single MEP and are accessible by more than one state machine:

a) MEPactive (20.9.1)
b) enableRmepDefect (20.9.2)
c) MAdefectIndication (20.9.3)
d) allRMEPsDead (20.9.4)
e) lowestAlarmPri (20.9.5)
f) presentRDI (20.9.6)
g) MEPprimaryVID (20.9.7)

The following variables may be present only in PBB-TE MAs, are local to a single PBB-TE MEP and are accessible by more than one state machine:

h) presentTraffic (20.9.8)
i) presentmmLoc (20.9.9)

The following variables are present only in Infrastructure Segment MAs, are local to a single Infrastructure Segment MEP, and are accessible by more than one state machine:

j) ISpresentTraffic (20.9.10)
k) ISpresentmmLoc (20.9.11)

The following variable is present only in ECMP path MAs, is local to a single ECMP path MEP, and is accessible by more than one state machine:

l) EpMEP (20.9.12)

20.9.1 MEPactive

A Boolean indicating the administrative state of the MEP. True indicates that the MEP is to function normally, and false that it is to cease functioning. This variable is available as a managed object [item e) in 12.14.7.1.3].

NOTE—MEPactive controls the BEGIN input to the MEP state machines. Therefore, for any MEP that has been completely configured, it is as much an indication of the operative state of the MEP as a control over that state.

20.9.2 enableRmepDefect

A Boolean indicating whether frames on the service instance monitored by this MEP's MA are enabled to pass through this Bridge Port by the spanning tree protocol (Clause 13) and VLAN topology management (Clause 11). Set true either if they are enabled, or if the MEP is not associated with a single value of the Port State and VID member set, else false. In a Bridge, the value of enableRmepDefect is determined from the Port State (8.4) of the spanning tree instance that controls the MEP's Primary VID, and that VID's member set (8.8.10), as shown in Table 20-2. This variable also controls the value output in the Port Status TLV (21.5.4).

Table 20-2—Deriving enableRmepDefect and Port Status TLV in a Bridge

Port State (8.4)	Bridge Port in Primary VID's member set	Port Status TLV (21.5.4)	enableRmepDefect
Disabled, blocked, listening, broken, discarding [a] or learning		psBlocked	False
Forwarding	No	psBlocked	False
	Yes	psUp	True

[a] "Discarding" is used in place of the values disabled, blocked, listening, or broken defined in IETF RFC 4318.

A MEP that is:

a) Configured in an MA that is not associated with a VID
b) On a Bridge that is running multiple instances of the spanning tree
c) On a Bridge Port that is not excluded by Static VLAN Registration Entries from membership in VIDs belonging to more than one spanning tree instance

can be unable to generate an unambiguous value for the Port Status TLV, because different MSTIs can be in different Port States. For a MEP in that position, enableRmepDefect is always true.

20.9.3 MAdefectIndication

A Boolean indicating the operational state of the MEP's MA. True indicates that at least one of the remote MEPs configured on this MEP's MA has failed, and false indicates either that all are functioning, or that the MEP has been active for less than the time-out period. MAdefectIndication is true whenever an enabled defect is indicated. That is, MAdefectIndication is true if and only if, for one or more of the variables someRDIdefect, someRMEPCCMdefect, someMACstatusDefect, errorCCMdefect, or xconCCMdefect, that variable is true and the corresponding priority of that variable from Table 20-1 is greater than or equal to the value of the variable lowestAlarmPri.

20.9.4 allRMEPsDead

A Boolean indicating that this MEP is receiving none of the remote MEPs' CCMs. allRMEPsDead is the logical AND of all of the rMEPCCMdefect variables.

20.9.5 lowestAlarmPri

An integer value indicating the lowest defect priority (see Table 20-1) that can trigger the generation of a Fault Alarm. This variable is a managed object [item k) in 12.14.7.1.3].

20.9.6 presentRDI

A Boolean value indicating the state of the RDI bit in CCMs transmitted by this MEP. presentRDI is true if and only if one or more of the variables someRMEPCCMdefect, someMACstatusDefect, errorCCMdefect, or xconCCMdefect is true, and if the corresponding priority of that variable, from Table 20-1, is greater than or equal to the value of the variable lowestAlarmPri.

20.9.7 MEPprimaryVID

An integer specifying a VID, one of the VIDs assigned to the MEP's MA, which is to be used as the Primary VID for this MEP. This variable is related to the managed object item d) in 12.14.7.1.3. It is not necessarily numerically equal to that object, however. MEPprimaryVID always contains the numerical value of the Primary VID. The managed object may contain 0, to indicate that the Primary VID is that of the MEP's MA, or contain the Primary VID itself, if the MA's VID is overridden for this particular MEP. In the case of a MEP associated with a PBB-TE MA, this value is not directly configurable but it takes the value of the ESP-VID field in the 3-tuple of the PBB-TE MA's ESP that has the MEP's MAC address in its ESP-SA field.

20.9.8 presentTraffic

A Boolean value indicating if at least one backbone service instance is configured to use the TESI's ESP upon which this PBB-TE MEP is transmitting CCMs. presentTraffic is TRUE if and only if the Backbone Service Instance table, of the CBP associated with this MEP, contains an entry that has in its B-VID and Default Backbone Destination fields the values of ESP-VID and ESP-DA of the monitored TESI's ESP that originates at the MEP.

20.9.9 presentmmLoc

presentmmLoc is the logical AND of presentRDI (20.9.6) and presentTraffic (20.9.8).

20.9.10 ISpresentTraffic

A Boolean value indicating if at least one TESI protected by the IPG is configured to use the segment monitored by the Infrastructure Segment MEP. ISpresentTraffic is TRUE if and only if the port upon which this MEP is configured is the outbound port of the entry in the FDB corresponding to the TESI protected by the IPG.

20.9.11 ISpresentmmLoc

ISpresentmmLoc is the logical AND of presentRDI (20.9.6) and ISpresentTraffic (20.9.10).

20.9.12 EpMEP

Boolean. This variable is used to condition actions related to ECMP path MEPs. It is true for ECMP path MEPs and false otherwise.

20.10 MEP Continuity Check Initiator variables

The following variables are local to the MEP Continuity Check Initiator state machine:

a) CCIenabled (20.10.1)
b) CCIsentCCMs (20.10.2)
c) MACstatusChanged (20.10.3)
d) Npaths (20.10.4)
e) flowHash[] (20.10.5)
f) pathN (20.10.6)
g) CCMcnt (20.10.7)

20.10.1 CCIenabled

Controls the transmission of CCMs. When set to true, CCMs are transmitted. When set to false, CCM transmission ceases. This variable is available as a managed object [item g) in 12.14.7.1.3].

20.10.2 CCIsentCCMs

Integer value. CCIsentCCMs is initialized to 1 when the MEP is created and may be used thereafter by xmitCCM() to fill the Sequence Number field of a transmitted CCM. This variable is available as a managed object [item w) in 12.14.7.1.3].

20.10.3 MACstatusChanged

Boolean. MACstatusChanged triggers the transmission of one extra CCM. If the Port Status TLV (21.5.4) or Interface Status TLV (21.5.5) is being transmitted by the MEP, and if CCMinterval indicates a transmission interval of 10 s or slower, MACstatusChanged is set to true whenever the value reported in either of those two TLVs changes. MACstatusChanged is reset to false by the MEP Continuity Check Initiator state machine.

20.10.4 Npaths

Integer value. The number of paths being tested by this MEP. The value is 1 (default) except in the case of ECMP path MEPs that may test a set of paths by using one destination address and different flow hash values.

20.10.5 flowHash[ ]

This variable is applicable only for ECMP path MEPs.

Array of 16-bit values. A set of flow hash values used to test a set of paths to a given destination address. The default is a single NULL value.

20.10.6 pathN

This variable is applicable only for ECMP path MEPs.

Integer value in the range 0..(Npaths – 1) and all arithmetic using this variable is modulo Npaths. The index of the current path (flow hash) being used in CCMs sent from the MEP. This value is shared with the Remote MEP state machine to enable correlation of received RDIs with the cycle of paths being tested.

20.10.7 CCMcnt

This variable is applicable only for ECMP path MEPs.

Integer value in the range 0..3 and all arithmetic using this variable is modulo 4. This variable is a counter used to send each flowHash[] value in four successive CCMs.

20.11 MEP Continuity Check Initiator procedures

The following procedure is local to the MEP Continuity Check Initiator state machine:

a) xmitCCM() (20.11.1)

20.11.1 xmitCCM()

xmitCCM() constructs and transmits a CCM on the Active SAP using an M_UNITDATA.request as follows:

a) Sets the destination_address parameter to the value from Table 8-18 corresponding to the MEP's MD Level. In the case of a PBB-TE associated MEP, SPBM path MEP, or ECMP path MEP, the destination_address parameter is set to the MAC address indicated by the ESP-DA field of the ESP having in its ESP-SA field the MAC address of the MEP. In the case of an SPBM VID MEP (27.18.1), the destination_address parameter is set to the SPBM group MAC address (27.15) associated with the source MEP and the SPBM default I-SID. In the case of an SPBM group MEP, the destination_address parameter is set to the SPBM group MAC address (27.15) assigned to the source MEP's CBP for the SPBM group MA's I-SID.
b) Sets the source_address parameter to the MAC address of the MEP [item i) in 12.14.7.1.3].
c) Sets the priority parameter according to the MEP's managed objects [item h) in 12.14.7.1.3].
d) Sets the drop_eligible parameter to false.
e) In the case of ECMP with flow filtering, the time_to_live and flow_hash parameters must be set. The time_to_live parameter is set to the TTL Value in the Flow Filtering Control Table entry on the CBP for the source MEP's VID [item d) in 12.16.5.5.2]. In the case of an SPBM VID MEP or SPBM group MEP, the flow_hash parameter is set to zero. In the case of an ECMP path MEP, the flow_hash parameter is set to the value of flowHash[pathN].
f) Places the MEP's MD Level (20.7.1) in the MD Level field (21.4.1).
g) Fills the CCM Interval field (21.6.1.3) with the CCM transmission interval [20.8.1, item e) in 12.14.6.1.3].
h) Fills the RDI field (21.6.1.1) with the presentRDI variable (20.9.6).
i) Should copy CCIsentCCMs (20.10.2) to the Sequence Number field of the CCM (21.6.3), else copies 0 into that field.
j) Places the MEP's MAID into the appropriate fields of the CCM [item a) in 12.14.1.2.2, item b) in 12.14.5.3.2, and 21.6.5.1 through 21.6.5.6].
k) Places the MEP's MEPID [item g) in 12.14.6.1.3] into the Maintenance association Endpoint Identifier field (21.6.4).
l) As controlled by the managed objects item e) in 12.14.3.1.3, item d) in 12.14.5.1.3, and item d) in 12.14.6.1.3, places a Sender ID TLV (21.5.3) in the CCM, identifying the transmitting system.
m) Optionally, places a Port Status TLV (21.5.4) in the CCM, reporting the status of the Bridge Port.
n) Optionally, places an Interface Status TLV (21.5.5) in the CCM, reporting the status of the Bridge Port.

o) Increments CCIsentCCMs by 1, wrapping around from 232 – 1 to 0.
p) Only in the case of a PBB-TE MEP, optionally fills the Traffic field (21.6.1.4) with the presentTraffic variable (20.9.8).
q) Only in the case of an Infrastructure Segment MEP, optionally fills the Traffic field (21.6.1.4) with the value ISpresentTraffic (20.9.10).

20.12 MEP Continuity Check Initiator state machine

Each MEP Continuity Check Initiator (19.2.9) instantiates one MEP Continuity Check Initiator state machine. The MEP Continuity Check Initiator state machine implements the function specified by the state diagram in Figure 20-2, the variable declarations in 20.10 and the procedures in 20.11.

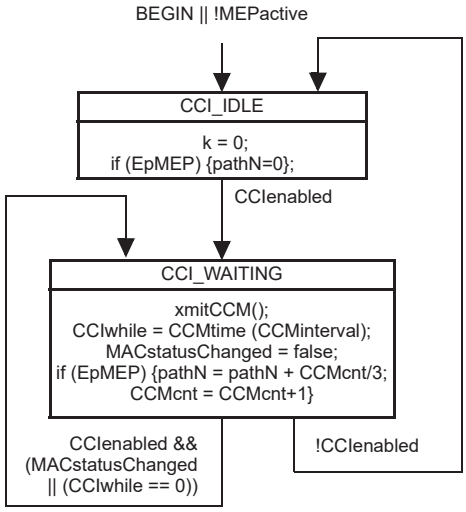


Figure 20-2—MEP Continuity Check Initiator state machine

NOTE—Figure 20-2 indicates that the setting of MACstatusChanged causes CCIwhile to be reset and thus changes the phase of the CCM transmission cycle. An alternative formulation of state machine could transmit an extra CCM, but not reset CCIwhile. Whether setting MACstatusChanged in a MEP causes CCIwhile to be reset is not specified by this standard.

20.13 MHF Continuity Check Receiver variables

The following variables are defined for the MHF Continuity Check Receiver:

a) MHFrecvdCCM (20.13.1)
b) MHFCCMPDU (20.13.2)

20.13.1 MHFrecvdCCM

A Boolean value set to true by the MHF OpCode Demultiplexer (19.3.6) when a CCM at the MHF's MD Level is received. Cleared by the MHF Continuity Check Receiver state machine.

20.13.2 MHFCCMPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the CCM PDU received by the MHF OpCode Demultiplexer (19.3.6) when a CCM at the MHF's MD Level is received.

20.14 MHF Continuity Check Receiver procedures

The following procedure is defined for the MHF Continuity Check Receiver:

a) MHFprocessCCM() (20.14.1)

20.14.1 MHFprocessCCM()

MHFprocessCCM() shall validate the received CCM according to 20.51.4 and discard the received CCM if invalid. Otherwise, MHFprocessCCM() records the FID, source_address, and Port number of the received CCM in the MHF's MIP CCM Database.

20.15 MHF Continuity Check Receiver state machine

The MHF Continuity Check Receiver state machine implements the functions specified by the state diagram in Figure 20-3, using the variables in 20.13 and procedures in 20.14.

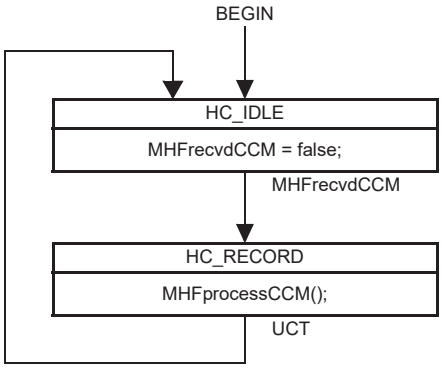


Figure 20-3—MHF Continuity Check Receiver state machine

20.16 MEP Continuity Check Receiver variables

The following variables are defined for the MEP Continuity Check Receiver:

a) CCMreceivedEqual (20.16.1)
b) CCMequalPDU (20.16.2)
c) CCMreceivedLow (20.16.3)
d) CCMlowPDU (20.16.4)
e) recvdMacAddress (20.16.5)
f) recvdRDI (20.16.6)
g) recvdInterval (20.16.7)
h) recvdPortState (20.16.8)
i) recvdInterfaceStatus (20.16.9)
j) recvdSenderId (20.16.10)
k) recvdFrame (20.16.11)
l) CCMsequenceErrors (20.16.12)

The following variable is present only in PBB-TE MEP or Infrastructure Segment MEP that supports the Traffic field (21.6.1.4), is local to a single PBB-TE MEP or Infrastructure Segment MEP, and is accessible by the MEP Mismatch state machines (20.26):

m) rcvdTrafficBit (20.16.13)

20.16.1 CCMreceivedEqual

Boolean flag. Set by the MEP Equal OpCode Demultiplexer (19.2.7) when a CCM at the MEP's MD Level is received. Cleared by the MEP Continuity Check Receiver state machine.

20.16.2 CCMequalPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the CCM PDU received by the MEP Equal OpCode Demultiplexer (19.2.7) when a CCM at the MEP's MD Level is received.

20.16.3 CCMreceivedLow

Boolean flag. Set by the MEP Low OpCode Demultiplexer (19.2.7) when a CCM below the MEP's MD Level is received. Cleared by the MEP Continuity Check Receiver state machine.

20.16.4 CCMlowPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the CCM PDU received by the MEP Low OpCode Demultiplexer (19.2.7) when a CCM below the MEP's MD Level is received.

20.16.5 recvdMacAddress

Set by the MEPprocessEqualCCM() procedure with the source_address from the last-received CCM from the remote MEP served by this copy of the Remote MEP state machine.

20.16.6 recvdRDI

Boolean flag. Set by MEPprocessEqualCCM() according to the RDI field of the last-received valid CCM.

20.16.7 recvdInterval

Timer counter indicating timer counter equivalent of the value encoded in the CCM Interval field of a received CCM. Set by MEPprocessEqualCCM().

20.16.8 recvdPortState

(optional) Enumerated variable indicating the contents of the Port Status TLV (21.5.4) of the last-received valid CCM or psNoPortStateTLV: Indicates either that no CCM has been received or that no Port Status TLV was present in the last CCM received. Set by MEPprocessEqualCCM().

20.16.9 recvdInterfaceStatus

(optional) Enumerated variable indicating the contents of the Interface Status TLV (21.5.5) of the last-received valid CCM or isNoInterfaceStatusTLV: Indicates either that no CCM has been received or that no Interface Status TLV was present in the last CCM received. Set by MEPprocessEqualCCM().

20.16.10 recvdSenderId

(optional) Enumerated variable indicating the contents of the Sender ID TLV (21.5.3) of the last-received valid CCM or isNoSenderIdTLV: Indicates either that no CCM has been received or that no Sender ID TLV was present in the last CCM received. Set by MEPprocessEqualCCM().

20.16.11 recvdFrame

Octet string holding a frame received by MEPprocessEqualCCM(). recvdFrame can be reconstructed either from the M_UNITDATA.indication information presented to the MEP through the Active SAP, or from the EM_UNITDATA.indication presented to the EISS Multiplex Entity. The size of recvdFrame indicates the size of the reconstructed frame. When set to the value NULL, the size of recvdFrame is 0.

20.16.12 CCMsequenceErrors

The total number of out-of-sequence CCMs received from all remote MEPs. This variable is readable as a managed object [item v) in 12.14.7.1.3].

20.16.13 rcvdTrafficBit

Boolean flag that is applicable only for PBB-TE MEPs and Infrastructure Segment MEPs supporting the Traffic field (21.6.1.4). Set by MEPprocessEqualCCM() according to the Traffic field of the last-received valid CCM.

20.17 MEP Continuity Check Receiver procedures

The following procedures are defined for the Continuity Check Receiver:

a) MEPprocessEqualCCM() (20.17.1)
b) MEPprocessLowCCM() (20.17.2)

20.17.1 MEPprocessEqualCCM()

Called by the MEP Continuity Check Receiver state machine whenever a CCM is received at the MD Level of the MEP. MEPprocessEqualCCM() processes the CCM contained in CCMequalPDU as follows:

a) MEPprocessEqualCCM() shall process the CCM according to 20.51.4.2, and may validate the CCM according to 20.51.4.3, and discard any frames that fail the validation.
b) Otherwise, if the MAID of the received CCM does not exactly match the MAID configured in the receiving MEP [item a) in 12.14.1.2.2, item b) in 12.14.5.3.2], then MEPprocessEqualCCM() sets xconCCMreceived (20.23.1) true (this procedural step being optional in the case of a PBB-TE MEP or Infrastructure Segment MEP, SPBM path MEP, or ECMP path MEP), reconstructs the frame containing the CCM into recvdFrame, and places a timer counter value into recvdInterval corresponding to the value of the CCM Interval field in the received CCM.
c) Otherwise, if:
    1) MEPID in the received CCM is not configured in the receiving MEP [item g) in 12.14.6.1.3], or
    2) MEPID in the received CCM matches the MEPID of the receiving MEP [item b) in 12.14.6.3.2], or
    3) CCM Interval field in the received CCM does not match that configured for the receiving MEP [item e) in 12.14.6.1.3],

then MEPprocessEqualCCM() sets errorCCMreceived (20.21.1) true, reconstructs the frame containing the CCM into recvdFrame, and places a timer counter value into recvdInterval corresponding to the value of the CCM Interval field in the received CCM.

d) Otherwise, MEPprocessEqualCCM()
   1) Copies the source_address parameter into recvdMacAddress.
   2) Copies the RDI field to recvdRDI.
   3) Optionally copies the Port Status TLV to recvdPortState.
   4) Optionally copies the Interface Status TLV to recvdInterfaceStatus.
   5) Optionally copies the Sender ID TLV to recvdSenderId.
   6) Optionally updates the Bridge's MIP CCM Database.
   7) Sets the rCCMreceived variable (20.19.6) for the particular instance of the Remote MEP state machine corresponding to the Maintenance association Endpoint Identifier field in the CCM.
   8) Only in the case of a PBB-TE MEP or Infrastructure Segment MEP, optionally copies the Traffic field (21.6.1.4) to rcvdTrafficBit (20.16.13).

MEPprocessEqualCCM() should also:

e) Compare the Sequence Number field in the received CCM to the value saved in the MEP CCM Database.
f) If both values are not 0, and if the new value is not 1 greater than the last, increment CCMsequenceErrors (20.16.12).
g) Store the received Sequence Number in the MEP CCM Database.

20.17.2 MEPprocessLowCCM()

Called by the MEP Continuity Check Receiver state machine whenever a CCM is received with an MD Level that is less than the MEP's MD Level (mdLevel, 20.7.1). MEPprocessLowCCM() processes the CCM contained in CCMlowPDU as follows:

a) MEPprocessLowCCM() shall process the CCM according to 20.51.4.2, and may validate the CCM according to 20.51.4.3, and discard any frames that fail the validation.
b) Otherwise, MEPprocessLowCCM() sets xconCCMreceived (20.23.1) true, reconstructs the frame containing the CCM into recvdFrame, and places a timer counter value into recvdInterval corresponding to the value of the CCM Interval field in the received CCM.

20.18 MEP Continuity Check Receiver state machine

The MEP Continuity Check Receiver state machine implements the functions specified by the state diagram in Figure 20-4, using the variables in 20.16 and procedures in 20.17.

20.19 Remote MEP variables

The following variables are local to the Remote MEP state machine:

a) rMEPCCMdefect (20.19.1)
b) rMEPlastRDI and rMEPlastRDI[i] (20.19.2)
c) rMEPlastPortState (20.19.3)
d) rMEPlastInterfaceStatus (20.19.4)
e) rMEPlastSenderId (20.19.5)
f) rCCMreceived (20.19.6)
g) rMEPmacAddress (20.19.7)

h) rMEPportStatusDefect (20.19.8)
i) rMEPinterfaceStatusDefect (20.19.9)
j) lastPathN (20.19.10)

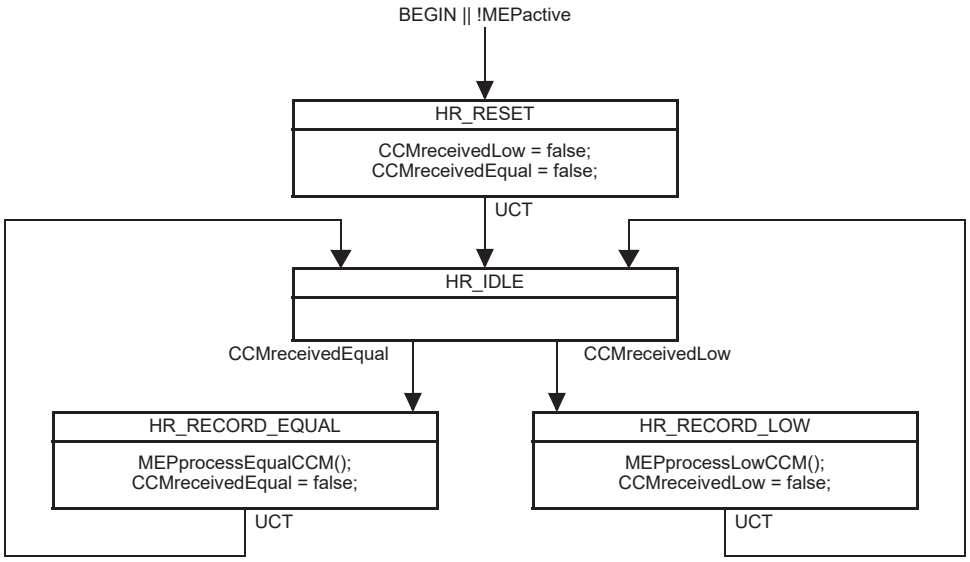


Figure 20-4—MEP Continuity Check Receiver state machine

20.19.1 rMEPCCMdefect

Reports the state of the remote MEP. When true, no CCM has been received from the remote MEP for at least (3.25 × CCMtime(CCMinterval)) seconds.

20.19.2 rMEPlastRDI and rMEPlastRDI[i]

Boolean flag. Contains the RDI flag from the last-received CCM. This variable is readable as a managed object [item e) in 12.14.7.6.3]. In the case of an ECMP path MEP, if Npaths > 1, there is a set of variables rMEPlastRDI[i] of size Npaths (20.10.4). In this case the variable rMEPlastRDI is the logical OR of the members of the set rMEPlastRDI[i]. Each member of the set rMEPlastRDI[i] is set if an RDI is received while pathN == i and is reset if no RDI is received while pathN == i in the last CCM cycle of the MEP Continuity Check Initiator state machine.

20.19.3 rMEPlastPortState

Enumerated value. Contains the value obtained from the Port Status TLV (21.5.4) of the last-received CCM or a value indicating that the last-received CCM contained no Port Status TLV. This variable is readable as a managed object [item f) in 12.14.7.6.3].

20.19.4 rMEPlastInterfaceStatus

Enumerated value. Contains the value obtained from the Interface Status TLV (21.5.5) of the last-received CCM or a value indicating that the last-received CCM contained no Interface Status TLV. This variable is readable as a managed object [item g) in 12.14.7.6.3].

20.19.5 rMEPlastSenderId

Enumerated value. Contains the value obtained from the Sender ID TLV (21.5.3) of the last-received CCM or a value indicating that the last-received CCM contained no Sender ID TLV. This variable is readable as a managed object [item h) in 12.14.7.6.3].

20.19.6 rCCMreceived

Boolean flag set true by MEPprocessEqualCCM() to indicate that a CCM has been received that matches the configured expectations of a particular Remote MEP state machine. Cleared to false by the Remote MEP state machine.

20.19.7 rMEPmacAddress

One field in each entry in the MEP CCM Database for a remote MEP, containing source_address of the last-received CCM from that remote MEP. This variable is readable as a managed object [item d) in 12.14.7.6.3].

20.19.8 rMEPportStatusDefect

A Boolean indicating that the remote MEP is reporting a failure in its Port Status TLV (21.5.4). It is true only if the last received CCM contained a Port Status TLV that contained some value other than psUp, i.e., the remote MEP's Bridge Port is not forwarding data. It is equal to (rMEPlastPortState!= psUp && rMEPlastPortState!= psNoPortStateTLV: Indicates either that no CCM has been received or that no Port Status TLV was present in the last CCM received).

20.19.9 rMEPinterfaceStatusDefect

A Boolean indicating that the remote MEP is reporting a failure in its Interface Status TLV (21.5.5). It is true only if the last received CCM contained an Interface Status TLV that contained some value other than isUp, i.e., the remote MEP's Bridge Port is not available for forwarding data. It is equal to (rMEPlastInterfaceStatus!= isUp && rMEPlastInterfaceStatus!= isNoInterfaceStatusTLV: Indicates either that no CCM has been received or that no Interface Status TLV was present in the last CCM received).

20.19.10 lastPathN

This variable is applicable only for ECMP path MEPs.

Integer value. The variable lastPathN holds the previous value of the pathN variable.

20.20 Remote MEP state machine

The Remote MEP state machine implements the function specified by the state diagram in Figure 20-5 and the variable declarations in 20.19, and utilizes the procedures in 20.17.

20.21 Remote MEP Error variables

The following variables are local to the Remote MEP Error state machine:

a) errorCCMreceived (20.21.1)
b) errorCCMlastFailure (20.21.2)
c) errorCCMdefect (20.21.3)

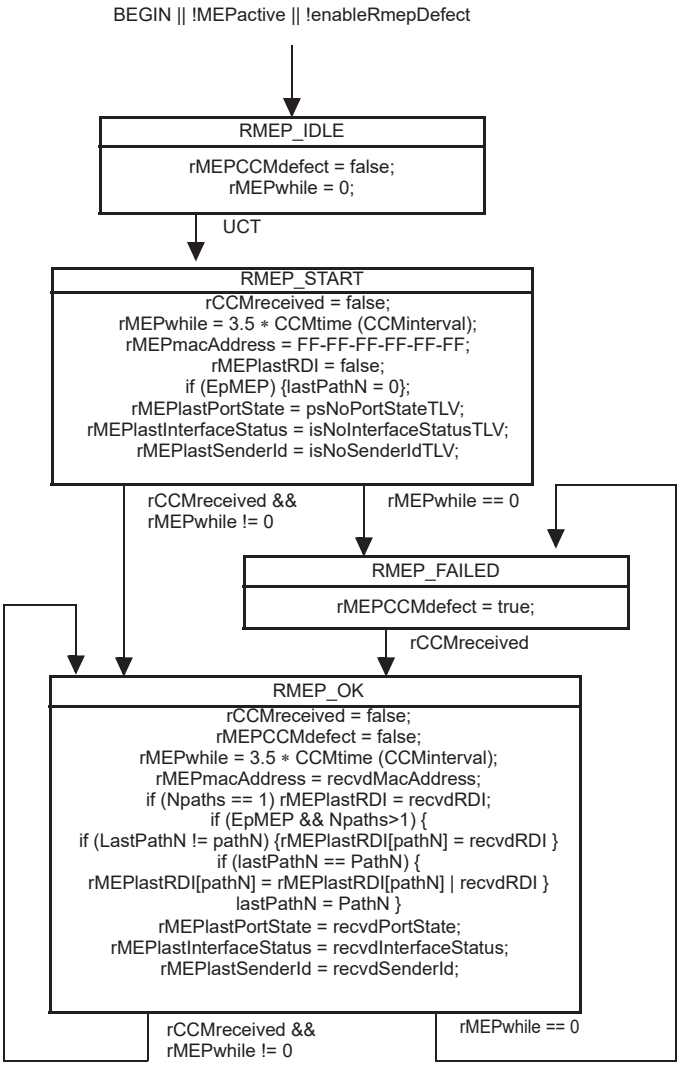


Figure 20-5—Remote MEP state machine

20.21.1 errorCCMreceived

Boolean flag set true by MEPprocessEqualCCM() if an invalid CCM is received. Cleared to false by the Remote MEP Error state machine.

20.21.2 errorCCMlastFailure

Octet string with the same characteristics as recvdFrame. Value controlled by the Remote MEP Error state machine. Readable as a managed object [item t) in 12.14.7.1.3]. Size is sufficient to retain a frame containing a maximum-length CCM in errorCCMlastFailure.

20.21.3 errorCCMdefect

A Boolean flag set and cleared by the Remote MEP Error state machine to indicate that one or more invalid CCMs has been received, and that 3.5 times that CCM's transmission interval has not yet expired. This variable is readable as a managed object [item r) in 12.14.7.1.3].

20.22 Remote MEP Error state machine

The Remote MEP Error state machine implements the function specified by the state diagram in Figure 20-6 and the variable declarations in 20.21.

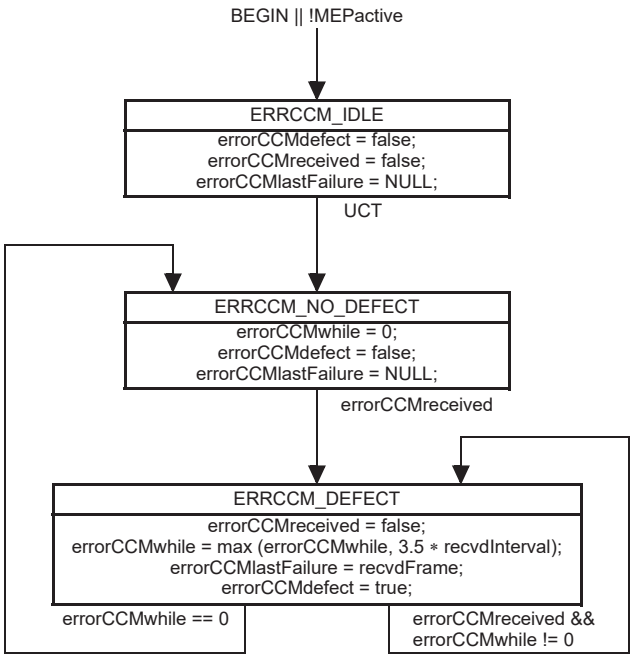


Figure 20-6—Remote MEP Error state machine

20.23 MEP Cross Connect variables

The following variables are local to the MEP Cross Connect state machine:

a) xconCCMreceived (20.23.1)
b) xconCCMlastFailure (20.23.2)
c) xconCCMdefect (20.23.3)

20.23.1 xconCCMreceived

Boolean flag set true by MEPprocessEqualCCM() when a cross connect CCM is received. Cleared to false by the MEP Cross Connect state machine.

20.23.2 xconCCMlastFailure

Octet string with the same characteristics as recvdFrame. Value controlled by the MEP Cross Connect state machine. Readable as a managed object [item u) in 12.14.7.1.3]. Size is sufficient to retain a frame containing a maximum-length CCM.

20.23.3 xconCCMdefect

A Boolean flag set and cleared by the MEP Cross Connect state machine to indicate that one or more cross connect CCMs has been received, and that 3.5 times of at least one of those CCMs' transmission interval has not yet expired. This variable is readable as a managed object [item s) in 12.14.7.1.3].

20.24 MEP Cross Connect state machine

The MEP Cross Connect state machine implements the function specified by the state diagram in Figure 20-7 and the variable declarations in 20.23.

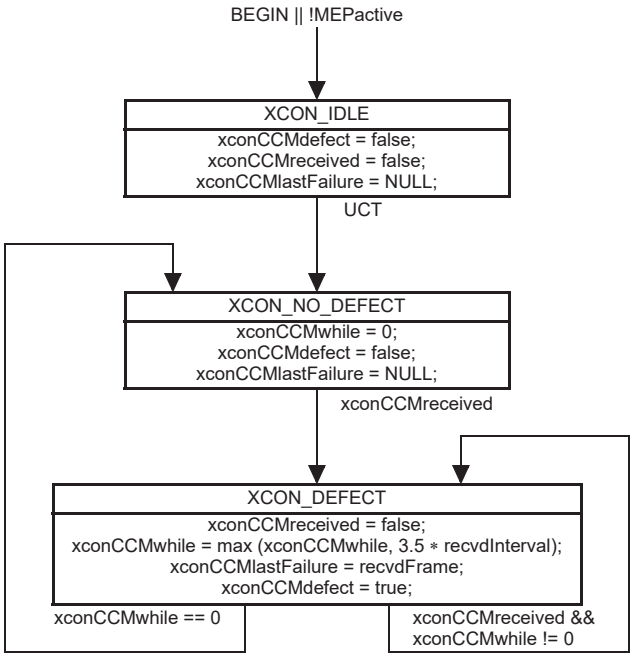


Figure 20-7—MEP Cross Connect state machine

20.25 MEP Mismatch variables

The following variables are local to the MEP Mismatch state machines for a PBB-TE MEP or Infrastructure Segment MEP implementing the Traffic field (21.6.1.4):

a) mmCCMreceived (20.25.1)
b) mmCCMdefect (20.25.2)
c) mmCCMTime (20.25.3)
d) disableLocdefect (20.25.4)
e) mmLocdefect (20.25.5)

20.25.1 mmCCMreceived

Boolean flag set to TRUE when rcvdTrafficBit (20.16.13) does not match the presentTraffic (20.9.8) in the case of a PBB-TE MEP or rcvdTrafficBit (20.16.13) does not match the ISpresentTraffic (20.9.10) in the case of an Infrastructure segment MEP.

20.25.2 mmCCMdefect

A Boolean flag set and cleared by the MEP Mismatch state machines to indicate that one or more CCMs with Traffic fields not matching the presentTraffic (20.9.8) have been received in the case of a state machine associated with a PBB-TE MEP or that one or more CCMs with ISpresentTraffic (20.9.10) has been received in the case of a state machine associated with an Infrastructure Segment MEP, over a period that is greater than 3.5 times the configured CCM transmission rate and given by the mmCCMTime (20.25.3). This variable is readable as a managed object [item ah) in 12.14.7.1.3].

20.25.3 mmCCMTime

The time used to initiate the mmCCMwhile timer. This is the time taken for a remote IB-BEB to send a CCM with the correct information in the Traffic field and is tied to the target protection switching time, i.e., 50 ms, as a mismatch would be normal prior to the completion of a protection switch. In the most generic case it is equal to the Detection Time + Restoration Procedure Time + Restoration Transfer time. This gives a time of 3.5 × CCM interval + Restoration Procedure Time + 1.25 × CCM interval. As a result its value is set to max (50 ms, 4.75 × CCMtime (CCMinterval) + 10 ms).

20.25.4 disableLocdefect

A Boolean that disables the indication of the mmLocdefect. The variable is always set to TRUE for PBB-TE MAs that are not part of a TE protection group. On a PBB-TE MEP associated with the working entity in one or more TE protection groups to which its monitoring TESI MA is assigned, disableLocdefect is TRUE if and only if either p.SF (26.10.3.3.2) or LoP (26.10.3.3.4) is TRUE on any of these TE protection groups. On a PBB-TE MEP associated with only one protection entity in all the TE protection groups to which it is assigned, disableLocdefect is TRUE if and only if FS (26.10.3.3.5) is TRUE on this TE protection group.

20.25.5 mmLocdefect

A Boolean flag set and cleared by the MEP Local Mismatch state machine to indicate that presentmmLoc (20.9.9) or ISpresentmmLoc (20.9.11) is set to TRUE, over a period of 50 ms [item ai) in 12.14.7.1.3].

20.26 MEP Mismatch state machines

The MEP Mismatch state machines implement the functions specified by the state diagrams in Figure 20-8, Figure 20-9, and the variable declarations in 20.25. There is one MEP Traffic Field Mismatch state machine and one MEP Local Mismatch state machine per PBB-TE MEP or Infrastructure Segment MEP implementing the Traffic field (21.6.1.4).

20.27 MP Loopback Responder variables

The following variables are local to the MP Loopback Responder state machine:

a) LBMreceived (20.27.1)
b) LBMPDU (20.27.2)

20.27.1 LBMreceived

Boolean variable, set to true by an MP OpCode Demultiplexer when an LBM is received, and cleared by an MP Loopback Responder state machine.

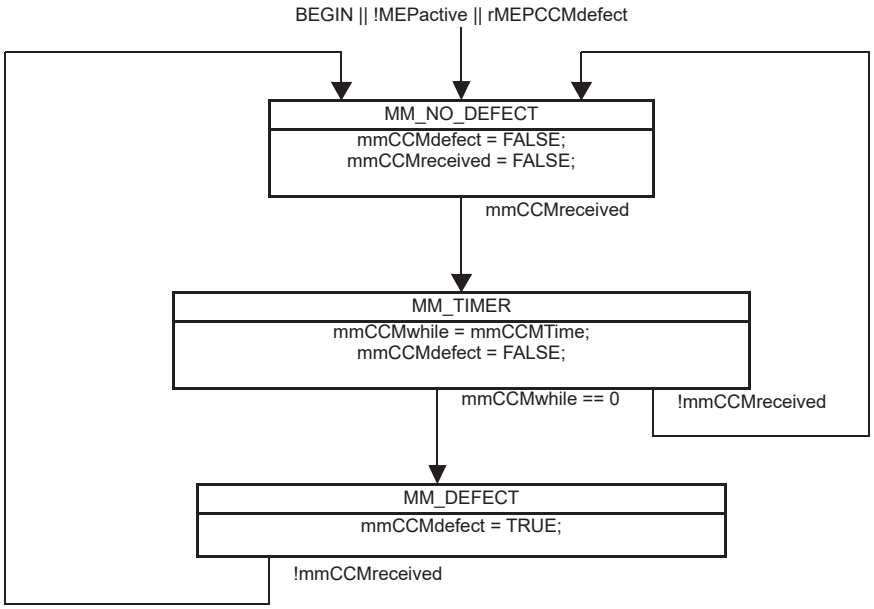


Figure 20-8—MEP Traffic Field Mismatch state machine

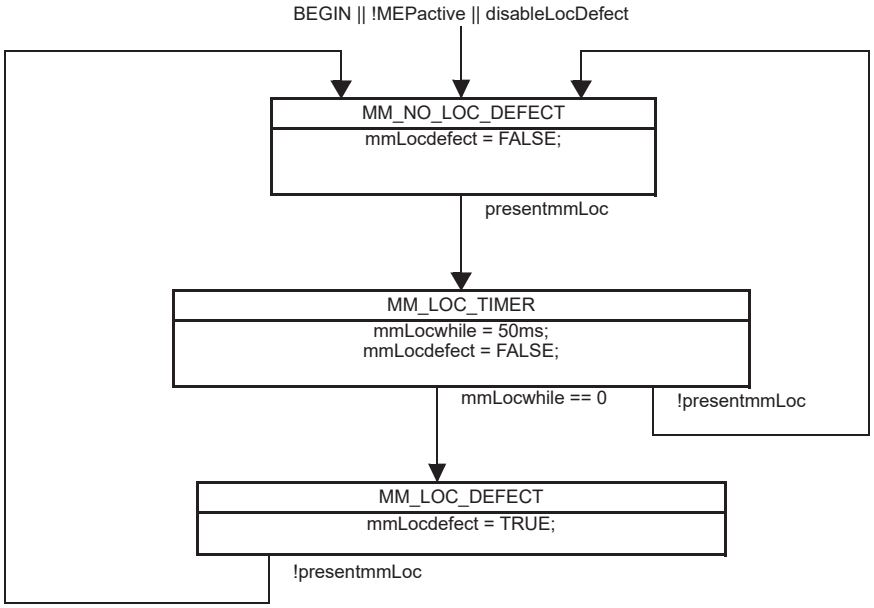


Figure 20-9—MEP Local Mismatch state machine

20.27.2 LBMPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the LBM PDU received by the an MP OpCode Demultiplexer (19.2.7) when an LBM is received.

20.28 MP Loopback Responder procedures

The following procedures are defined for the Loopback Responder:

a) ProcessLBM() (20.28.1)
b) xmitLBR() (20.28.2)

20.28.1 ProcessLBM()

Called by the MP Loopback Responder state machine whenever an LBM is received. ProcessLBM() processes the LBM in LBMPDU as follows:

a) If :
   1) the destination_address parameter contains an individual MAC address that does not match the MAC address of the receiving MP and
   2) the MP Loopback Responder state machine does not reside in a PBB-TE or SPBM VID MHF,

   ProcessLBM() discards the LBM and performs no further processing.
b) If the destination_address parameter contains a Group address and the MP Loopback Responder state machine resides in an MHF associated with neither PBB-TE nor SPBM (rather than in a MEP), ProcessLBM() discards the LBM and performs no further processing.
c) If the source_address parameter is a Group, and not an individual MAC address, ProcessLBM() discards the frame and performs no further processing.
d) ProcessLBM() shall process the LBM according to 20.51.4.2, and may validate the LBM according to 20.51.4.3, and discard any frames that fail the validation.
e) If the MP Loopback Responder state machine resides in a PBB-TE MEP and the LBM carries a PBB-TE MIP TLV, ProcessLBM() discards the LBM and performs no further processing.
f) If the MP Loopback Responder state machine resides in a PBB-TE or SPBM VID MHF and:
   1) There is no PBB-TE MIP TLV or
   2) There is a PBB-TE MIP TLV but the address carried in the MIP MAC address field does not match the MAC address of the receiving MIP,

   ProcessLBM() forwards the LBM to the Passive MHF Multiplexer and performs no further processing.
g) Otherwise, ProcessLBM() calls xmitLBR() to generate and transmit an LBR.

20.28.2 xmitLBR()

Called by ProcessLBM() to transmit an LBR. xmitLBR() constructs an LBR from the LBM contained in LBMPDU, and transmits it to the Active SAP using an M_UNITDATA.request as follows:

a) Sets the destination_address parameter to the source_address of the received LBM if the MP is not associated with a PBB-TE MA; otherwise to:
   1) The value of the ESP-DA of the MA's ESP that has the replying MEP's MAC address [item i) in 12.14.7.1.3] in its ESP-SA field, if the MEP is a PBB-TE MEP; or otherwise to
   2) The value carried in the Reverse MAC field contained in the PBB-TE MIP TLV of the received LBM, if this is a group MAC address; otherwise to
   3) The source_address of the received LBM.
b) Sets the source_address parameter to the MAC address of the replying MP if the MP is not a PBB-TE MHF; or otherwise to:
   1) The destination_address of the received LBM if this is an individual MAC address; or otherwise to

2) The value carried in the Reverse MAC field contained in the PBB-TE MIP TLV of the received LBM.

c) If the LBM was received at a PBB-TE MHF and contains a PBB-TE MIP TLV, then the vlan_identifier in the LBR is set to the value in the Reverse VID field; otherwise, the vlan_identifier in the LBR is set to the value of the Primary VID associated with the replying MP [item d) in 12.14.7.1.3, item a) in 12.14.3.2.2, item c) in 12.14.5.3.2].

d) In the case of ECMP with flow filtering, the flow_hash parameter is set to zero and the time_to_live parameter is set to 63.

e) The priority parameter and the drop-eligible parameter are copied from the LBM.

f) Changes the OpCode field (21.4.3) from LBM to LBR.

g) Copies the remainder of the LBM's mac_service_data_unit verbatim to the LBR.

h) If the replying MP is a MEP, increments the LBR transmission counter by 1 [item ad) in 12.14.7.1.3].

20.29 MP Loopback Responder state machine

The MP Loopback Responder state machine implements the functions specified by the state diagram in Figure 20-10, using the variables in 20.27 and the procedures in 20.28. Although the definition of the MP Loopback Responders in 19.2.10 and 19.3.8 requires the instantiation of an MP Loopback Responder state machine in every MP, in practice, the number of MP Loopback Responder state machines implemented in a system cannot be determined from external observation of the system.

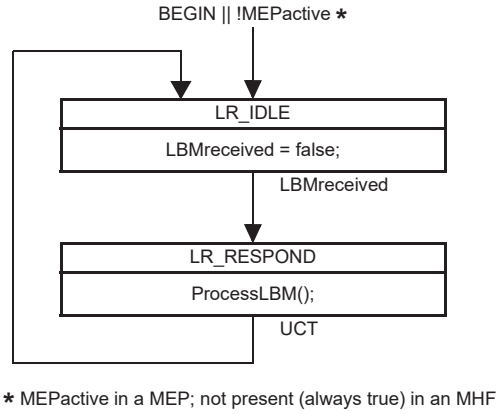


Figure 20-10—MP Loopback Responder state machine

20.30 MEP Loopback Initiator variables

The following variables are local to the MEP Loopback Initiator transmit state machine and the MEP Loopback Initiator receive state machine:

a) LBMsToSend (20.30.1)
b) nextLBMtransID (20.30.2)
c) expectedLBRtransID (20.30.3)
d) LBIactive (20.30.4)
e) xmitReady (20.30.5)
f) LBRreceived (20.30.6)
g) LBRPDU (20.30.7)

20.30.1 LBMsToSend

The integer number of LBMs that the MEP Loopback Initiator transmit state machine is to transmit. Set by a management operation [item c) in 12.14.7.3.2]. Setting this variable to a nonzero value starts transmission of LBMs. LBMsToSend is decremented by 1 by the MEP Loopback Initiator transmit state machine with each transmission.

20.30.2 nextLBMtransID

The value to place in the Loopback Transaction Identifier field of the next LBM transmitted by xmitLBM(). nextLBMtransID is incremented by 1 by the MEP Loopback Initiator transmit state machine with each transmission. This variable is available as a managed object [item x) in 12.14.7.1.3].

20.30.3 expectedLBRtransID

The value expected to be found in the Loopback Transaction Identifier field of the next LBR received by ProcessLBR(). Altered by ProcessLBR() (see 20.33.1).

20.30.4 LBIactive

A Boolean flag indicating whether the MEP Loopback Initiator transmit state machine is (true) or is not (false) actively engaged in a requested operation. Set to true by the MEP Loopback Initiator transmit state machine after LBMsToSend is set to a nonzero value by a management operation. Reset to false by the MEP Loopback Initiator transmit state machine 5 s after the last LBM is transmitted or the last LBR is received, whichever comes later.

20.30.5 xmitReady

A Boolean flag set to true by the Bridge Port to indicate that another LBM can be transmitted. Reset to false by the MEP Loopback Initiator transmit state machine.

20.30.6 LBRreceived

Boolean flag. Set by the MEP Equal OpCode Demultiplexer (19.2.7) when an LBR at the MEP's MD Level is received. Cleared by the MEP Loopback Initiator receive state machine.

20.30.7 LBRPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the LBR PDU received by the MEP Equal OpCode Demultiplexer (19.2.7) when an LBR at the MEP's MD Level is received.

20.31 MEP Loopback Initiator transmit procedures

The following procedure is local to the MEP Loopback Initiator transmit state machine:

a) xmitLBM() (20.31.1)

20.31.1 xmitLBM()

xmitLBM() is called by the MEP Loopback Initiator transmit state machine. It constructs and transmits an LBM on the Active SAP using an M_UNITDATA.request as follows:

a) Sets the destination_address parameter from the appropriate managed object [item b) in 12.14.7.3.2] or in the case of an SPBM VID MEP [item g) in 12.14.7.3.2]. If the MEP is configured on a PBB-TE MA, the destination_address parameter is set to the MAC address indicated by the value of the ESP-DA field of the MA's ESP that has the MEP's MAC address indicated in its ESP-SA field.
b) Sets the source_address parameter to the MAC address of the MEP [item i) in 12.14.7.1.3].
c) Sets the priority and drop_eligible parameters from the appropriate managed object [item e) in 12.14.7.3.2].
d) In the case of ECMP with flow filtering, the flow_hash parameter is set from the appropriate managed object [item h) in 12.14.7.3.2] and the time_to_live parameter is set to 63.
e) Copies nextLBMtransID (20.30.2) to the Loopback Transaction Identifier field (21.7.3) of the LBM.
f) If the MEP is configured on a PBB-TE MA, constructs a PBB-TE MIP TLV using in the MIP MAC address field the target address parameter from the appropriate managed object [item b) in 12.14.7.3.2] and in the Reverse VID field the parameter [item f) in 12.14.7.3.2]; if the MEP is a root in a point-to-multipoint TESI, the Reverse MAC field is also included in the PBB-TE MIP TLV carrying the ESP-SA value of any of the MA's point-to-point ESPs; if the MEP is a leaf in a point-to-multipoint TESI, the Reverse MAC field carries the ESP-DA of the point-to-multipoint ESP; the PBB-TE MIP TLV is not used if the LBM target address in 12.14.7.3.2 is associated with any of the values in the ESP-DA field of the monitored MA's ESPs.
g) If the MEP is configured on an SPBM VID MA, constructs a PBB-TE MIP TLV using in the MIP MAC address field the target address parameter from the appropriate managed object [item b) in 12.14.7.3.2].
h) Constructs a Data TLV from the appropriate managed object [item d) in 12.14.7.3.2] if and only if that managed object has a nonzero length.
i) As controlled by the managed objects item e) in 12.14.3.1.3, item d) in 12.14.5.1.3, and item d) in 12.14.6.1.3, places a Sender ID TLV (21.5.3), identifying the transmitting system, in the LBM.
j) Increments nextLBMtransID (20.30.2) by 1, wrapping around from $2^{32} - 1$ to 0.

20.32 MEP Loopback Initiator transmit state machine

A MEP creates a single instance of the MEP Loopback Initiator transmit state machine. The MEP Loopback Initiator transmit state machine implements the function specified by the state diagram in Figure 20-11 and the procedures in 20.31. It shares with the MEP Loopback Initiator receive state machine the variable declarations in 20.30.

20.33 MEP Loopback Initiator receive procedures

The following procedure is local to the MEP Loopback Initiator receive state machine:

a) ProcessLBR() (20.33.1)

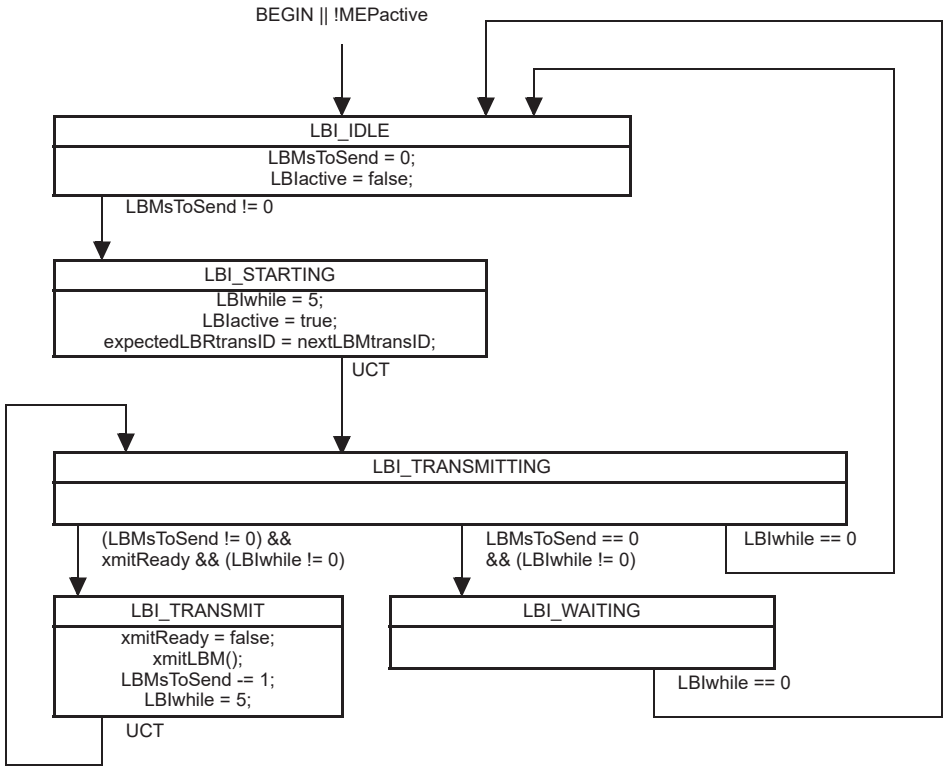


Figure 20-11—MEP Loopback Initiator transmit state machine

20.33.1 ProcessLBR()

Called by the MEP Loopback Initiator receive state machine whenever an LBR is received. ProcessLBR() processes the LBR in LBRPDU as follows:

a) If the I/G bit of the source_address indicates a Group address, or if the destination_address does not match the MAC address of the receiving MP, ProcessLBR() discards the received LBR.

b) ProcessLBR() shall process the LBM according to 20.51.4.2, and may validate the received LBR according to 20.51.4.3, and discard it if invalid.

c) If the LBR is not discarded, and if and only if LBIactive is true, the Loopback Transaction Identifier field of the LBR is compared to expectedLBRtransID:

   1) If the two values are equal, then the number of correct LBRs received [item y) in 12.14.7.1.3] is incremented by 1.

   2) If the two values are unequal, then the value from the received Loopback Transaction Identifier field is copied into expectedLBRtransID, and the number of incorrect LBRs received [item z) in 12.14.7.1.3] is incremented by 1.

   3) Regardless of whether the two values were equal, expectedLBRtransID is then incremented by 1.

d) ProcessLBR() may perform a bit-by-bit comparison of the received LBR against the LBM with the matching Loopback Transaction Identifier, except for the OpCode field, and increment a managed object [item aa) in 12.14.7.1.3] if they do not match.

20.34 MEP Loopback Initiator receive state machine

A MEP creates a single instance of the MEP Loopback Initiator receive state machine. The MEP Loopback Initiator receive state machine implements the function specified by the state diagram in Figure 20-12 and the procedures in 20.33. It shares with the MEP Loopback Initiator transmit state machine the variable declarations in 20.30.

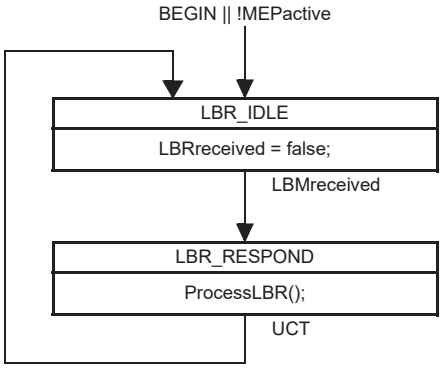


Figure 20-12—MEP Loopback Initiator receive state machine

20.35 MEP Fault Notification Generator variables

The following variables are local to the MEP Fault Notification Generator state machine:

a) fngPriority (20.35.1)
b) fngDefect (20.35.2)
c) fngAlarmTime (20.35.3)
d) fngResetTime (20.35.4)
e) someRMEPCCMdefect (20.35.5)
f) someMACstatusDefect (20.35.6)
g) someRDIdefect (20.35.7)
h) highestDefectPri (20.35.8)
i) highestDefect (20.35.9)

20.35.1 fngPriority

An integer specifying the priority of the last defect reported in a Fault Alarm. fngPriority takes the same values as highestDefectPri (20.35.8).

20.35.2 fngDefect

An enumerated value specifying the last defect reported in a Fault Alarm. fngDefect takes the same values as highestDefect (20.35.9).

20.35.3 fngAlarmTime

The time that one or more defects must be present before a Fault Alarm is issued. Default value 2.5 s. Also a managed object [item l) in 12.14.7.1.3].

20.35.4 fngResetTime

The time, after a Fault Alarm, that no defects must be present before another Fault Alarm is enabled. Default value 10 s. Also a managed object [item m) in 12.14.7.1.3].

20.35.5 someRMEPCCMdefect

A Boolean indicating the aggregate state of the Remote MEP state machines. True indicates that at least one of the Remote MEP state machines is not receiving valid CCMs from its remote MEP, and false that all Remote MEP state machines are receiving valid CCMs. someRMEPCCMdefect is the logical OR of all of the rMEPCCMdefect variables for all of the Remote MEP state machines on this MEP. This variable is readable as a managed object [item q) in 12.14.7.1.3].

20.35.6 someMACstatusDefect

A Boolean indicating that one or more of the remote MEPs is reporting a failure in its Port Status TLV (21.5.4) or Interface Status TLV (21.5.5). It is true either if some remote MEP is reporting that its interface is not isUp (i.e., at least one remote MEP's interface is unavailable), or if all remote MEPs are reporting a Port Status TLV that contains some value other than psUp (i.e., all remote MEPs' Bridge Ports are not forwarding data). It is thus the logical OR of the following two terms:

a) The logical AND, across all remote MEPs, of the rMEPportStatusDefect variable OR
b) The logical OR, across all remote MEPs, of the rMEPinterfaceStatusDefect variable.

This variable is readable as a managed object [item p) in 12.14.7.1.3].

20.35.7 someRDIdefect

A Boolean indicating the aggregate health of the remote MEPs. True indicates that at least one of the Remote MEP state machines is receiving valid CCMs from its remote MEP that has the RDI bit set, and false that no Remote MEP state machines are receiving valid CCMs with the RDI bit set. someRDIdefect is the logical OR of all of the rMEPlastRDI and rMEPlastRDI[i] variables for all of the Remote MEP state machines on this MEP. This variable is readable as a managed object [item o) in 12.14.7.1.3].

20.35.8 highestDefectPri

An integer value indicating the priority of the defect named in the variable highestDefect. See also Table 20-1.

20.35.9 highestDefect

An enumerated value indicating the highest priority defect among the variables xconCCMdefect (20.23.3), errorCCMdefect (20.21.3), someRMEPCCMdefect (20.35.5), someMACstatusDefect (20.35.6), and someRDIdefect (20.35.7), as limited by lowestAlarmPri (20.9.5). This variable is readable as a managed object [item c) in 12.14.7.7.2]. The variables, their priorities, and the enumerated values of highestDefect are shown in Table 20-1.

20.36 MEP Fault Notification Generator procedures

The following procedure is local to the MEP Fault Notification Generator state machine:

a) xmitFaultAlarm() (20.36.1).

20.36.1 xmitFaultAlarm()

Transmits a Fault Alarm (12.14.7.7). The identity of the MEP and the variable fngDefect (20.35.2), specifying the cause of the Fault Alarm, are transmitted in the Fault Alarm PDU. The format and method of transmission of the Fault Alarm is not specified in this standard.

20.37 MEP Fault Notification Generator state machine

A MEP creates a single instance of the MEP Fault Notification Generator state machine. The MEP Fault Notification Generator state machine implements the function specified by the state diagram in Figure 20-13, the variables in 20.35, and the procedure in 20.36. The current state of the MEP Fault Notification Generator state machine is available in a managed object [item f) in 12.14.7.1.3].

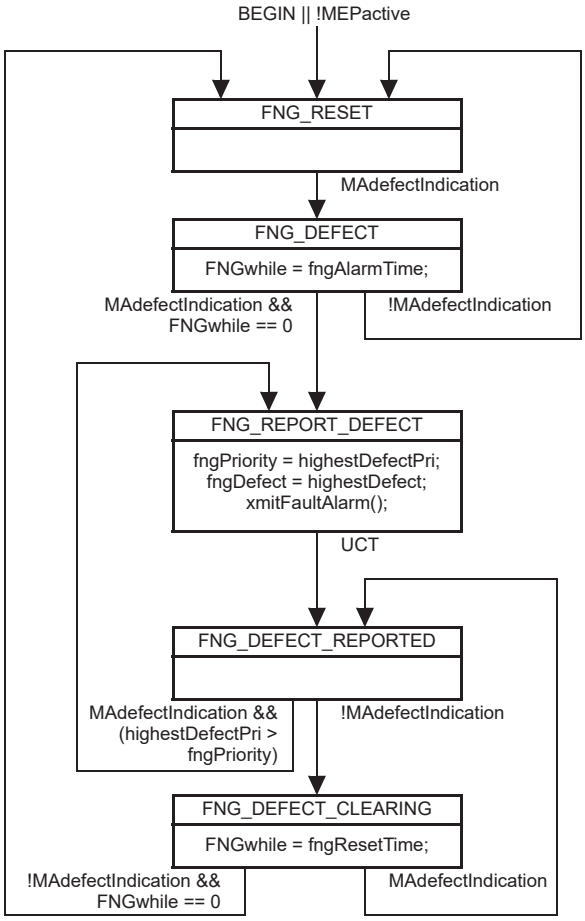


Figure 20-13—MEP Fault Notification Generator state machine

20.38 MEP Mismatch Fault Notification Generator variables

The following variables are local to the MEP Mismatch Fault Notification Generator state machine for a PBB-TE MEP or Infrastructure Segment MEP implementing the Traffic field (21.6.1.4):

a) mfngAllowed (20.38.1)
b) mmdefectIndication (20.38.2)
c) mfngAlarmTime (20.38.3)
d) mfngResetTime (20.38.4)

20.38.1 mfngAllowed

A Boolean indicating the mismatch defect is allowed to generate a Fault Alarm. Its value is configurable as a managed object [item ag) in 12.14.7.1.3].

20.38.2 mmdefectIndication

A Boolean indicating the presence of the mismatch defect that is allowed to generate a Fault Alarm. It corresponds to the logical AND of the variables mfngAllowed (20.38.1), mmCCMdefect (20.25.2), and mmLocdefect (20.25.5).

20.38.3 mfngAlarmTime

The time that one or more defects must be present before a mismatch Fault Alarm is issued. Default value 2.5 s. Also a managed object [item l) in 12.14.7.1.3].

20.38.4 mfngResetTime

The time, after a mismatch Fault Alarm, that no defects must be present before another mismatch Fault Alarm is enabled. Default value 10 s. Also a managed object [item m) in 12.14.7.1.3].

20.39 MEP Mismatch Fault Notification Generator procedures

The following procedure is local to the MEP Mismatch Fault Notification Generator state machine for a PBB-TE MEP or Infrastructure Segment MEP implementing the Traffic field (21.6.1.4):

a) xmitFaultAlarm() (20.36.1)

20.39.1 xmitFaultAlarm()

Transmits a Fault Alarm (12.14.7.7). The identity of the MEP and a value indicating that the cause of the Fault Alarm is a mismatch defect, are transmitted in the Fault Alarm PDU. The format and method of transmission of the Fault Alarm is not specified in this standard.

20.40 MEP Mismatch Fault Notification Generator state machine

A PBB-TE MEP or Infrastructure Segment MEP implementing the Traffic field (21.6.1.4) creates a single instance of the MEP Mismatch Fault Notification Generator state machine. The MEP Mismatch Fault Notification Generator state machine implements the function specified by the state diagram in Figure 20-14, the variables in 20.38, and the procedure in 20.39. The current state of the MEP Mismatch Fault Notification Generator state machine is available in a managed object [item ak) in 12.14.7.1.3].

20.41 MEP Linktrace Initiator variables

The following variables are local to the MEP Linktrace Initiator variables:

a) nextLTMtransID (20.41.1)
b) ltmReplyList (20.41.2)

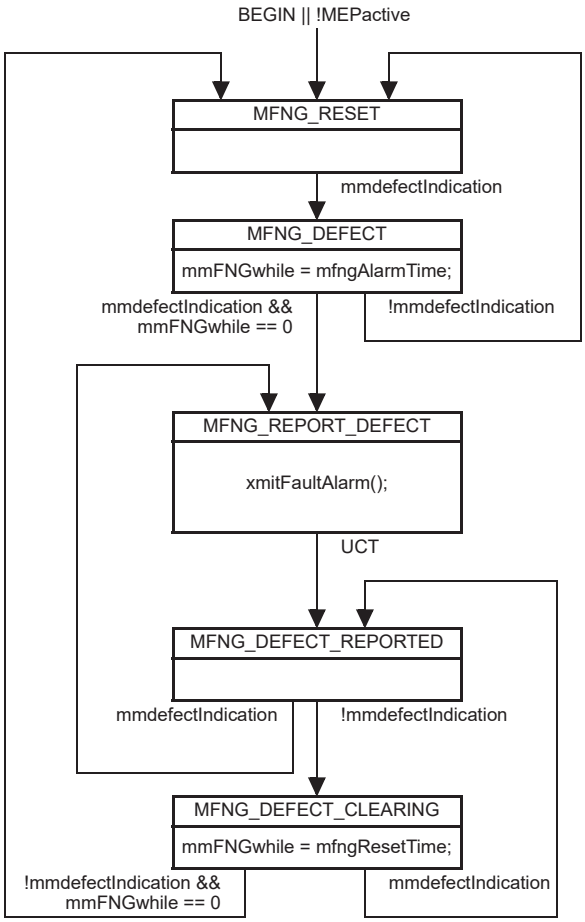


Figure 20-14—MEP Mismatch Fault Notification Generator state machine

20.41.1 nextLTMtransID

The value to place in the LTM Transaction Identifier of the next LTM transmitted by xmitLTM(). nextLTMtransID is incremented by 1 by the MEP Linktrace Initiator variables with each transmission. This variable is also a managed object [item ab) in 12.14.7.1.3].

20.41.2 ltmReplyList

The list of recently-issued LTMs and their corresponding LTRs. An LTM entry, with no attached LTR entries, is added to this list by xmitLTM() each time an LTM is transmitted, and an LTR entry is attached to an LTM entry in this list, by ProcessLTR(), each time an LTR corresponding to an LTM in the list is received. The MEP does not remove any entry from this list before 5 s have elapsed since the transmission of the corresponding LTM, unless the addition of another LTM or LTR entry would exceed the maximum resources allocated for this list. This variable constitutes the Linktrace database for a given MEP and is also a managed object (12.14.7.5.3).

Each LTR entry contains the following variables:

a) ltrFlags (20.41.2.1)
b) ltrReplyTTL (20.41.2.2)
c) ltrLastEgressId (20.41.2.3)
d) ltrNextEgressId (20.41.2.4)
e) ltrRelayAction (20.41.2.5)
f) ltrIngressAction (20.41.2.6)
g) ltrIngressAddress (20.41.2.7)
h) ltrIngressPortIdSubtype (20.41.2.8)
i) ltrIngressPortId (20.41.2.9)
j) ltrEgressAction (20.41.2.10)
k) ltrEgressAddress (20.41.2.11)
l) ltrEgressPortIdSubtype (20.41.2.12)
m) ltrEgressPortId (20.41.2.13)
n) ltrSenderIdTlv (20.41.2.14)
o) ltrOrgSpecTlv (20.41.2.15)

20.41.2.1 ltrFlags

The bit string returned in the Flags field (21.9.1) of the LTR, including the FwdYes and TerminalMEP bits.

20.41.2.2 ltrReplyTTL

The integer value returned in the Reply TTL field (21.9.4) of the LTR.

20.41.2.3 ltrLastEgressId

The octet string returned in the Last Egress Identifier field (21.9.7.1) of the LTR Egress Identifier TLV.

20.41.2.4 ltrNextEgressId

The integer value returned in the Next Egress Identifier field (21.9.7.2) of the LTR Egress Identifier TLV.

20.41.2.5 ltrRelayAction

The enumerated value returned in the Relay Action field (21.9.5) of the LTR. The enumerated values are listed in Table 21-27.

20.41.2.6 ltrIngressAction

The enumerated value returned in the Ingress Action field (21.9.8.1) of the Reply Ingress TLV (21.9.8) of the LTR. The enumerated values are listed in Table 21-30. An enumerated value of 0 indicates that no Reply Ingress TLV was returned in the LTR.

20.41.2.7 ltrIngressAddress

The MAC address of the MP on the Ingress Port. Contents are undefined if no Reply Ingress TLV was returned in the LTR.

20.41.2.8 ltrIngressPortIdSubtype

An enumerated value as specified by IEEE Std 802.1AB, indicating the format of ltrIngressPortId. Contents are undefined if no Reply Ingress TLV was returned in the LTR.

20.41.2.9 ltrIngressPortId

An octet string as specified by IEEE Std 802.1AB, identifying the Ingress Port, in the format identified in ltrIngressPortIdSubtype.

20.41.2.10 ltrEgressAction

The enumerated value returned in the Egress Action field (21.9.9.1) of the Reply Egress TLV (21.9.9) of the LTR. The enumerated values are listed in Table 21-32. A value of 0 indicates that no Reply Egress TLV was returned in the LTR.

20.41.2.11 ltrEgressAddress

The MAC address of the MP on the Egress Port. Contents are undefined if no Reply Egress TLV was returned in the LTR.

20.41.2.12 ltrEgressPortIdSubtype

An enumerated value as specified by IEEE Std 802.1AB, indicating the format of ltrEgressPortId. Contents are undefined if no Reply Ingress TLV was returned in the LTR.

20.41.2.13 ltrEgressPortId

An octet string as specified by IEEE Std 802.1AB, identifying the Egress Port, in the format identified in ltrEgressPortIdSubtype.

20.41.2.14 ltrSenderIdTlv

An octet string identifying the transmitting system, as received in the Sender ID TLV (21.5.3), if one was present in the LTR.

20.41.2.15 ltrOrgSpecTlv

An octet string containing the Organization-Specific TLVs (21.5.2), if any were present in the LTR.

20.42 MEP Linktrace Initiator procedures

The following procedure is local to the MEP Linktrace Initiator:

a) xmitLTM() (20.42.1)

20.42.1 xmitLTM()

xmitLTM() is called whenever the Transmit Linktrace Message management operation (12.14.7.4) is invoked. It constructs and transmits an LTM on the Active SAP, or on the MEP LTI SAP if the operation is invoked on an Up MEP, using an M_UNITDATA.request as follows:

a) Sets the destination_address parameter to the value from Table 8-19 corresponding to the MEP's MD Level. If the MEP is configured on a PBB-TE MA, the destination_address parameter is the MAC address indicated by the value of the ESP-DA field of the MA's ESP that has the MEP's MAC address indicated in its ESP-SA field. If the MEP is configured on an SPBM VID MA, the destination_address parameter is set to the value configured in the LTM management request [item f) in 12.14.7.4.2].
b) Sets the source_address parameter and Original MAC Address field (21.8.5) to the MAC address of the MEP [item i) in 12.14.7.1.3].
c) If the MEP is configured on a PBB-TE MA, constructs a PBB-TE MIP TLV using in the MIP MAC address field a null field and in the Reverse VID field the parameter [item e) in 12.14.7.4.2]; if the

MEP is a root in a point-to-multipoint TESI, the Reverse MAC field is also included in the PBB-TE MIP TLV carrying the ESP-SA value of any of the MA's point-to-point ESPs; if the MEP is a leaf in a point-to-multipoint TESI, the Reverse MAC field carries the ESP-DA of the point-to-multipoint ESP.

d) In the case of ECMP with flow filtering, the flow_hash parameter is set to the value specified in the appropriate managed object [item g) in 12.14.7.4.2] and the time_to_live parameter is set to 63.
e) Sets the priority parameter to the same value as for CCMs [item h) in 12.14.7.1.3].
f) Copies nextLTMtransID [item ab) in 12.14.7.1.3] to the LTM Transaction Identifier field (21.8.3) of the LTM.
g) Sets the LTM Egress Identifier TLV (21.8.8) to a value that is unique among all Bridges in the Management Domain.
h) Sets the Target MAC Address field (21.8.6) from the appropriate managed object [item c) in 12.14.7.4.2].
i) Sets the LTM TTL field (21.8.4) from the appropriate managed object [item d) in 12.14.7.4.2].
j) Sets the UseFDBonly bit of the Flags field (21.8.1) from the appropriate managed object [item b) in 12.14.7.4.2], and sets all other bits of the Flags field to 0.
k) As controlled by the managed objects item e) in 12.14.3.1.3, item d) in 12.14.5.1.3, and item d) in 12.14.6.1.3, places a Sender ID TLV (21.5.3), identifying the transmitting system, in the LTM.
l) Creates a new entry in the ltmReplyList variable (20.41.2) for this LTM, identified by the LTM Transaction Identifier in nextLTMtransID (20.41.1).
m) Increments nextLTMtransID (20.41.1) by 1, wrapping around from $2^{32} - 1$ to 0.

If the addition of this LTM entry would exceed the resources allocated to ltmReplyList, then the oldest LTM entries in ltmReplyList are deleted until sufficient resources are available to hold the new LTM entry.

20.43 MEP Linktrace Initiator receive variables

The following variables are local to the MEP Linktrace Initiator receive state machine:

a) LTRreceived (20.43.1)
b) LTRPDU (20.43.2)

20.43.1 LTRreceived

Boolean flag. Set by the MEP Equal OpCode Demultiplexer (19.2.7) when an LTR at the MEP's MD Level is received. Cleared by the MEP Linktrace Initiator receive state machine.

20.43.2 LTRPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the LTR PDU received by the MEP Equal OpCode Demultiplexer (19.2.7) when an LTR at the MEP's MD Level is received.

20.44 MEP Linktrace Initiator receive procedures

The following procedure is local to the MEP Linktrace Initiator receive state machine:

a) ProcessLTR() (20.44.1)

20.44.1 ProcessLTR()

The ProcessLTR() procedure is called by the MEP Linktrace Initiator receive state machine whenever an LTR is received, and processes the LTR contained in the LTRPDU variable as follows:

a) If the destination_address of the LTR does not match the MAC address of the MEP, or if the LTR fails the validation criteria of 20.51.4, ProcessLTR() shall discard the LTR without counting it, and no further processing takes place.
b) Otherwise, if the LTR Transaction Identifier field matches an LTM entry in the ltmReplyList variable, then a new LTR entry is attached to that LTM entry, containing the information returned in the LTR.
c) Otherwise, the number of unexpected LTRs received [item ac) in 12.14.7.1.3] is incremented by 1.

If the addition of this LTR entry would exceed the resources allocated to ltmReplyList, then the oldest LTM entries in ltmReplyList (the oldest LTR entries, if only one LTM entry is present) are deleted until sufficient resources are available to hold the new LTR entry.

20.45 MEP Linktrace Initiator receive state machine

One instance of the MEP Linktrace Initiator receive state machine is instantiated by each MEP Linktrace Initiator. The MEP Linktrace Initiator receive state machine implements the function specified by the state diagram in Figure 20-15, the variables in 20.43, and the procedures in 20.44.

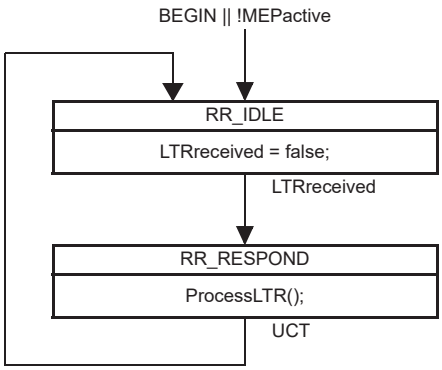


Figure 20-15—MEP Linktrace Initiator receive state machine

20.46 Linktrace Responder variables

The following variables are local to the Linktrace Responder:

a) nPendingLTRs (20.46.1)
b) LTMreceived (20.46.2)
c) LTMPDU (20.46.3)

20.46.1 nPendingLTRs

An integer value used to track the number of LTRs that have been enqueued for transmission by enqueLTR() and not yet transmitted by xmitOldestLTR(). Can be reset to 0 by clearPendingLTRs().

20.46.2 LTMreceived

A Boolean value set when a valid LTM is received and cleared by the LTM Receiver state machine.

20.46.3 LTMPDU

Structure. Loaded with the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the LTM PDU received by the MEP Equal OpCode Demultiplexer (19.2.7) when an LTM at the MEP's MD Level is received.

20.47 LTM Receiver procedures

The following procedures are local to the LTM Receiver state machine:

a) ProcessLTM() (20.47.1)
b) clearPendingLTRs() (20.47.2)
c) ForwardLTM() (20.47.3)
d) enqueLTR() (20.47.4)

20.47.1 ProcessLTM()

Called by the LTM Receiver state machine when an LTM is received and processes the LTM contained in the LTMPDU, making the decision whether to call ForwardLTM() to forward the LTM, and whether to call enqueLTR() to enqueue an LTR for transmission, according to 20.3.2. The received LTM is first validated.

a) ProcessLTM() validates the received LTM according to 20.51.3. If the LTM is invalid, no further validation steps are performed.
b) Otherwise, the LTM TTL field (21.8.4) of the received LTM is examined. If its value is 0, the LTM is invalid, and no further validation steps are performed.
c) Otherwise, if the vlan_identifier identifies an ESP-VID or SPBM VID the LTM is valid, and no further validation steps are performed.
d) Otherwise, if the destination_address parameter of the LTM is a Group address, the LTM is valid, and no further validation steps are performed.
e) Otherwise, if both:
    1) The LTM was received from a Linktrace SAP, and not from the originating Up MEP through its MEP LTI SAP and
    2) The destination_address parameter of the LTM is the individual MAC address of the receiving MP [item i) in 12.14.7.1.3 for a MEP, the MAC address of the Bridge Port for an MHF],

    then the LTM is valid.
f) Otherwise, the LTM is invalid.

20.47.1.1 LTM paths through a Bridge

If the LTM is valid, processing proceeds according to the following subclauses. Otherwise, ProcessLTM() discards the LTM, and no further processing takes place.

Figure 20-16 illustrates a number of (but not all) possible paths taken by an LTM through a Bridge. The gray circles indicate the processing of an LTM and the possible forwarding of a modified copy of the LTM. The LTR path is not shown.

NOTE—All of the MPs shown in Figure 20-16 are at the same MD Level.

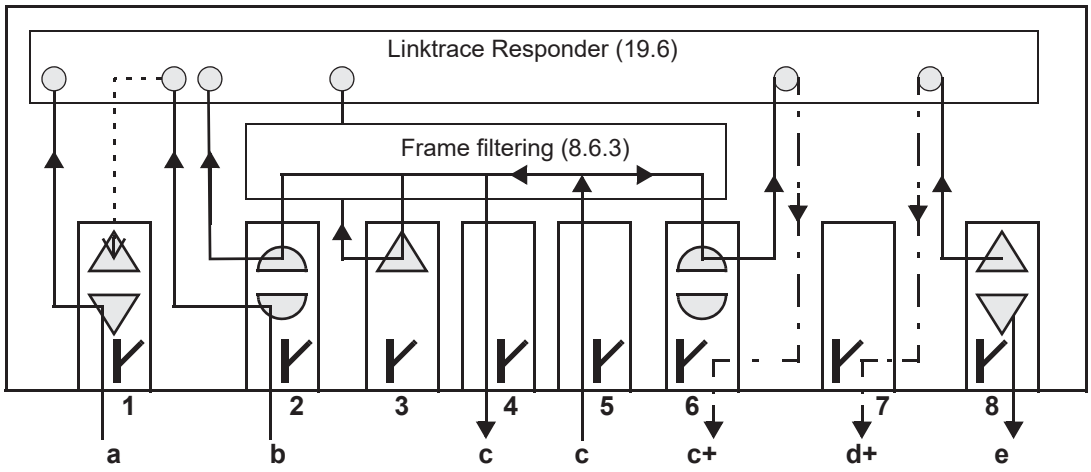


Figure 20-16—Linktrace Responder, MEPs, MHFs, and LOMs

a) An LTM is detected by a Down MEP as it enters Port 1. It is deflected to the Linktrace Responder through the MEP Linktrace SAP.
b) An LTM is detected by an MHF as it enters Port 2. It is deflected to the Linktrace Responder through the MHF Linktrace SAP, which determines that the Target MAC Address would be forwarded out Port 1, on which there is a MEP. The LTM is not actually forwarded to the MEP.
c) An LTM enters on Port 5, which has no MHF, and if it is a multicast, the LTM is distributed to Ports 2, 3, 4, and 6 by the Frame filtering function (8.6.3). The original, unaltered LTM passes out Port 4. The Up MEP in Port 3 and the MHFs in Ports 2 and 6 deliver the LTM to the Linktrace Responder. The Linktrace Responder discards the LTMs received on Port 2 and 3, but forwards an updated version of the LTM through the LOM on Port 6.
d) The Up MEP on Port 8 generates an LTM, which it forwards to the Linktrace Responder. The Linktrace Responder decides to forward an updated version of the LTM through the LOM on Port 7. (The Linktrace Responder might equally well have forwarded it through some other Port's MHF.)
e) The Down MEP on Port 8 generates an LTM and transmits it through its Active SAP to the LAN attached to Port 8.

If an LTM is forwarded, the forwarding takes place immediately. If an LTR is generated in response to the LTM, it is enqueued for later transmission by the LTR Transmitter state machine (20.50).

20.47.1.2 Ingress Port, vlan_identifier, and Egress Port determination

In 20.3.2 and Figure 20-16, item a) through item e) all require ProcessLTM() to determine the Ingress and Egress Ports for this received LTM. The Ingress Port is the Bridge Port on which the LTM entered the Bridge, whether through a MEP, an MHF, or an LOM. In item d)), where an LTM is generated by an Up MEP and passed through a MEP LTI SAP to the Linktrace Responder, the Ingress Port is the Bridge Port of the originating MEP.

If received from an EISS SAP, the vlan_identifier of the received LTM is included in the EM_UNITDATA.indication. If received from an ISS SAP, the vlan_identifier of the received LTM is that configured in the MEP, MHF, or LOM that received the LTM, or if none, is the PVID (IEEE Std 802.1AC) of the Ingress Port.

The Egress Port is the Bridge Port on which a data frame whose destination_address is equal to the Target MAC Address carried in the LTM, or in the case of an MP associated with a PBB-TE MA, the destination_address of the LTM, and whose vlan_identifier matched that of the LTM, would be forwarded. This determination is made in two steps:

a) ProcessLTM() first queries the FDB (8.8). The set of potential transmission ports, normally created by Active topology enforcement (8.6.1), is the set of all Bridge Ports that are both in the active set of the vlan_identifier of the LTM and that are in the Forwarding state for that vlan_identifier, except that the Ingress Port is excluded from the set. The query uses the Target MAC Address field of the LTM as the destination_address of the lookup, the Original MAC Address field of the LTM as the source_address, and the vlan_identifier of the LTM. In the case of an MP associated with a PBB-TE or SPBM VID MA, the query uses the destination_address and the vlan_identifier of the LTM as the corresponding parameters for the lookup. If the MP is associated with ECMP with flow filtering, the query uses the flow_hash parameter in the lookup process, when required. The output from this query is a (perhaps reduced) set of potential transmission ports. If the resultant set contains one and only one Bridge Port, that Bridge Port is the Egress Port, and item b)) is not performed. If the resultant set contains more than one Bridge Port, and the MP is associated with a PBB-TE MA, those Bridge Ports are all Egress Ports, and step b is not performed.

NOTE 1—If there are only two Bridge Ports that are members of the VID's member set, the Ingress Port was one of those two Bridge Ports, and the Ingress Port is not connected to a shared medium, then this step can identify the Egress Port even if the FDB is not used for this vlan_identifier.

NOTE 2—This query cannot produce an Egress Port that is the same as the Ingress Port, since the Ingress Port is not included in the set of potential transmission ports.

b) If the FDB could not produce a unique Egress Port, and the MPs serving the vlan_identifier of the LTM are maintaining a MIP CCM Database, and the UseFDBonly bit of the Flags field of the LTM is 0, then ProcessLTM() queries the MIP CCM Database to see whether the target MAC address and vlan_identifier have been retained in that database. If so, and if the Port number in the MIP CCM Database is not the same as the Ingress Port, that Port number identifies the Egress Port.

It is possible that neither of these two steps are able to determine the Egress Port; when a unique Egress Port cannot be determined, an LTM is never forwarded by MHFs other than PBB-TE MHFs or SPBM VID MHFs. PBB-TE MHFs associated with point-to-multipoint TESIs forward LTMs even if multiple Egress Ports are identified. MHFs associated with SPBM VID MAs forward group addressed LTMs even if multiple Egress Ports are identified.

20.47.1.3 LTM is received by a Down MEP

In case a) in 20.47.1.1, illustrated in Figure 20-16, the LTM is received by a Down MEP, and delivered to the Linktrace Responder through its MEP Linktrace SAP (19.2.14). In this case, ProcessLTM() performs the following steps:

a) If the Target MAC Address carried in the LTM is the MAC address of the receiving MEP, then the LTM has reached its target. ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MEP Linktrace SAP of the receiving Down MEP.
b) Otherwise, if the spanning tree state of the Bridge Port and vlan_identifier of the LTM is not Forwarding, the LTM is discarded and no further processing takes place.
c) Otherwise, the Ingress and Egress Ports are determined according to 20.47.1.2. If a unique Egress Port cannot be determined, then the LTM is discarded, and no further processing takes place.
d) Otherwise, i.e., a unique Egress Port was found, ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the Linktrace SAP through which the LTM was received. The LTM is discarded, and no further processing takes place.

20.47.1.4 LTM is received by a Down MHF or originated by an Up MEP

In case b) in 20.47.1.1, illustrated in Figure 20-16, the LTM is received by a Down MHF. In case d) in 20.47.1.1, illustrated in Figure 20-16, the LTM is originated by an Up MEP. In either case, ProcessLTM() performs the following steps:

a) If the LTM was generated by an Up MEP, item b)) and item c)) are skipped, and processing continues with item d)), as follows.

b) If the Target MAC Address carried in the LTM is the MAC address of the receiving MHF, then the LTM has reached its target. ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the Linktrace SAP through which the LTM was received. The LTM is discarded, and no further processing takes place.

c) Otherwise, if the spanning tree state of the Bridge Port and vlan_identifier of the LTM is not Forwarding, the LTM is discarded and no further processing takes place.

NOTE—This test prevents spurious LTRs from being generated on Backup Ports on a shared medium.

d) Otherwise, the Ingress and Egress Ports are determined according to 20.47.1.2. If an Egress Port cannot be determined, then the LTM is discarded, and no further processing takes place.

e) There are three cases for further processing of the LTM, depending on whether, as it passes through the Egress Port, a frame with the LTM's vlan_identifier would first encounter an Up MEP, an Up MHF, or neither. These described in item f)), item g)), item h)), and item i)), as follows.

f) If an Up MHF would be encountered on the Egress Port, then:

   1) ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MHF Linktrace SAP of the Egress Port's Up MHF.

   2) If the target MAC address carried in the LTM is the Egress Port Up MHF's MAC address, then the LTM is discarded, and no further processing takes place.

   3) Otherwise, if the LTM TTL field equals 0 or 1, the LTM is discarded and no further processing takes place.

   4) Otherwise, ProcessLTM() calls ForwardLTM() (20.47.3) to forward an altered copy of the LTM through the LOM Linktrace SAP of the LOM on the identified Egress Port.

g) If an Up MEP at the MD Level of the LTM would be encountered on the Egress Port, then:

   1) ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MHF Linktrace SAP of the Ingress Port's Down MHF, or the MEP LTI SAP of the Up MEP, that delivered the LTM to the Linktrace Responder.

   2) The LTM is discarded, and no further processing takes place.

h) Otherwise, if an Up MEP higher than the MD Level of the LTM would be encountered on the Egress Port, then the LTM is discarded, and no further processing takes place.

i) If neither an Up MHF, nor an Up MEP at an MD Level higher than or equal to the LTM, would be encountered on the Egress Port, then:

   1) ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MHF Linktrace SAP of the Ingress Port's Down MHF.

   2) If the LTM TTL field equals 0 or 1, the LTM is discarded and no further processing takes place.

   3) Otherwise, ProcessLTM() calls ForwardLTM() (20.47.3) to forward an altered copy of the LTM through the LOM Linktrace SAP of the LOM that a frame with the LTM's vlan_identifier would first encounter when passing out through the identified Egress Port.

20.47.1.5 LTM is received by an Up MEP

In case c) in 20.47.1.1, illustrated in Figure 20-16, an LTM enters a Bridge on a Bridge Port that has no MEP or MHF and therefore only an LOM. The LTM can therefore be received by an Up MEP such as the one on Port 3 of Figure 20-16. Processing of an LTM received on an Up MEP proceeds as follows:

a) If the Target MAC Address carried in the LTM is the MAC address of the receiving MEP, then the LTM has reached its target. ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MEP Linktrace SAP of the receiving Up MEP. The LTM is discarded, and no further processing takes place.
b) Otherwise, the Ingress and Egress Ports are determined according to 20.47.1.2. If the Egress Port cannot be determined, or if the Egress Port is not the Bridge Port on which the receiving MEP is configured, then the LTM is discarded and no further processing takes place.
c) Otherwise, (i.e., the Egress Port is that of the receiving Up MEP) ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MEP Linktrace SAP of the receiving Up MEP. The LTM is then discarded.

20.47.1.6 LTM is received by an Up MHF

In case c) in 20.47.1.1, illustrated in Figure 20-16, an LTM enters a Bridge on a Bridge Port that has no MEP or MHF and therefore only an LOM. The LTM can therefore be received by an Up MHF such as the ones on Port 2 and Port 6 of Figure 20-16. Processing of an LTM received on an Up MHF proceeds as follows:

a) If the Target MAC Address carried in the LTM is the MAC address of the receiving Up MHF (i.e., that of the Bridge Port on which that MHF resides), then the LTM has reached its target. ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MHF Linktrace SAP of the receiving Up MHF. The LTM is discarded, and no further processing takes place.
b) Otherwise, the Ingress and Egress Ports are determined according to 20.47.1.2. If the Egress Port cannot be determined, or if the Egress Port is not the Bridge Port on which the receiving MHF is configured, then the LTM is discarded, and no further processing takes place.
c) Otherwise,
    1) ProcessLTM() calls enqueLTR() (20.47.4) to enqueue an LTR for the MHF Linktrace SAP of the receiving Up MHF.
    2) If the LTM TTL field equals 0 or 1, the LTM is discarded and no further processing takes place.
    3) Otherwise, ProcessLTM() calls ForwardLTM() (20.47.3) to forward an altered copy of the LTM through the MHF Linktrace SAP of the LOM on the same Bridge Port as the Up MHF that received the LTM.

20.47.2 clearPendingLTRs()

Clears the queue of pending LTRs for this MP. Resets nPendingLTRs to 0.

20.47.3 ForwardLTM()

Constructs and transmits a single LTM. Using the original input LTM and the Linktrace Responder SAP through which the LTM (LTR) is to be output, ForwardLTM() performs the following steps:

a) Uses the MAC address of the LOM owning the SAP specified for output as the source_address parameter of the LTM.
b) Uses the destination_address and priority parameters of the input LTM as the destination_address and priority of the forwarded LTM.
c) Sets the drop_eligible parameter of the forwarded LTM to false.

d) Uses the same value for the vlan_identifier parameter for the forwarded LTM that was presented with the received LTM.
e) In the case of ECMP with flow filtering, the flow_hash parameter and the time_to_live parameter of the forwarded LTM are set to values presented with the received LTM.
f) In PBB-TE related MAs, uses the destination_address, source_address, and vlan_identifier of the input LTM and sets the drop_eligible parameter of the forwarded LTM to FALSE.
g) Copies, verbatim, all fields and TLVs, regardless of whether known to the Linktrace Responder, from the input LTM to the forwarded LTM, except that ForwardLTM():
    1) Places in the forwarded LTM TTL field the value from the input LTM TTL field decremented by 1.
    2) Changes the value in the LTM Egress Identifier TLV to identify the forwarding Linktrace Responder.
    3) Deletes the Sender ID TLV (21.5.3), if present in the LTM.
    4) Optionally, places a Sender ID TLV (21.5.3), identifying the forwarding system, in the LTM.
h) Transmits the forwarded LTM on the specified SAP.

20.47.4 enqueLTR()

Constructs and enqueues a single LTR for later transmission by xmitOldestLTR() as follows. Using the input LTM and the Linktrace Responder SAP through which the LTR is to be output, enqueLTR() performs the following steps:

a) Uses the MAC address contained in the LTM's Original MAC Address field as the destination_address of the LTR. If the MP is associated with a PBB-TE MA, the LTR uses as destination_address,
    1) The value carried in the Reverse MAC field, contained in the PBB-TE MIP TLV of the received LTM, if this is a group MAC address; otherwise,
    2) The source_address of the received LTM.
b) Uses the MAC address of the MP owning the SAP specified for output as the source_address of the LTR, if the MP is not a PBB-TE MHF; otherwise, the LTR uses as the source_address:
    1) The value of the destination_address of the received LTM if this is an individual MAC address; otherwise,
    2) The value carried in the Reverse MAC field, contained in the PBB-TE MIP TLV of the received LTM,
c) If the LTR includes a Reply Egress TLV [see the following item r))], uses the Primary VID of the MP on that Egress Port as the vlan_identifier of the LTR, else it uses the Primary VID of the MP on the Ingress Port as the vlan_identifier of the LTR. In PBB-TE related MA's, sets the vlan_identifier parameter as the value carried in the Reverse VID field contained in the PBB-TE MIP TLV of the received LTM.
d) Sets the priority parameter to the same value as for CCMs [item h) in 12.14.7.1.3].
e) In the case of ECMP with flow filtering, the flow_hash parameter is set to zero and the time_to_live parameter is set to 63.
f) Sets the drop_eligible parameter to FALSE.
g) Places its own version in the Version field.
h) If its own version is lower than that of the received LTM, sets all bits and fields in the transmitted PDU that are reserved in its own version, including all bits between the portion of the last header field defined for its own version and the first TLV, to 0.
i) Sets the FwdYes bit of the Flags field to 1 if the LTM was forwarded by the Linktrace Responder, or 0 if not.

j) Sets the TerminalMEP bit of the Flags field to 1 if the MP reported in either the Reply Ingress TLV or the Reply Egress TLV is a MEP, or 0 if not.

k) Copies the Flags field, excepting the FwdYes bit and the TerminalMEP bit, from the LTM to the LTR.

l) Copies the LTM Transaction Identifier field from the LTM to the LTR Transaction Identifier field of the LTR.

m) Copies the LTM Egress Identifier TLV (21.8.8) value from the LTM to the Last Egress Identifier field (21.9.7.1) of the LTR Egress Identifier TLV, or places 0 in that field, if there is no LTM Egress Identifier TLV in the received LTM (see J.4).

n) Sets the Next Egress Identifier field (21.9.7.2) of the LTR Egress Identifier TLV to a value that identifies the forwarding Linktrace Responder (see 21.8.8).

o) Places one less than the value in the LTM TTL field of the LTM in the Reply TTL field of the LTR;

p) Sets the Relay Action field according to Table 21-27.

q) If the LTM was not received by a Down MEP or Down MHF, does not place a Reply Ingress TLV in the LTR; otherwise,

   1) Fills the Ingress Action field of a Reply Ingress TLV (21.9.8) with the appropriate value according to Table 21-30;

   2) Places the receiving MP's MAC address in the Ingress MAC Address field of the Reply Ingress TLV; and

   3) Optionally, fills the remainder of the Reply Ingress TLV with the receiving MP's Port ID information.

r) If the LTM was received by a Down MEP, or if no Egress Port was identified, or if no Up MEP nor Up MHF belonging to the LTM's MA is configured on the Egress Port, does not place a Reply Egress TLV in the LTR; otherwise,

   1) Fills the Egress Action field of a Reply Egress TLV (21.9.9) with the appropriate value according to Table 21-32;

   2) Places the Egress Port's Up MP's MAC address in the Egress MAC Address field of a Reply Egress TLV in the LTM; and

   3) Optionally, fills the remainder of the Reply Egress TLV with Egress Port's Port ID information.

s) As controlled by the managed objects item e) in 12.14.3.1.3, item d) in 12.14.5.1.3, and item d) in 12.14.6.1.3, places a Sender ID TLV (21.5.3), identifying the replying Bridge, in the LTM.

t) Copies, verbatim, all other TLVs in the input LTM to the LTR, except for the Sender ID TLV (21.5.3), which is not copied.

NOTE 1—Forwarding all unknown TLVs in both the LTM and the LTR enables future revisions of this standard, and designers of Organization-Specific TLVs, to add new capabilities.

NOTE 2—The resultant LTR can be larger than the maximum frame size for the media-dependent sublayer on which the LTR is to be transmitted, causing the LTR to be discarded.

u) Increments nPendingLTRs by 1.

20.48 LTM Receiver state machine

One instance of the LTM Receiver state machine is instantiated by Bridge's Linktrace Responder. The LTM Receiver state machine implements the function specified by the state diagram in Figure 20-17, the variables in 20.46, and the procedures in 20.47.

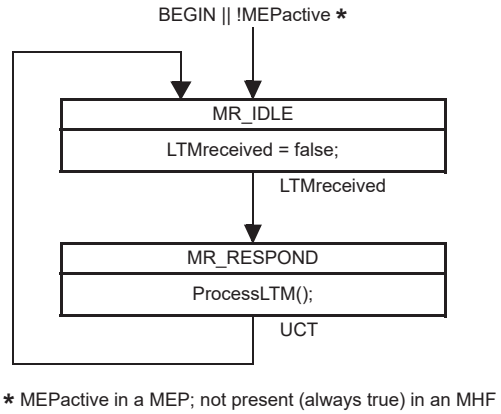


Figure 20-17—LTM Receiver state machine

20.49 LTR Transmitter procedure

The following procedure is local to the LTR Transmitter state machine:

a) xmitOldestLTR() (20.49.1)

20.49.1 xmitOldestLTR()

If and only if nPendingLTRs is nonzero, dequeues a single LTR and transmits it, and decrements nPendingLTRs by 1.

20.50 LTR Transmitter state machine

One instance of the LTR Transmitter state machine is instantiated by Bridge's Linktrace Responder. The LTR Transmitter state machine implements the function specified by the state diagram in Figure 20-18, the variables in 20.46, and the procedures in 20.47.

This state machine implements the requirement of (20.3.2) to wait a random time interval after receiving an LTM before transmitting an LTR by means of a free running 1 s timer, the expiry of which triggers all LTR transmissions. This method avoids the need to create and manage a timer for every LTM received. Any other implementation that meets the requirements of 20.3.2 can be used in place of this state machine.

20.51 CFM PDU validation and versioning

The purpose of this subclause is to state specific goals to be achieved by CFM with respect to the relationship of this and future versions of this standard, and to define the procedures necessary to meet those goals.

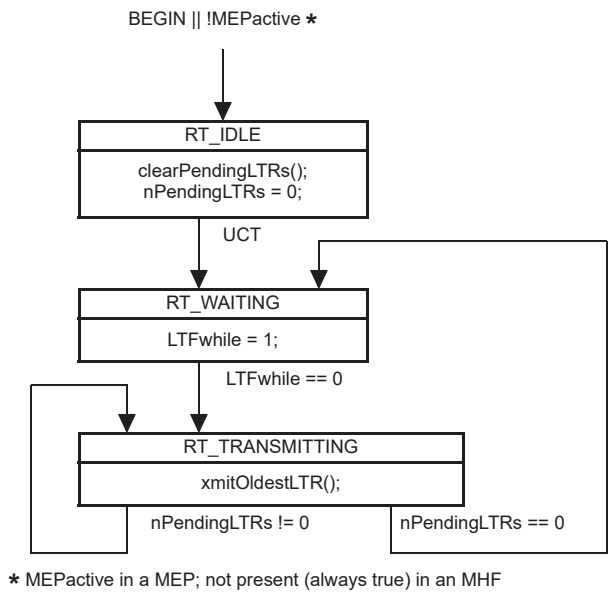


Figure 20-18—LTR Transmitter state machine

20.51.1 Goals of CFM PDU versioning

The goals of CFM with respect to the relationship of this and future versions of this standard are to ensure that:

a) Implementations of this standard will interoperate with implementations of future versions of this standard.
b) Implementers will be able to offer proprietary, nonstandard extensions to this standard with enhanced functionality.
c) Conformant but extended implementations of this standard will not restrict the ability of future versions of this standard to extend the standard functionality.

20.51.2 PDU transmission

In order to ensure that future versions of CFM will be compatible with implementations of this standard, certain requirements are placed on transmitted CFM PDUs:

a) The fixed header fields shall be transmitted exactly as specified in this standard.
b) All bits defined as “reserved” in this standard, e.g., unused bits in the Flags field, shall be transmitted as 0.
c) Additional fields shall not be added to the fixed header specified in this standard.
d) Code points reserved in this standard, or in ITU-T G.8013/Y.1731, e.g., additional values for the OpCode field in the fixed header (Table 21-3), the Type field in a TLV (Table 21-5), or the reserved values in Table 21-18 for the Maintenance Domain Name Format, shall not be transmitted in any CFM PDU.
e) Additional fields shall not be added to any TLV specified in this standard.

Organization-Specific TLVs can be defined by any organization possessing an OUI or a CID, and may be transmitted by an implementation conformant to this standard.

NOTE—The preceding is not an exhaustive list of the restrictions on the transmission of CFM PDUs; it is only a list of the specifications that are most important to future compatibility.

20.51.3 PDU validation

CFM PDUs that fail certain specified tests are discarded by MPs. This requirement is described here as a two-pass processing algorithm, first a Validation Pass, and then an Execution Pass. The Validation Pass is performed first. If and only if it succeeds, the Execution Pass is performed. This description does not preclude other algorithms. For example, an MP could process a CFM PDU in one pass, building a tentative list of changes to the affected state machines and databases, and commit the changes only after the processing has succeeded. However, the behavior of such an implementation shall be indistinguishable, in terms of externally observable behavior (i.e., Management Objects and protocol frames) from the two-pass algorithm described in this subclause.

20.51.4 Validation pass

During the Validation pass, no changes are made to any CFM database other than the updating of certain management counter variables. No protocol state machines are affected, and no changes are made to any CFM PDUs that can be transmitted by the receiving MP. The description of the Validation pass is split into three parts:

a) Operations required of an MP Level Demultiplexer (20.51.4.1)
b) Operations required of all MP components when performing the Validation pass (20.51.4.2)
c) Operations that are required of some MP components, and optional for others (20.51.4.3)

20.51.4.1 Validation pass operations required of an MP Level Demultiplexer

If the following test fails, the receiving MP Level Demultiplexer (19.2.6) shall consider the CFM PDU invalid and discard it:

a) The length of the mac_service_data_unit is long enough to contain a complete MD Level field.

20.51.4.2 Validation pass operations required of MP components

All bits declared “reserved” in this standard, e.g., unused bits in the Flags field, shall be ignored by the receiving MP.

The receiving MP processes the CFM PDU in accordance with the numerically lower of 1) the Version field in the CFM PDU and 2) the highest Version number known to the receiving implementation. That is, a Version 1 implementation receiving a Version 0 CFM PDU processes it according to Version 0 of this standard, and it processes a Version 2 CFM PDU according to Version 1. The IEEE 802.1 Working Group places the imposition on future versions of this standard that all earlier version implementations can process their CFM PDU properly.

As an example of the use of this rule, if a new Flags field bit is defined in Versions 2 and 3, then a Version 3 implementation receiving a Version 1 CFM PDU will ignore that bit, even though the bit is defined in both Version 2 and Version 3, and even though the bit is actually set.

NOTE 1—One effect of this rule is that an implementation conformant to this Version of this standard, Version 0, ignores the Version field in a received CFM PDU.

The following criteria shall not be used by a CFM entity to validate a received CFM PDU:

a) The fixed header can be longer than the length specified by the version of this standard indicated by the CFM PDU’s Version field.
b) Bits can be set in reserved bits of the Flags field.
c) A TLV can have a Type field not specified by this standard.

d) A TLV's Length field can be larger than the value (if any) specified in this standard. (This allows TLVs to be extended in future Versions.)

e) Either the First TLV Offset field, or the Length field of the last TLV, in the CFM PDU, can indicate a position for the first (next) TLV that coincides with the end of the mac_service_data_unit containing the CFM PDU. That is, the End TLV can be missing from the CFM PDU if the frame is longer than or equal to the minimum frame size for the media-dependent MAC sublayer.

NOTE 2—These latter criteria cannot be used by a CFM entity to validate a received CFM PDU. This helps to ensure that the CFM PDUs transmitted by future versions of this standard will be considered valid by implementations of the current version (0) of this standard. These criteria can, however, be used by test equipment in order to test the conformance of a system to this standard, e.g., to the rules in 20.51.2.

20.51.4.3 Validation pass operations required of some receiving MP components

The following Validation pass tests are required of some receiving MP components, and are optional for other MP components, as specified in other subclauses. If performed, and if any test fails, the receiving System shall consider the CFM PDU invalid and discard it.

a) The fixed header length, as determined by the First TLV Offset field (21.4.5), is not shorter than the length specified by the version selected according to 20.51.4.2.

b) The fixed-length header does not run over the end of the mac_service_data_unit.

c) A TLV Length field does not run over the end of the mac_service_data_unit.

d) A TLV Length field does not indicate a length that is shorter than the minimum length for that TLV as specified by the Version field of the CFM PDU.

e) Every header field and TLV in the CFM PDU meets the validity criteria specified in the header field and TLV definitions in Clause 21 (see the Validation Test headings in that clause).

20.51.5 Execution pass

The CFM PDU is processed in the Execution Pass. Changes to the CFM databases can be made, the state machines can change states, and the contents of future CFM PDUs can be affected by these changes. The receiving MP:

a) Processes the CFM PDU in accordance with the numerically lower of 1) the Version field in the CFM PDU; and 2) the highest Version number known to the receiving implementation.

b) Processes only those fields in the fixed header portion of the CFM PDU that are defined in the selected Version of the standard, and ignores any extra octets in the fixed header, if the fixed header is longer than the length specified by the selected Version.

c) Ignores any TLV with a Type field not specified by the selected Version.

d) Does not process any part of the CFM PDU following the End TLV (the lack of an End TLV is not an error).

e) Ignores any octets following those specified by the selected Version, if any TLV's Length field is larger than the value (if any) specified the selected Version.

f) Ignores all bits undefined in this standard, e.g., unused bits in the Flags field.

Unlike the loss of ST BPDUs, the loss of CFM PDUs cannot completely disrupt the function of the network. Also, unlike other control protocols such as the IEEE 802.3 Slow Protocols, CFM PDUs can be presented at an arbitrarily high rate. Therefore, a Bridge shall ensure that receiving CFM PDUs on all Bridge Ports at the maximum possible rate supported by the MAC Services underlying those ports shall not significantly increase the probability of the failure of the Bridge to maintain loop-free forwarding paths in the bridged network. Rather, the Bridge's CPU can be protected against excess CFM PDUs in a similar manner as for other potential Denial of Service attacks.

20.51.6 Future extensions

It is expected that future versions of this protocol will utilize the above versioning rules in order to extend the CFM PDU format in any number of ways, including perhaps:

a) Adding new fields to the header by increasing the minimum size of the First TLV Offset field, and placing the new header fields after the First TLV Offset field in the Version 0 header.
b) Adding new TLVs and extending the lengths of existing TLVs with new fields.
c) Adding a new TLV, that is the first TLV to be processed, by renaming the First TLV Offset field to the "First Version 0 TLV Position," adding a new "Version X Header Length" field following the fields in the Version 0 header, and inserting one or more Version X TLVs just ahead of the first required Version 0 TLV.
d) Adding new information, perhaps fixed-length information, that is required to follow the End TLV specified in Version 0.

Other methods for extending the CFM PDU format are certainly possible. It is therefore critical that Version 0 implementations adhere to the versioning requirements of this clause.

NOTE—The extension options discussed in this clause are reserved for use by future versions of this standard. Each one is a violation of 20.51.2, 20.51.4, and/or 20.51.5. The Organization-Specific TLV is the only available compliant extension to this standard.

20.52 PDU identification

A received CFM PDU is associated with a particular MP. Every data frame, including one carrying a CFM PDU, has some means, either explicit or implicit, by which that frame can be associated by the receiver with a particular service instance. In a Bridge that is not VLAN aware, there is only one service instance. In a VLAN Bridge, the vlan_identifier (6.8) identifies the service instance. The means by which the appropriate receiving MP for processing a received CFM PDU is selected are as follows:

a) The direction (PHY side or MAC Relay Entity side) from which the CFM PDU was received.
b) The implicit or explicit association of the frame with a particular service instance (the vlan_identifier).
c) The MD Level field in the CFM Header.

Once the frame containing the CFM PDU has been delivered to the appropriate entity within an MP, the destination_address can be used to decide whether the CFM PDU is to be processed or discarded, as specified in the description of each entity.

The MAID and/or Maintenance association Endpoint Identifier field is not used to identify the receiving MP. Thus, if the Individual MP address model (see J.6) is used by a particular Bridge, and each MP uses its Bridge Port's individual MAC address, then the VID, MD Level, and flow direction uniquely identify the receiving MEP. If the Shared MP address model is used by a Bridge, so that Up MPs in the Bridge can share a MAC address, then the specific Bridge Port that is the target of an LBM can be genuinely ambiguous. This ambiguity allows the designer to trade the value of detailed information against cost of obtaining that information.

20.53 Use of transaction IDs and sequence numbers

Each CCM, LBM, and LTM has a field (21.6.3, 21.7.3, and 21.8.3) that is incremented for each PDU transmitted of each type, so that consecutively transmitted PDUs are in numerical order. The variables that control these fields are CCIsentCCMs (20.10.2, for CCM), nextLBMtransID (20.30.2, for LBM), and nextLTMtransID (20.41.1, for LTM).

In theory, every MEP in a Bridge has a CCIsentCCMs variable, a nextLBMtransID variable, and a nextLTMtransID variable, independently from every other MEP. Therefore, any number of MEPs in a single Bridge could be transmitting independent streams of LBMs and LTMs as long as they have different MAC addresses. (If they had the same MAC address, they could not tell each others' LBRs and LTRs apart.)

In practice, there can be fewer instances of these variables and their corresponding state machines than one each per MEP. The managed objects in Clause 12, particularly the definitions of the MEP's LBR counters [item y) in 12.14.7.1.3 and item z) in 12.14.7.1.3] and the responses permitted to the Transmit Loopback Messages command (12.14.7.3.3), are specified so that any number of MEP Loopback Initiator transmit state machines, from one to the number of MEPs, can be implemented. Each state machine can increment its own nextLBMtransID variable to determine the next transmitted Loopback Transaction Identifier field. Similarly, the allowed responses to the Transmit Linktrace Message command (12.14.7.4.3) provide the same latitude for the number of nextLTMtransID variables implemented. The resources for transmitting LTMs or streams of LBMs can then be used serially, rather than simultaneously, by different MEPs in the same Bridge.

On the other hand, every MEP that is incrementing its CCIsentCCMs variable has its own instance of that variable, and thus its own MEP Continuity Check Initiator state machine, because the Remote MEP state machines receiving those CCMs are tracking each MEP's sequence of CCMs independently. A MEP can also transmit 0 in every CCM's Sequence Number field.

21. Encoding of CFM PDUs

This clause specifies the method of encoding CFM PDUs. The specifications include the following:

a) Format used to encapsulate or decapsulate a CFM PDU in a frame (21.2).
b) Format of the Common CFM Header, used in all CFM PDUs (21.4).
c) Format used for all Type, Length, Value (TLV) information elements that can be included in CFM PDUs (21.5).
d) Formats of the Continuity Check Message (CCM, 21.6), the Loopback Message and Loopback Reply (LBM and LBR, 21.7), the Linktrace Message (LTM, 21.8), Linktrace Reply (LTR, 21.9), Send Frame Message (SFM, 29.4.3), and the Reflected Frame Message (RFM, 29.4.2).

NOTE—Clause 18 introduces the principles of CFM operation and the network architectural concepts that support it. Clause 19 breaks down the CFM protocol entities into their components. Clause 20 specifies the protocols operated by the components of each MP. The use of CFM within systems and networks is further described in Clause 22.

21.1 Structure, representation, and encoding

All CFM PDUs shall contain an integral number of octets.

The octets in a CFM PDU are numbered starting from 1 and increasing in the order they are put into the MSDU that accompanies a request to or indication from the instance of the MAC Internal Sublayer Service (ISS or EISS) used by a CFM entity.

The bits in an octet are numbered from 1 to 8 in order of increasing bit significance, where 1 is the LSB in the octet.

Where octets and bits within a CFM PDU are represented using a diagram, octets shown higher on the page than subsequent octets and octets shown to the left of subsequent octets at the same height on the page are lower numbered; bits shown to the left of other bits within the same octet are higher numbered.

Where two or more consecutive octets are represented as hexadecimal values, lower numbered octet(s) are shown to the left and each octet following the first is preceded by a hyphen, e.g., 01-80-C2-00-00-00.

When consecutive octets are used to encode a binary number, the lower octet number has the more significant value. When consecutive bits within an octet are used to encode a binary number, the higher bit number has the most significant value. When bits within consecutive octets are used to encode a binary number, the lower octet number composes the more significant bits of the number. A flag is encoded as a single bit, and is set (True) if the bit takes the value 1, and clear (False) otherwise. The remaining bits within the octet can be used to encode other protocol fields.

21.2 CFM encapsulation

The means for identifying CFM PDUs consists of two octets containing the EtherType value shown (in hexadecimal notation) in Table 21-1.

Table 21-1—CFM PDU Encapsulation EtherType

Name	Value
IEEE 802.1Q CFM PDU Encapsulation EtherType	89-02

21.3 CFM request and indication parameters

21.3.1 destination_address parameter

There are three classes of CFM PDUs in terms of the CFM entities to which they are addressed:

a) Those addressed to all MEPs in a service instance (CCM).
b) Those addressed to the set of MPs immediately adjacent to the transmitting MP, at a certain MD Level, in a service instance (LTM).
c) Those addressed to a single, specific MP (LBM, LBR, LTR).

Frames carrying CFM PDUs belonging to two different MAs, but at the same MD Level, are distinguished from each other in the same manner as data frames are distinguished from each other in the corresponding service instances monitored by those MAs.

In a VLAN Bridge, it is the VID that distinguishes service instances. CCMs monitoring a service instance distinguished by its VID use the group MAC addresses listed in Table 8-18 as the destination_address. LTMs monitoring a VID-distinguished service instance use those shown in Table 8-19. All but the last three bits of the destination_address are fixed by the OpCode, either CCM or LTM. As shown in these two tables, the last three bits of the destination_address match the MD Level field of the CFM PDU Header. CFM PDUs belonging to MAs monitoring service instances distinguished by their I-SID use the same set of destination addresses as those belonging to MAs monitoring VLAN service instances. MAs monitoring TESIs are distinguished from MAs monitoring VLAN services by the vlan_identifier parameters and from each other by the 3-tuples <ESP-DA, ESP-SA, ESP-VID> of their ESPs. CFM PDUs belonging to PBB-TE MAs use the MAC address identified in the ESP-DA fields of their ESP identifiers.

21.3.2 source_address parameter

The individual MAC address of the MP transmitting the PDU. This is the MAC address of the transmitting MP. An MP's MAC address is not necessarily unique; MPs configured on the same Bridge Port can share the same MAC address. The principles used to allocate Organization Unique Identifiers (OUIs) required that universally unique MAC addresses (those with the U/L bit = 0, see 8.2 of IEEE Std 802-2014 [B5]) not be used to create MP MAC addresses separately from a physical instance of an IEEE 802 MAC. See J.6 for a discussion of possible assignments of MAC addresses to MPs.

Validation Test: The source_address parameter contains an Individual, and not a Group, MAC address.

21.4 Common CFM Header

The format of a CFM PDU is shown in Table 21-2. A CFM PDU is identified by the encapsulation described in 21.2. Octets 1 through 4, including the MD Level, Version, OpCode, Flags, and First TLV Offset fields, constitute the Common CFM Header.

21.4.1 MD Level

(most significant 3 bits) Integer identifying the Maintenance Domain Level (MD Level) of the frame. Higher numbers correspond to higher MAs, those with the greatest physical reach, with the highest values for customers' CFM frames. Lower numbers correspond to lower MAs, those with more limited physical reach, with the lowest values for single Bridges or physical links.

21.4.2 Version

(least significant 5 bits) The protocol version number, always 0. Ignored on receipt.

Table 21-2—Common CFM Header format

Field	Octet
MD Level	1 (high-order 3 bits)
Version	1 (low-order 5 bits)
OpCode	2
Flags	3
First TLV Offset	4
Varies with value of OpCode	5
End TLV (0)	First TLV Offset + 5

21.4.3 OpCode

(1 octet) The OpCode field specifies the format and meaning of the remainder of the CFM PDU. Certain values of the OpCode field are reserved for allocation by IEEE 802.1 and/or other organizations. The values for the various CFM PDU types are shown in Table 21-3. When assigning new OpCode values, pairs of CFM PDUs that operate in stimulus-response fashion, such as the LBM/LBR or the LTM/LTR pairs, will use even/odd pairs of values such that the odd (numerically larger) of the two values is the stimulus, and the even (numerically smaller) the response.

Table 21-3—OpCode Field range assignments

CFM PDU or organization	OpCode range
Reserved for IEEE Std 802.1	0
Continuity Check Message (CCM)	1
Loopback Reply (LBR)	2
Loopback Message (LBM)	3
Linktrace Reply (LTR)	4
Linktrace Message (LTM)	5
Reflected Frame Message (RFM)	6
Send Frame Message (SFM)	7
Reserved for IEEE Std 802.1Q	8–31
Defined by ITU-T G.8013/Y.1731	32–63
Reserved for IETF (RFC 7319 [B44])	64–95
Reserved for IEEE Std 802.1	96–255

21.4.4 Flags

(1 octet) The use of the Flags field is defined separately for each OpCode.

21.4.5 First TLV Offset

(1 octet) The offset, starting from the first octet following the First TLV Offset field, up to the first TLV in the CFM PDU. The value of the First TLV Offset field shall be transmitted as indicated in the specification for each of the OpCode field values, as follows (21.6.2, 21.7.2, 21.8.2, and 21.9.2).

21.5 TLV format

TLV stands for *Type, Length, Value* and denotes a method of encoding variable-length and/or optional information in a PDU. TLVs are not aligned to any particular word or octet boundary. TLVs follow each other with no padding between TLVs.

21.5.1 General format for CFM TLVs

The TLV format is shown in Table 21-4.

Table 21-4—TLV format

Field	Octet
Type	1
Length	2–3
(Value)	4

21.5.1.1 Type

(1 octet) Required. If 0, no Length or Value fields follow. If not 0, at least the Length field follows the Type field. The Type field is encoded as shown in Table 21-5.

21.5.1.2 Length

(2 octets) Required if the Type field is not 0. Not present if the Type field is 0. The 16 bits of the Length field indicate the size, in octets, of the Value field. 0 in the Length field indicates that there is no Value field.

21.5.1.3 Value

(Length specified by the Length field) Optional. Not present if the Type field is 0 or if Length field is 0.

21.5.2 Organization-Specific TLV

Type = 31. Any organization can define TLVs for use in CFM. The format for such TLVs is shown in Table 21-6. The “OUI/CID” is an organizationally unique identifier or a Company ID, obtainable from IEEE.[36] The Subtype is required, so that an additional OUI/CID will not be required if more Organization-Specific TLV are required by an owner of an OUI/CID.

[36] Interested applicants should contact the IEEE Standards Department of The Institute of Electrical and Electronics Engineers (https://standards.ieee.org/regauth/index.html).

Table 21-5—Type Field values

TLV or organization	Type field
End TLV	0
Sender ID TLV	1
Port Status TLV	2
Data TLV	3
Interface Status TLV	4
Reply Ingress TLV	5
Reply Egress TLV	6
LTM Egress Identifier TLV	7
LTR Egress Identifier TLV	8
PBB-TE MIP TLV	9
Data Part 1 TLV (29.3.3.2)	10
Data Part 2 TLV (29.3.3.2)	11
Truncated Data TLV (29.3.3.2)	12
Reserved for IEEE Std 802.1Q	13–30
Organization-Specific TLV	31
Defined by ITU-T G.8013/Y.1731	32–63
Reserved for IETF (RFC 7319 [B44])	64–95
Reserved for IEEE Std 802.1	96–255

Table 21-6—Organization-Specific TLV format

Field	Octet
Type = 31	1
Length	2–3
OUI/CID	4–6
Subtype	7
Value (optional)	8 – (Length + 3)

This TLV category is provided to allow different organizations, such as IEEE 802.1, IEEE 802.3, ITU-T, as well as individual software and equipment vendors, to define TLVs that advertise information to remote entities attached to the same media, subject to the following restrictions:

a) Information transmitted in an Organization-Specific TLV shall not require the recipient to violate any requirement in this standard.
b) Information transmitted in one Organization-Specific TLV shall not be used to provide a means for sending messages that are larger than would fit within a single CFM PDU.
c) Organization-Specific TLVs shall conform to 20.51.

21.5.3 Sender ID TLV

Type = 1. Identifies the Bridge on which the transmitting MP is configured and may also include a management address for that Bridge. The allowed values are those contained in the Chassis ID TLV and Management Address TLV in IEEE Std 802.1AB, modified to fit into a CFM TLV, as shown in Table 21-7. Whether the Sender ID TLV is transmitted, and what information is included in the TLV, are controlled by managed objects [item e) in 12.14.3.1.3, item d) in 12.14.5.1.3, item d) in 12.14.6.1.3].

Table 21-7—Sender ID TLV format

Field	Octet
Type = 1	1
Length	2–3
Chassis ID Length	4
Chassis ID Subtype	5
Chassis ID	6 – (Chassis ID Length + 5)
Management Address Domain Length	(Chassis ID Length + 6)
Management Address Domain	(Chassis ID Length + 7) – (Chassis ID Length + Management Address Domain Length + 6)
Management Address Length	(Chassis ID Length + Management Address Domain Length + 7)
Management Address	(Chassis ID Length + Management Address Domain Length + 8) – (Length + 3)

Validation Test: The Length field is large enough to contain all of the fields indicated as being present by the Chassis ID Length, Management Address Domain Length, and/or Management Address Length fields.

21.5.3.1 Chassis ID Length

(1 octet) The length, in octets, of the Chassis ID field. 0 if no Chassis ID is specified. Always present.

Validation Test: The Chassis ID Length field either is 0, or is less than (TLV Length field value – 1).

21.5.3.2 Chassis ID Subtype

(1 octet) The **chassis ID subtype**, as specified by IEEE Std 802.1AB, identifying the type of the component referenced by the Chassis ID field. Not present if the Chassis ID Length field contains 0.

21.5.3.3 Chassis ID

(Length specified by the Chassis ID Length field) Identifies the chassis. Specified by IEEE Std 802.1AB. Not present if the Chassis ID Length field contains 0.

21.5.3.4 Management Address Domain Length

(1 octet) The Management Address Domain Length field contains the length, in octets, of the Management Address Domain field. If 0, or if the TLV's Length field indicates that the Management Address Domain Length field is not present, then the Management Address Domain, Management Address Length, and Management Address fields are not present.

21.5.3.5 Management Address Domain

(Length specified by the Management Address Domain Length field) The Management Address Domain field specifies the format and type of the contents of the Management Address field, as well as a management mechanism. The format of the Management Address Domain field shall be that of an Object Identifier (OID), as specified by section 8.19 in ITU-T X.690 (2002). The OID references a TDomain (IETF RFC 2579). Standard values that are useful for the Management Address Domain field include, but are not limited to,

— transportDomainUdpIpv4, indicating Simple Network Management Protocol (SNMP) over User Datagram Protocol (UDP) over IPv4 (IETF RFC 3419).

— transportDomainUdpIpv6, indicating SNMP over UDP over IPv6 (IETF RFC 3419).

— snmpIeee802Domain, indicating SNMP over the MAC Service (IETF RFC 4789).

This field is not present if the Management Address Domain Length field is not present or contains a 0.

21.5.3.6 Management Address Length

(1 octet) The length, in octets, of the Management Address field. This field is not present if the Management Address Domain Length field is not present or contains a 0.

21.5.3.7 Management Address

(Length specified by the Management Address Length field) Identifies a TransportDomain (IETF RFC 3419, IETF RFC 4789) through which the Bridge in which the transmitting MP is configured can be managed. The format of the Management Address field is specified by the MIB module defining the TransportDomain. This field is not present if the Management Address Domain Length field is not present or contains a 0, or if the Management Address Length field is not present or contains a 0.

NOTE—The contents of the Management Address Domain and Management Address are defined in terms of MIB modules. Therefore, a published MIB module is required in order to define a specific valued that can be used in the Management Address Domain field. However, the use of Management Address Domain field by a system does not require that the system be manageable via SNMP; the published MIB module could define, for example, a TransportDomain for a proprietary Command Line Interpreter over ITU-T X.25 [B50].

21.5.4 Port Status TLV

Type = 2. The Port Status TLV indicates the ability of the Bridge Port on which the transmitting MEP resides to pass ordinary data, regardless of the status of the MAC. The value of this TLV is driven by the MEP variable enableRmepDefect (20.9.2), as shown in Table 21-9. The format of this TLV is shown in Table 21-8. Any change in the Port Status TLV's value triggers one extra transmission of that Bridge Port's MEPs' CCMs.

Table 21-8—Port Status TLV format

Field	Octet
Type = 2	1
Length	2–3
See Table 21-9	4

Validation Test: The Port Status TLV contains one of the values listed in Table 21-9.

Table 21-9—Port Status TLV values

mnemonic	Ordinary data passing freely through the Port	value
psBlocked	No: enableRmepDefect = false	1
psUp	Yes: enableRmepDefect = true	2

A MEP that is configured in a Bridge in a position that is not associated with a single value for the Port State and VID member set, e.g., a MEP in position 5 in Figure 22-9, on a Bridge running multiple spanning tree instances via MSTP, shall not transmit the Port Status TLV.

21.5.5 Interface Status TLV

Type = 4. The Interface Status TLV indicates the status of the interface on which the MEP transmitting the CCM is configured (which is not necessarily the interface on which it resides, see J.6), or the next lower interface in the IETF RFC 2863 IF-MIB. The format of this TLV is shown in Table 21-10. The enumerated values are shown in Table 21-11. These values correspond to the values for ifOperStatus in IETF RFC 2863.

Table 21-10—Interface Status TLV format

Field	Octet
Type = 4	1
Length	2–3
See Table 21-11	4

Validation Test: The Interface Status TLV field contains one of the values listed in Table 21-11.

Table 21-11— Interface Status TLV values

mnemonic	Interface Status (IETF RFC 2863 ifOperStatus)	value
isUp	up	1
isDown	down	2
isTesting	testing	3
isUnknown	unknown	4
isDormant	dormant	5
isNotPresent	notPresent	6
isLowerLayerDown	lowerLayerDown	7

21.5.6 Data TLV

Type = 3. Zero or more octets of arbitrary data. Serves several purposes, including reflected data frame in RFM, to be decapsulated data in SFM, the transmission of different frame sizes to test Maximum Service Data Unit Size capabilities and the testing for data-specific error dependencies. The Data TLV may be included in the LBM and the LBR, the RFM, and the SFM, but not in any other CFM PDU. The contents of the Data TLV shall not be examined or interpreted by the receiver of any CFM PDU except an LBR. The format of the Data TLV is shown in Table 21-12.

Table 21-12—Data TLV format

Field	Octet
Type = 3	1
Length	2–3
Data	4 – (Length + 3)

21.5.7 End TLV

Required. Type = 0. Length and Value fields are not present. The End TLV is the last TLV in the CFM PDU. (Lack of the End TLV does not invalidate a received CFM PDU, but certain cases where frames receive extra headers, e.g., MACsec or additional VLAN tags, can cause errors if it is not present.) The format of the End TLV is shown in Table 21-13.

Table 21-13—End TLV format

Field	Octet
Type = 0	1

21.6 CCM format

The format of the CCM is shown in Table 21-14. In order to limit the resources required to generate and receive CCMs, the following restrictions apply to the format of the CCM:

a) The Maintenance Domain Name and Short MA Name are encoded in a manner such that an MP can treat all of the fields from the Maintenance Domain Name Format field through the Short MA Name field as a unit when deciding whether a received CCM does or does not belong to the receiving MP's MA. That is, the MP can perform a binary comparison of these fields in a received CCM to the fields it would transmit in its own CCMs. This means, for example, that two Maintenance Domain Names differing, e.g., only by trailing spaces or by upper/lower case substitutions, can be interpreted to denote different MAs.

b) The portion of the PDU allocated for the MAID is limited to 48 octets, in order to minimize the memory requirements of a hardware implementation of a MEP.

An MP shall be able to receive and process any valid CCM PDU that is 128 octets in length or less, starting with the MD Level/Version octet and including the End TLV. An MP shall not transmit a CCM PDU exceeding this length. An MP may discard as invalid any received CCM PDU that exceeds this length.

Table 21-14—CCM format

Field	Octet
Common CFM Header	1–4
Sequence Number	5–8
Maintenance association Endpoint Identifier	9–10
Maintenance Association Identifier	11–58
Defined by ITU-T G.8013/Y.1731	59–74
Reserved for definition in future versions of the protocol [a]	
Optional CCM TLVs	First TLV Offset + 5 [b]
End TLV (0)	First TLV Offset + 5, if no Optional CCM TLVs are present

[a] This field has 0 length in this version 0 of CFM. It is shown in order to stress that additional information can be present in future versions of CFM, and that a version 0 receiver ignores its contents, if present.
[b] Octet 75 for transmitted CCMs.

21.6.1 Flags

(1 octet) The Flags field of the Common CFM Header is split into four parts for the CCM as follows:

a) RDI field (21.6.1.1)
b) Reserved field (21.6.1.2)
c) CCM Interval field (21.6.1.3)
d) Traffic field (21.6.1.4)

21.6.1.1 RDI

The MSB of the Flags field is the RDI bit. This bit is set to 1 if the transmitting MEP's presentRDI variable (20.9.6) is set, and 0 if not.

21.6.1.2 Reserved

The bits of the Flags field not including the RDI field, the Traffic field, and the CCM Interval field are set to 0 by the transmitting MP, and are not to be examined by the receiving MP [item b) in 20.51.2].

21.6.1.3 CCM Interval

The least significant 3 bits of the Flags field constitute the CCM Interval field. The CCM Interval field is encoded as specified in Table 21-15.

NOTE—The maximum CCM Lifetime in Table 21-15 is equal to 3.5 times the CCM Interval. The minimum CCM Lifetime is the maximum CCM Lifetime minus 1/4 of the CCM Interval, the minimum required granularity of the timer variables CCIwhile, rMEPwhile, errorCCMwhile, and xconCCMwhile.

Validation Test: The CCM Interval field does not contain the value 0.

21.6.1.4 Traffic field

In the case of a PBB-TE MA or Infrastructure Segment MA, the second most significant bit of the Flags field is the Traffic bit. This bit if supported, is used to indicate the presence of backbone service instances in the monitored TESI or the assignment of TESIs in the monitored Infrastructure Segments. This bit is set to 1

Table 21-15—CCM Interval field encoding

Transmission Interval	max. CCM Lifetime	min. CCM Lifetime	CCM Interval field
invalid			0
3 1/3 ms (300 Hz)	11 2/3 ms	10 5/6 ms	1
10 ms	35 ms	32.5 ms	2
100 ms	350 ms	325 ms	3
1 s	3.5 s	3.25 s	4
10 s	35 s	32.5 s	5
1 min	3.5 min	3.25 min	6
10 min	35 min	32.5 min	7

if the transmitting MEP's presentTraffic variable (20.9.8) is set in the case of a PBB-TE MEP or the transmitting MEP's ISpresentTraffic variable (20.9.10) is set in the case of a Infrastructure Segment MEP, and 0 if not. This field is not examined if the receiving MPs are not PBB-TE or Infrastructure Segment MEPs supporting the traffic field.

21.6.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in a CCM is transmitted as 70.

Validation Test: The First TLV Offset field of the Common CFM Header in a CCM contains a value greater than or equal to 70.

21.6.3 Sequence Number

(4 octets) A MEP either transmits a 0 in this field or copies to it the contents of the CCIsentCCMs variable (20.10.2).

21.6.4 Maintenance association Endpoint Identifier

(2 octets) Contains an integer value. This TLV specifies from which MEP the CCM was transmitted.

Validation Test: MEPID is in the range 1–8191.

21.6.5 Maintenance Association Identifier

(48 octets) This field contains the MAID of the transmitting MEP. It is divided into six subfields, plus, if necessary, a pad of octets contains 0 to fill out its fixed length. The subfields are as follows:

a) Maintenance Domain Name Format (21.6.5.1)
b) Maintenance Domain Name Length (21.6.5.2)
c) Maintenance Domain Name (21.6.5.3)
d) Short MA Name Format (21.6.5.4)
e) Short MA Name Length (21.6.5.5)
f) Short MA Name (21.6.5.5)

The total length of these fields, including padding, if present, shall be exactly 48 octets. There are two possible formats of the Maintenance Association Identifier field, as shown in Table 21-16 and Table 21-17, depending on whether the Maintenance Domain Name is present.

Table 21-16—CCM Maintenance Association Identifier field format: Maintenance Domain present

Field	Octet
Maintenance Domain Name Format (not 1)	1
Maintenance Domain Name Length	2
Maintenance Domain Name	3 – (mdnl [a] + 2)
Short MA Name Format	(mdnl + 3)
Short MA Name Length	(mdnl + 4)
Short MA Name	(mdnl + 5) – (mdnl + smanl [b] + 4)
0 pad, if necessary	(mdnl + smanl + 5) – 48

[a] Maintenance Domain Name Length.
[b] Short MA Name Length.

Table 21-17—CCM Maintenance Association Identifier field format: Maintenance Domain not present

Field	Octet
Maintenance Domain Name Format (1)	1
Short MA Name Format	2
Short MA Name Length	3
Short MA Name	4 – (smanl [a] + 3)
0 pad, if necessary	(smanl + 4) – 48

[a] Short MA Name Length.

21.6.5.1 Maintenance Domain Name Format

(1 octet) Specifies the format of the Maintenance Domain Name field. The Maintenance Domain Name Format is encoded according to Table 21-18.

21.6.5.2 Maintenance Domain Name Length

(1 octet) Specifies the length in octets of the Maintenance Domain Name field. Not present if the Maintenance Domain Name Format field specifies “No Maintenance Domain Name present” (1).

Validation Test: The Maintenance Domain Name Length in a CCM, if present, is greater than or equal to 1, and less than or equal to 43.

Table 21-18—Maintenance Domain Name Format

Maintenance Domain Name Format field	Value
Reserved for IEEE Std 802.1	0
No Maintenance Domain Name present	1
Domain Name-based string [a]	2
MAC address + 2-octet integer	3
Character string [b]	4
Reserved for IEEE Std 802.1	5–31
Defined by ITU-T G.8013/Y.1731	32–63
Reserved for IEEE Std 802.1	64–255

[a] This is a string the terminal substring of which is an IETF RFC 1035 DNS Name, and the remainder of which is a text string, following the syntax of a DNS Name, denoting the identity of a particular Maintenance Domain.
[b] This is an IETF RFC 2579 DisplayString, with the exception that character codes 0–31 (decimal) are not used.

21.6.5.3 Maintenance Domain Name

(Length specified by the Maintenance Domain Name Length field) Contains the Maintenance Domain Name, in the format specified by the Maintenance Domain Name Format field. Not present if the Maintenance Domain Name Format field specifies “No Maintenance Domain Name present” (1).

21.6.5.4 Short MA Name Format

(1 octet) Specifies the format of the Short MA Name field. The Short MA Name Format is encoded according to Table 21-19.

Table 21-19—Short MA Name Format

Short MA Name Format field	Value
Reserved for IEEE Std 802.1	0
Primary VID	1
Character string [a]	2
2-octet integer	3
IETF RFC 2685 VPN ID	4
Reserved for IEEE Std 802.1	5–31
ICC-based format as specified in ITU-T G.8013/Y.1731	32
Defined by ITU-T G.8013/Y.1731	33–63
Reserved for IEEE Std 802.1	64–255

[a] This is an IETF RFC 2579 DisplayString, with the exception that character codes 0–31 (decimal) are not used.

21.6.5.5 Short MA Name Length

(1 octet) Specifies the length in octets of the Short MA Name field.

Validation Test: The Short MA Name Length in a CCM contains a value greater than or equal to 1.

Validation Test: The Short MA Name Length in a CCM does not indicate that the Short MA Name runs over the 48-octet limit for the MAID.

21.6.5.6 Short MA Name

(Length specified by the Short MA Name Length field) Contains the Short MA Name, in the format specified by the Short MA Name Format field.

21.6.6 Defined by ITU-T G.8013/Y.1731

(16 octets) The use of this field is defined by ITU-T G.8013/Y.1731. A value of 0 should be transmitted in this field.

21.6.7 Optional CCM TLVs

The following TLVs should be included, as allowed by their specifications, in every CCM transmitted:

a) Sender ID TLV (21.5.3)
b) Port Status TLV (21.5.4)
c) Interface Status TLV (21.5.5)

The following TLV may be included in any CCM transmitted:

d) Organization-Specific TLV (21.5.2)

The Optional CCM TLVs in this subclause may be placed in any order by the MEP transmitting the CCM. The receiving MP shall not depend upon any particular ordering of the Optional CCM TLVs in a CCM for its proper operation.

21.7 LBM and LBR formats

The format of the LBM and LBR is shown in Table 21-20.

Table 21-20—LBM and LBR formats

Field	Octet
Common CFM Header	1–4
Loopback Transaction Identifier	5–8
Reserved for definition in future versions of the protocol [a]	
Additional LBM/LBR TLVs	First TLV Offset + 5 [b]
End TLV (0)	First TLV Offset + 5, if no Additional LBM/LBR TLVs are present

[a] This field has 0 length in this version 0 of CFM. It is shown in order to stress that additional information can be present in future versions of CFM, and that a version 0 receiver ignores its contents, if present.

[b] Octet 9 for transmitted LBMs.

21.7.1 Flags

(1 octet) In an LBM, the Flags field of the Common CFM Header is set to 0 by the transmitting MP, and is not examined by the receiving MP.

21.7.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in an LBM or LBR is transmitted as 4.

Validation Test: The First TLV Offset field of the Common CFM Header in an LBM or LBR contains a value greater than or equal to 4.

21.7.3 Loopback Transaction Identifier

(4 octets) A MEP copies the contents of the nextLBMtransID variable (20.30.2) to this field.

21.7.4 Additional LBM/LBR TLVs

The following TLV shall be included in every LBM transmitted by a MEP to a MIP configured on a PBB-TE MA as specified in 21.7.5. The TLV will not be present in any other type of MA.

a) PBB-TE MIP TLV (21.7.5)

The following TLV should be included in every LBM transmitted:

b) Sender ID TLV (21.5.3)

The following TLV can be included by management action in any LBM transmitted:

c) Data TLV (21.5.6)

The following TLV may be included in any LBM transmitted:

d) Organization-Specific TLV (21.5.2)

The PBB-TE MIP TLV, if present, shall be placed first. The other Additional LBM/LBR TLVs may be placed in any order by the MEP transmitting the LBM.

21.7.5 PBB-TE MIP TLV

Type = 9. Used only in MAs monitoring PBB-TE services. It enables MIPs to selectively intercept LBMs that are targeting them. The PBB-TE MIP TLV is not used if the target address of the LBM or LTM is associated with any of the values in the ESP-DA field of the monitored MA's ESPs; otherwise, it shall be present; The format of the PBB-TE MIP TLV is illustrated in Table 21-21.

Table 21-21—PBB-TE MIP TLV format

Field	Octet
Type = 9	1
Length	2–3
MIP MAC address	4–9
Reverse VID	10–11
Reverse MAC	12–17

Validation Test: The MIP MAC address field contains an individual MAC address.

Validation Test: The Reverse MAC field contains an Individual, or a group MAC address as specified in 21.7.5.3.

Validation Test: The Length field either is 8, indicating that no Reverse MAC field is present, or is 14, and thus contains the Reverse MAC field.

21.7.5.1 MIP MAC address

The MIP MAC address contains the destination MAC address for LBMs transmitted by the MEP [item b) in 12.14.7.3.2]. In the case of LTMs, this field in null.

21.7.5.2 Reverse VID

The Reverse VID field is used by the MIPs in order to set the vlan_identifier parameters on LBRs and LTRs. Its value is provided by the operator on the initiation of the LBM [item f) in 12.14.7.3.2] or the LTM [item e) in 12.14.7.4.2]. In the case of point-to-point TESIs, its value is the ESP-VID of the MA's ESP that has the MEP's MAC address in its ESP-DA field.

21.7.5.3 Reverse MAC

This Reverse MAC field refers to the ESP-SA of any of the point-to-point ESPs of the MA, if the LBM/LTM is initiated on a root PBB-TE MEP or to the ESP-DA of the point-to-multipoint ESP of the MA, if the LBM/LTM is initiated on any of the leaf MEPs.

21.8 LTM format

The format of the LTM is shown in Table 21-22.

Table 21-22—LTM format

Field	Octet
Common CFM Header	1–4
LTM Transaction Identifier	5–8
LTM TTL	9
Original MAC Address	10–15
Target MAC Address	16–21
Reserved for definition in future versions of the protocol [a]	
Additional LTM TLVs	First TLV Offset + 5 [b]
End TLV (0)	First TLV Offset + 5, if no Additional LTM TLVs are present

[a] This field has 0 length in this version 0 of CFM. It is shown in order to stress that additional information can be present in future versions of CFM and that a version 0 receiver ignores its contents, if present.
[b] Octet 22 for transmitted LTMs.

21.8.1 Flags

(1 octet) In the LTM, the Flags field of the Common CFM Header specifies certain options as shown in Table 21-23.

Table 21-23—LTM Flags field

Mnemonic	Meaning	Bit
UseFDBonly	If set, indicates that only MAC addresses learned in a Bridge's FDB, and not information saved in the MIP CCM Database, is to be used to determine the Egress Port.	8 (MSB)
Reserved	Transmitted as 0, and ignored by the receiver.	7–1

21.8.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in an LTM is be transmitted as 17.

Validation Test: The First TLV Offset field of the Common CFM Header in an LTM contains a value greater than or equal to 17.

21.8.3 LTM Transaction Identifier

(4 octets) A MEP copies the contents of the nextLTMtransID variable (20.41.1) to this field.

21.8.4 LTM TTL

(1 octet) The number of hops remaining to this LTM. Decremented by 1 by each Linktrace Responder that handles the LTM. One less than this value is returned in the LTR. If 0 or 1 on input, the LTM is not transmitted to the next hop. If 0 on input, no LTR is returned. The value of the LTM TTL field in the LTM transmitted by the originating MEP is controlled by a managed object [item d) in 12.14.7.4.2]; the default value if none is specified is 64.

21.8.5 Original MAC Address

(6 octets) The MAC address of the MEP that originated the LTM. This can be different from the source MAC address of an LTM because each MIP along the path puts its own MAC address in the source MAC address field, while retaining the Original MAC Address Field.

Validation Test: The Original MAC Address field contains an Individual, and not a Group, MAC address.

21.8.6 Target MAC Address

(6 octets) Specifies an individual MAC address, the path to which the LTM is intended to trace. Any individual MAC address can be specified in this field. See also 20.3.1.

Validation Test: The Target MAC Address field contains an Individual, and not a Group, MAC address.

21.8.7 Additional LTM TLVs

The following TLV shall be included in every LTM by each MP originating or forwarding an LTM:

a) LTM Egress Identifier TLV (21.8.8)

The following TLVs may be included in an LTM by each MP originating or forwarding an LTM:

b) Sender ID TLV (21.5.3)
c) Organization-Specific TLV(s) (21.5.2)

The following TLV shall be included in every LTM transmitted by a MEP configured on a PBB-TE MA. The TLV will not be present in any other type of MA.

d) PBB-TE MIP TLV (21.7.5)

The Additional LTM TLVs may be placed in any order by the MP transmitting the LTM.

21.8.8 LTM Egress Identifier TLV

Type = 7. Identifies the MEP Linktrace Initiator that is originating, or the Linktrace Responder that is forwarding, this LTM. The low-order (highest numbered) six octets contain an EUI-48 IEEE MAC address unique to the system in which the MEP Linktrace Initiator or Linktrace Responder resides. The high-order (lowest numbered) two octets contain an integer value sufficient to uniquely identify the transmitted LTM; a constant value (e.g., 0) is sufficient for this purpose, since a Bridge initiates or forwards only a single copy of an LTM. The format of the LTM Egress Identifier TLV is illustrated in Table 21-24.

Table 21-24—LTM Egress Identifier TLV format

Field	Octet
Type = 7	1
Length	2–3
Egress Identifier	4–11

NOTE—For most Bridges, the address of any MAC attached to the Bridge will suffice for the low-order six octets, and 0 for the high-order octets. In some situations, e.g., if multiple virtual Bridges utilizing emulated LANs are implemented in a single physical system, the high-order two octets can be used to differentiate among the transmitting entities.

21.9 LTR format

The format of the LTR is shown in Table 21-25.

Validation Test: The Reply Ingress TLV (21.9.8), the Reply Egress TLV (21.9.9), or both, are present.

21.9.1 Flags

(1 octet) In the LTR, the Flags field of the Common CFM Header specifies certain options as shown in Table 21-26.

Table 21-25—LTR format

Field	Octet
Common CFM Header	1–4
LTR Transaction Identifier	5–8
Reply TTL	9
Relay Action	10
Reserved for definition in future versions of the protocol [a]	
Additional LTR TLVs	First TLV Offset + 5 [b]
End TLV (0)	First TLV Offset + 5, if no Additional LTR TLVs are present

[a] This field has 0 length in this version 0 of CFM. It is shown in order to stress that additional information can be present in future versions of CFM, and that a version 0 receiver ignores its contents, if present.

[b] Octet 11 for transmitted LTRs.

Table 21-26—LTR Flags field

Mnemonic	Meaning	Bit
UseFDBonly	Copied from LTM.	8 (MSB)
FwdYes	The LTM was (1) or was not (0) forwarded.	7
TerminalMEP	The MP reported in the Reply Egress TLV (Reply Ingress TLV, if the Reply Egress TLV is not present) is a MEP.	6
Reserved	Copied from LTM.	5–1

21.9.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in an LTR is transmitted as 6.

Validation Test: The First TLV Offset field of the Common CFM Header in an LTR contains a value greater than or equal to 6.

21.9.3 LTR Transaction Identifier

(4 octets) The value from the LTM Transaction Identifier field in the LTM that triggered the transmission of this LTR.

21.9.4 Reply TTL

(1 octet) One less than the value from the LTM TTL field in the LTM that triggered the transmission of this LTR. If the LTM TTL field contained a 0, no LTR is transmitted.

21.9.5 Relay Action

(1 octet) Reports how the data frame targeted by the LTM would be passed through the MAC Relay Entity to the Egress Bridge Port, as shown in Table 21-27.

Validation Test: The value in the Relay Action field is one of the values enumerated in 21.9.5.

Table 21-27—Relay Action field values

Mnemonic	Relay action	Value
RlyHit	The LTM reached an MP whose MAC address matches the target MAC address.	1
RlyFDB	The Egress Port was determined by consulting the FDB [item a) in 20.47.1.2].	2
RlyMPDB	The Egress Port was determined by consulting the MIP CCM Database [item b) in 20.47.1.2].	3

21.9.6 Additional LTR TLVs

The following TLV shall be included in an LTR according to 20.3.2:

a) LTR Egress Identifier TLV (21.9.7)

One or both of the following TLVs shall be included in an LTR according to 20.3.2:

b) Reply Ingress TLV (21.9.8)
c) Reply Egress TLV (21.9.9)

The following TLVs may be included in an LTR:

d) Sender ID TLV (21.5.3)
e) Organization-Specific TLV (21.5.2)

The Additional LTR TLVs may be placed in any order by the MP transmitting the LTR. The receiving MEP shall not depend upon any particular ordering of the Additional LTR TLVs in an LTR for its proper operation.

21.9.7 LTR Egress Identifier TLV

Type = 8. Identifies the source and destination of the LTM that triggered transmission of this LTR. The format of the LTR Egress Identifier TLV is illustrated in Table 21-28.

Table 21-28—LTR Egress Identifier TLV format

Field	Octet
Type = 8	1
Length	2–3
Last Egress Identifier	4–11
Next Egress Identifier	12–19

21.9.7.1 Last Egress Identifier

(8 octets) Identifies the MEP Linktrace Initiator that originated, or the Linktrace Responder that forwarded, the LTM to which this LTR is the response. This field takes the same value as the LTM Egress Identifier TLV of that LTM, or the value 0, if no LTM Egress Identifier TLV was present in that LTM.

21.9.7.2 Next Egress Identifier

(8 octets) Identifies the Linktrace Responder that transmitted this LTR, and can forward the LTM to the next hop. This field takes the same value as the LTM Egress Identifier TLV of the forwarded LTM, if any. If the FwdYes bit of the Flags field is false, the contents of this field are undefined, i.e., any value can be transmitted, and the field is ignored by the receiver.

21.9.8 Reply Ingress TLV

Type = 5. The format of the Reply Ingress TLV is shown in Table 21-29. The Reply Ingress TLV is transmitted if and only if the Bridge Port on which the LTM was received has an MP in the MA specified by the LTM.

Table 21-29—Reply Ingress TLV format

Field	Octet
Type = 5	1
Length	2–3
Ingress Action	4
Ingress MAC Address	5–10
Ingress Port ID Length	11
Ingress Port ID Subtype	12
Ingress Port ID	13 – (Length + 3)

Validation Test: The value in the Ingress Action field is one of the values enumerated in 21.9.8.1.

Validation Test: The Ingress MAC Address field contains an Individual, and not a Group, MAC address.

Validation Test: The Length field either is 7, indicating that no Ingress Port ID field is present, or is (9 + the Ingress Port ID Length field) or larger, and thus contains the Ingress Port ID field.

21.9.8.1 Ingress Action

(1 octet) Reports how the data frame targeted by the LTM would be received on the receiving MP, as shown in Table 21-30.

21.9.8.2 Ingress MAC Address

(6 octets) The MAC address that can be used as the Destination MAC address of an LBM intended for the ingress MP.

Table 21-30—Ingress Action field values

Mnemonic	Ingress action	Value
IngOK	The target data frame would be passed through to the MAC Relay Entity.	1
IngDown	The Bridge Port's MAC_Operational parameter is false. [a]	2
IngBlocked	The target data frame would not be forwarded if received on this Port due to active topology enforcement (8.6.1). (See Figure 22-1 to see how this is possible.)	3
IngVID	The ingress port is not in the member set of the LTM's VID, and ingress filtering is enabled, so the target data frame would be filtered by ingress filtering (8.6.2).	4

[a] This value could be returned, for example, by an operational Down MEP that has another Down MEP at a higher MD Level on the same Bridge Port that is causing the Bridge Port's MAC_Operational parameter to be false.

21.9.8.3 Ingress Port ID Length

(1 octet) The length, in octets, of the Ingress Port ID field. Cannot be 0. If the Length field of the Reply Ingress TLV is less than 8, then the Ingress Port ID Length field, Ingress Port ID Subtype field, and Ingress Port ID field are not present.

21.9.8.4 Ingress Port ID Subtype

(1 octet) The **port ID subtype**, as specified by IEEE Std 802.1AB, identifying the format of the Ingress Port ID field. If the Length field of the Reply Ingress TLV is less than 8, then the Ingress Port ID Subtype field is not present.

21.9.8.5 Ingress Port ID

(Length specified by the Ingress Port ID Length field) The Ingress Port, identified by the **port ID** specified by IEEE Std 802.1AB, in the chassis identified in the Sender ID TLV. If the Length field of the Reply Ingress TLV is less than 8, then the Ingress Port ID field is not present.

21.9.9 Reply Egress TLV

Type = 6. The format of the Reply Egress TLV is shown in Table 21-31. The Reply Egress TLV is included in the LTR if and only if the Bridge Port on which the LTM would be relayed could be identified, and is an MP in the MA specified by the LTM.

Validation Test: The value in the Egress Action field is one of the values enumerated in 21.9.9.1.

Validation Test: The Egress MAC Address field contains an Individual, and not a Group, MAC address.

Validation Test: The Length field either is 7, indicating that no Egress Port ID field is present, or is (9 + the Egress Port ID Length field) or larger, and thus contains the Egress Port ID field.

21.9.9.1 Egress Action

(1 octet) Reports how the data frame targeted by the LTM would be passed through Egress Bridge Port, as shown in Table 21-32.

Table 21-31—Reply Egress TLV format

Field	Octet
Type = 6	1
Length	2–3
Egress Action	4
Egress MAC Address	5–10
Egress Port ID Length	11
Egress Port ID Subtype	12
Egress Port ID	13 – (Length + 3)

Table 21-32—Egress Action field values

Mnemonic	Egress action	Value
EgrOK	The targeted data frame would be forwarded.	1
EgrDown	The Egress Port can be identified, but that Bridge Port's MAC_Operational parameter is false.	2
EgrBlocked	The Egress Port can be identified, but the data frame would not pass through the Egress Port due to active topology management (8.6.1), i.e., the Bridge Port is not in the Forwarding state.	3
EgrVID	The Egress Port can be identified, but the Bridge Port is not in the LTM's VID's member set, so would be filtered by egress filtering (8.6.4).	4

21.9.9.2 Egress MAC Address

(6 octets) The MAC address that can be used as the Destination MAC address of an LBM intended for the egress MP.

21.9.9.3 Egress Port ID Length

(1 octet) The length, in octets, of the Egress Port ID field. Cannot be 0. If the Length field of the Reply Egress TLV is less than 8, then the Egress Port ID Length field, Egress Port ID Subtype field, and Egress Port ID field are not present.

21.9.9.4 Egress Port ID Subtype

(1 octet) The **port ID subtype**, as specified by IEEE Std 802.1AB, identifying the format of the Egress Port ID field. If the Length field of the Reply Egress TLV is less than 8, then the Egress Port ID Subtype field is not present.

21.9.9.5 Egress Port ID

(Length specified by the Egress Port ID Length field) The Egress Port, identified by the **port ID** specified by IEEE Std 802.1AB, in the chassis identified in the Sender ID TLV. If the Length field of the Reply Egress TLV is less than 8, then the Egress Port ID field is not present.

22. CFM in systems

The relationships among MPs, and between the MPs and the other entities in a Bridge, are configurable. This configuration determines how CFM is used in a network and determines what parts of the Bridges and LANs comprising a network are protected by an MA. This clause provides both specifications and explanatory text to assist the implementor and system administrator to make efficient use of CFM. This clause:

a) Specifies how the EISS Multiplex Entity (6.17) is used to support MPs for multiple MAs associated with service instances supported by EISS-SAPs (22.1).
b) Specifies the creation of MPs in a Bridge (22.2).
c) Suggests methods for the efficient assignment of MD Levels to Maintenance Domains (22.3).
d) Specifies the use of MPs in stations (22.4).
e) Clarifies issues related to the scaling of resources required to run CFM (22.5).
f) Shows how MPs can be placed in Provider Bridges (22.6).
g) Suggests methods for using CFM in the enterprise environment, as opposed to the provider environment (22.7).
h) Provides guidance for the implementation of CFM in Bridges designed before the development of this standard (22.8).

NOTE—Clause 18 introduces the principles of CFM operation and the network architectural concepts that support it. Clause 19 breaks down the CFM protocol entities into their components. Clause 20 specifies the protocols operated by the components of each MP, and Clause 21 specifies the PDU formats used by those protocols.

22.1 CFM shims in Bridges

CFM is instantiated by configuring an MA, which maintains a single service instance. If multiple MAs, monitoring VLAN service instances, are configured on a single Bridge Port, the vlan_identifier parameter of the EISS and the MD Level in the CFM PDUs are used to multiplex CFM PDUs for the various MAs. Non-CFM data frames for these service instances are distinguished only by vlan_identifier: the particular service instance to which a non-CFM data frame belongs, if multiple service instances share the same VID, distinguished only by MD Level, is undetermined. MAs that monitor backbone or TESIs use I-SIDs or a combination of destination addresses, source addressees, and ESP-VIDs, respectively as service distinguishing parameters, instead of VIDs.

22.1.1 Preliminary positioning of MPs

Figure 22-1 illustrates how MPs are associated with particular VIDs or TESIs. The EISS Multiplex Entity (6.17) distributes frames across an array of ISS- or EISS-SAPs, each of which can have a “column” of MPs at different MD Levels and orientations (Up or Down). Several MEPs and MHFs are shown, distinguished by VID and MD Level in this manner.

NOTE—For MPs monitoring backbone service instances, it is the Backbone Service Instance Multiplex Entity (6.18) that is used to distinguish MPs by I-SIDs and associate MPs with particular backbone service instances as illustrated in Figure 26-2.

An MP that has its Passive SAP closer to the MAC Relay Entity than its Active SAP is called a “Down MEP” or “Down MHF,” because it points down, away from the MAC Relay Entity, in Figure 22-1. An MP that has its Passive SAP further away from the MAC Relay Entity than its Active SAP is called an “Up MEP” or “Up MHF.” The Bridge Port in Figure 22-1 is configured with five Up MEPs, three Up MHFs, three Down MHFs, and three Down MEPs. A single LOM is positioned below the per-VID Down MEPs.

Figure 22-1 illustrates a Down MEP, at MD Level 1, configured on the ISS below the Bridge Port connectivity entity. The service instance its MA protects encompasses all data frames passing through the Bridge Port, no matter what VID they are associated with.

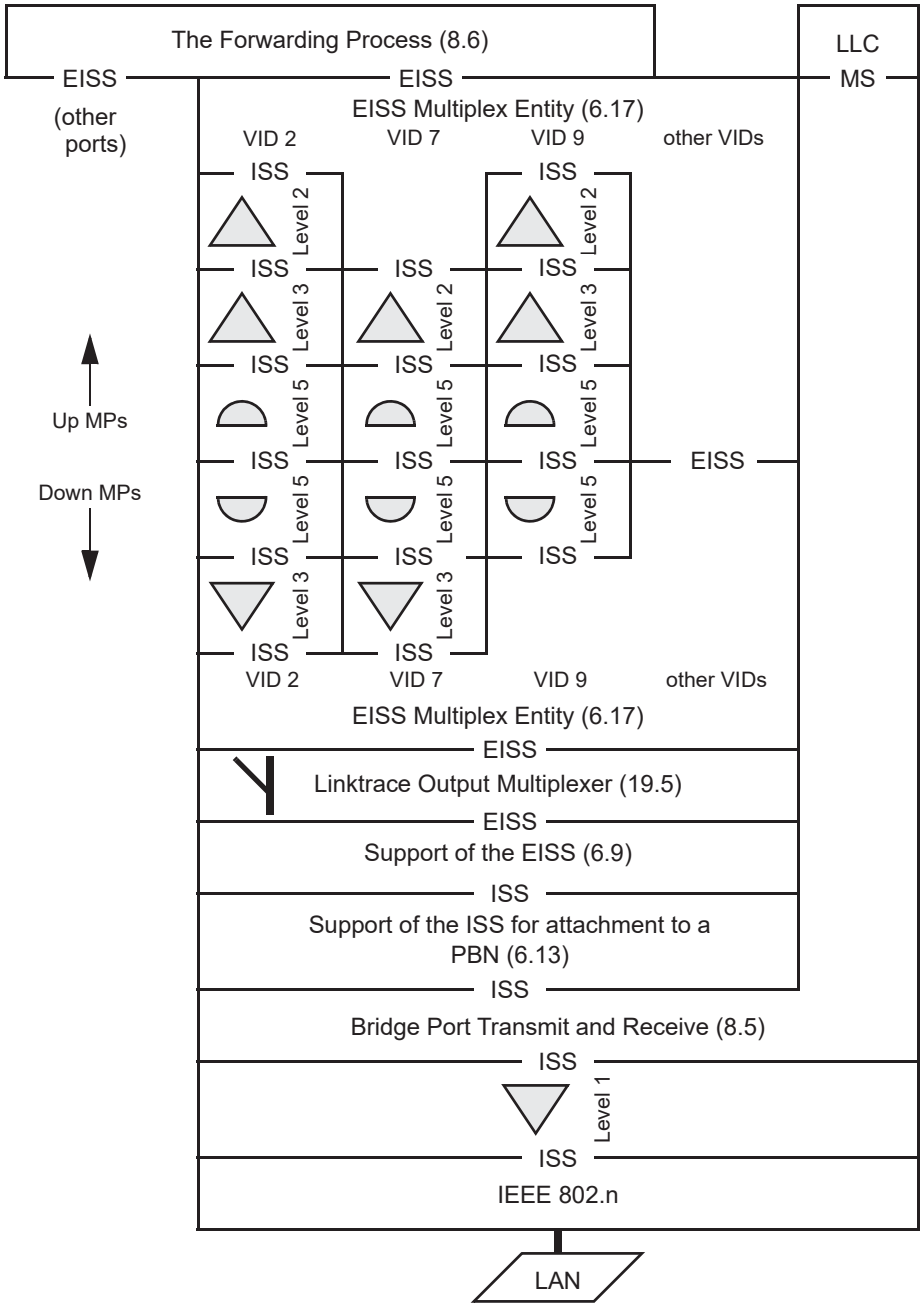


Figure 22-1—MEPs and MIPs distinguished by VID (incomplete picture)

22.1.2 CFM and the Forwarding Process

Figure 22-1 is incomplete, because it does not illustrate the relationship of CFM to the various components of the Forwarding Process (8.6). These components are illustrated in Figure 8-12. Readers can notice two facts about Figure 8-12:

a) The functions in Figure 8-12 can be divided into two groups. The first group, described in 8.6.1 through 8.6.5, consists of filtering functions that determine a set of potential transmission ports for

each frame received at a reception port. The second group, described in 8.6.6 through 8.6.8, consists of queuing functions that control the transmission of the frame at each port in the resulting set of potential transmission ports.

b) The parameters passed from component to component in Figure 8-12 are exactly those of the EISS; therefore, each of the components in Figure 8-12 could be described as a shim.

From these facts, readers can reconstruct Figure 8-12 in a manner that is functionally identical, but is better suited to illustrate the relationship between CFM and the Forwarding Process. This reconstruction is shown in Figure 22-2.

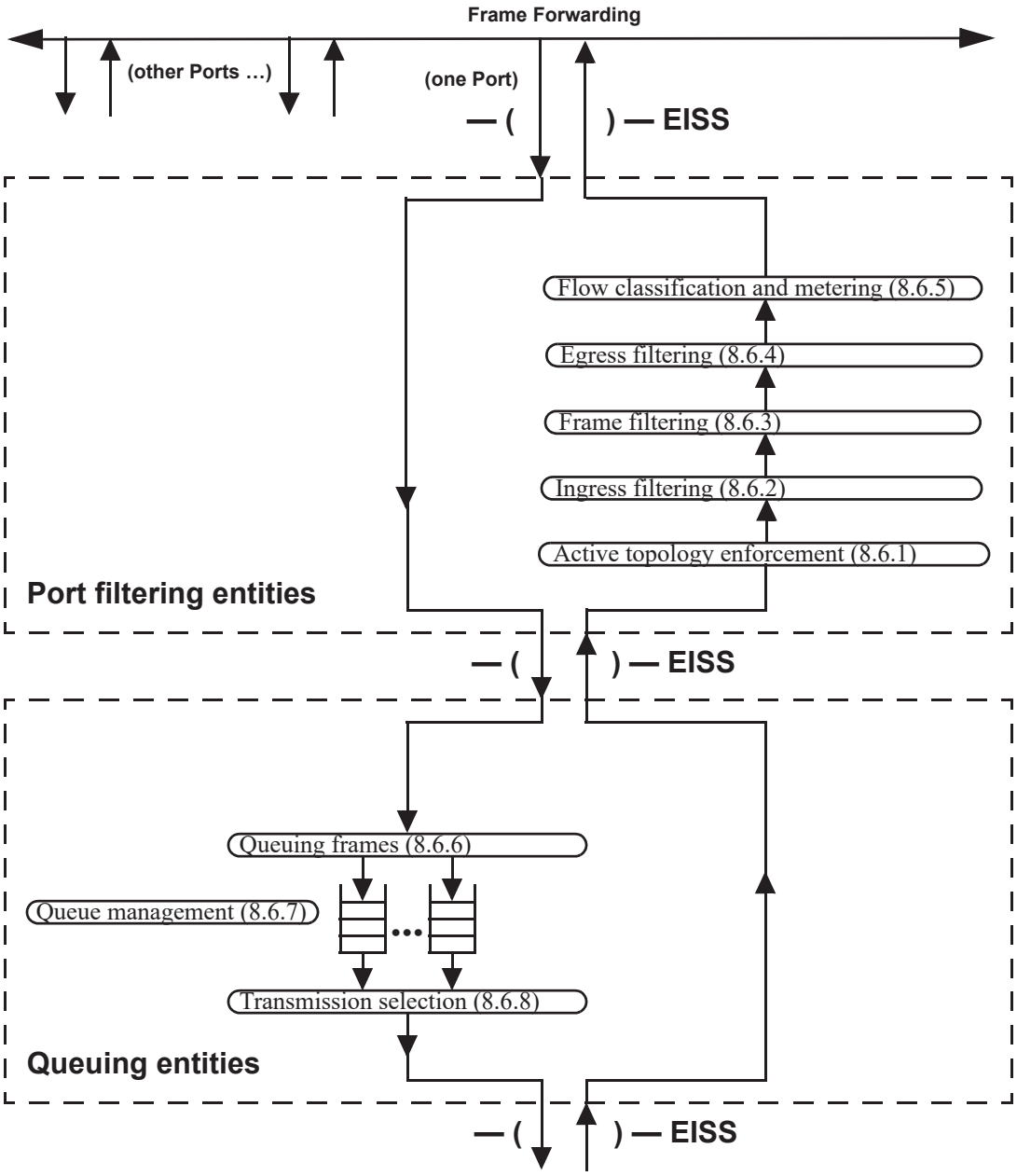


Figure 22-2—Alternate view of Forwarding process

22.1.3 Up/Down separation of MPs

An additional transformation to Figure 22-1 is required before the relationship between the Forwarding Process and CFM can be shown clearly. By adding a further pair of EISS Multiplex Entities between the Up MPs and the Down MPs in Figure 22-1, the entire set of Up MPs can be shown as a single shim, as can the entire set of Down MPs. This transformation is illustrated in Figure 22-3.

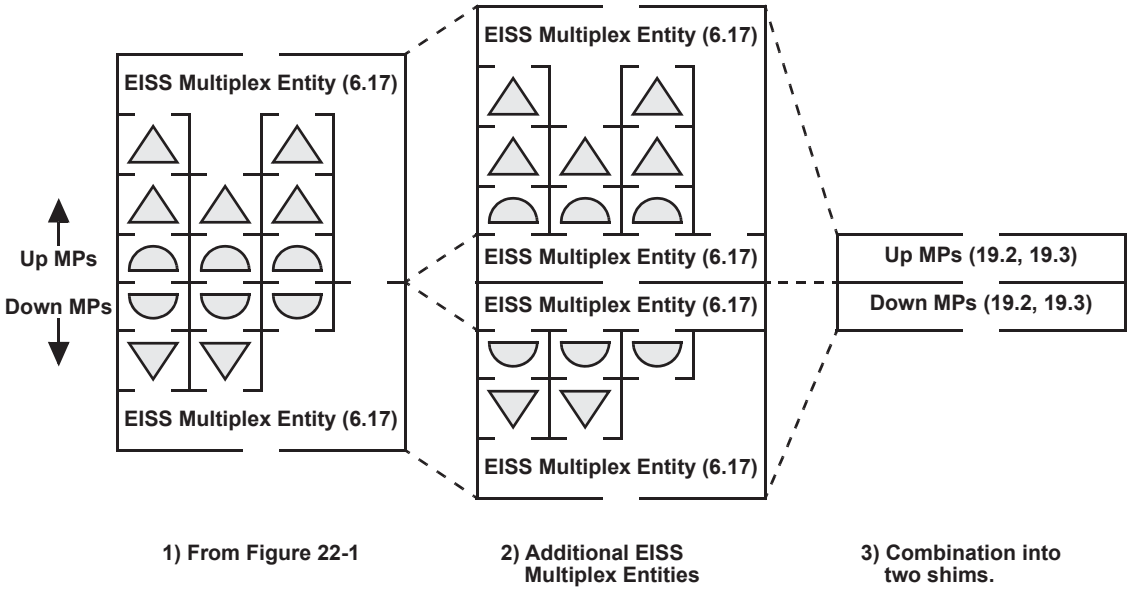


Figure 22-3—Combining per-VLAN MPs into two shims

Figure 22-4 combines Figure 22-1 with Figure 22-2, and shows the relationship of CFM to the various components of the Forwarding Process. MEPs and MHFs source and sink CFM PDUs. CFM PDUs are treated by the Port filtering entities in the same manner as ordinary data. Thus, the five Up MEPs of Figure 22-4 can transmit and receive CFM PDUs through the Bridge even when the Bridge Port is blocked. Similarly, the two Down MEPs in Figure 22-4 operate normally, transmitting CFM PDUs to and receiving them from the LAN, even if the Bridge Port is blocked. However, no frames, neither CFM PDUs nor ordinary data, can pass through the Port filtering entities when the VID to which those frames or CFM PDUs belong is filtered.

Also shown in Figure 22-4 are the positions of the DoSAPs and ISAPs introduced in Clause 18. The DoSAP provides access to a service instance (an instance of the MAC Service) and exists independently of any MA that might be created to protect it. The DoSAPs and ISAPs therefore can be associated with the specific inter-shim SAPs at the points indicated in Figure 22-4. The DoSAPs and ISAPs are attached to the Port filtering entities, because that is where the decisions are made on whether frames belonging to the service instance are or are not allowed to pass through the Bridge Port.[37] It does not matter to which side of the EISS Multiplex Entity one considers the DoSAPs and ISAPs to be attached. Except for the topmost Down MEP in each stack of Down MPs, the DoSAP is not coincident with the Passive SAP of the MEP protecting the DoSAP's service instance; the DoSAP is separated from its MA by the MHFs and/or MEPs at higher MD Levels. Even for that topmost Down MEP, an MHF for a higher MD Level can separate that MEP from its DoSAP. This gap is illustrated in Figure 22-5 and Figure 22-6, where the service instance, DoSAP to DoSAP, is shown in gray, but the MEPs protecting that service are separated from the DoSAPs by MHFs belonging to a service instance at a higher MD Level.

[37] The DoSAP is not attached to an MP's Passive SAP because the DoSAP and its associated service instance exist regardless of whether the service instance is protected by an MA.

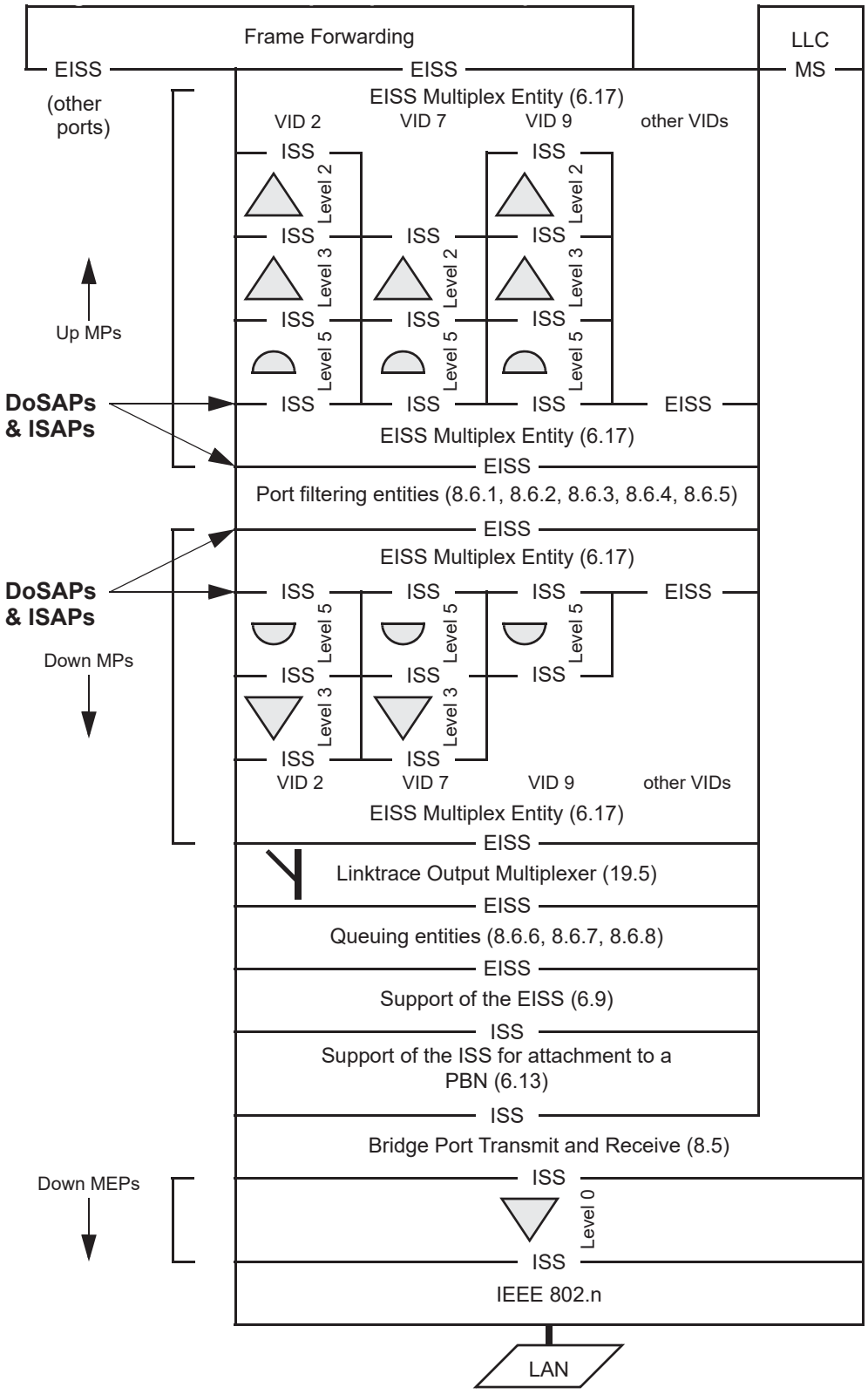


Figure 22-4—More complete picture of MP placement in a Bridge Port

In the “stack” of MPs on a single Bridge Port, the following rules apply:

a) All Up MEPs belonging to MAs that are attached to specific VIDs are placed above the Port filtering entities (8.6.1, 8.6.2, and 8.6.4). Separately for each VID, there can be from zero to eight Up MEPs, ordered by increasing MD Level, from the upper EISS toward Port filtering. In the case of PBB-TE MAs, more than one Up MEP can share the VID and MD Level.

b) For each MA there can be at most one MIP, consisting of an Up MHF just above, and a Down MHF just below, the Port filtering entities. Both MHFs are at the same MD Level, higher than the highest MEP on the same VID, if any. Backbone Service Instance MHFs use the Backbone Service Instance Multiplex Entity (6.18) and are placed as depicted in Figure 26-2.

c) Up to eight Down MEPs belonging to MAs that are attached to the same list of VIDs are placed between the Down MHF, if any, and the Queuing entities (8.6.6, 8.6.7, and 8.6.8). They are placed in order of decreasing MD Level, from the Port filtering entities to the Queuing entities, including any Down MHF.

d) No Down MEPs exist for PBB-TE MAs.

e) An LOM is positioned below the Down MPs belonging to MAs that are attached to specific VIDs to handle forwarded LTMs.

f) Up to eight Down MEPs, ordered from highest MD Level to lowest, belonging to MAs not attached to any specific VID, can be placed below Bridge Port connectivity (8.5.1). They are ordered by decreasing MD Level going away from the MAC Relay Entity (see also 22.1.8).

g) Up to 8 Up MEPs, ordered from highest MD Level to lowest, belonging to Backbone Service Instance MAs that are identified by the same I-SID, can be placed below the Bridge Port connectivity (8.5.1) using the Backbone Service Instance Multiplex Entity (6.18) as depicted in Figure 26-2. They are ordered by decreasing MD Level going away from the multiplexed SAP.

h) Up to 8 Down MEPs, ordered from highest MD Level to lowest, belonging to Backbone Service Instance MAs that are identified by the same I-SID, can be placed below the Bridge Port connectivity (8.5.1) using the Backbone Service Instance Multiplex Entity (6.18) as depicted in Figure 26-2. They are ordered by decreasing MD Level going away from the MAC Relay Entity.

i) All of the Down MEPs below Bridge Port connectivity have lower MD Levels than any Down MP attached to a VID that is emitted untagged by the Support of the EISS.

j) Any shim that introduces an EtherType tag insulates the MPs above and below it, removing any MD Level restriction between the separated groups of MPs.

A single Port on a Bridge could, in theory, have MHFs for multiple service instances at different MD Levels. However, that would require a vector of 4094 MD Level registers instead of one register to identify the CFM PDUs to be deflected to the Bridge’s Higher Layer Entities. This capability is optional.

22.1.4 Service instances over multiple Bridges

Figure 22-4 completes the sequence of expansions starting with Figure 18-5 and continuing with Figure 18-6 and Figure 18-7. In this sequence, Figure 22-4 illustrates Bridge Port b of Bridge 2 in Figure 18-5 through Figure 18-7. The service instances illustrated in those three figures all use VID 9 in Figure 22-4. The Up MEPs for VID 9 at MD Levels 3 and 2 are the Up MEPs protecting the provider MD Level and the operator MD Level service instances, respectively, and the pair of MHFs at MD Level 5 on VID 9 provide a customer MD Level MIP. Figure 22-4 also illustrates two other sets of service instances sharing the same Bridge Port using VIDs 2 and 7.

Additional views of service instances spanning two Bridges are shown in Figure 22-5 and Figure 22-6. Figure 22-5 shows a service instance protected by Up MPs, and Figure 22-6 shows a service instance protected by Down MPs.

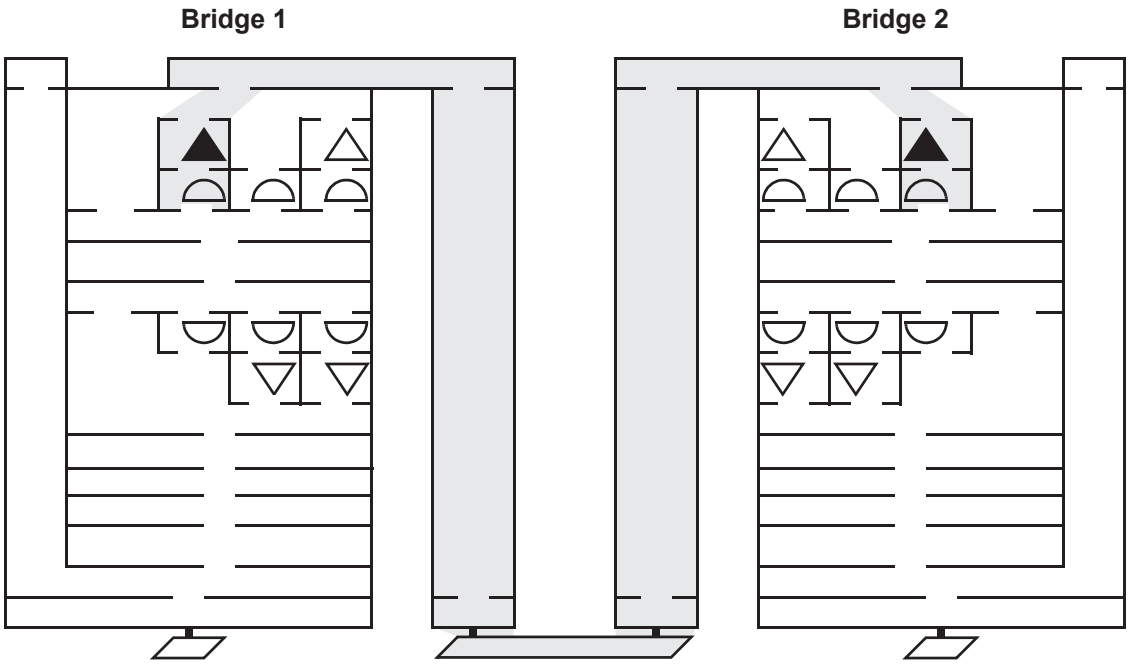


Figure 22-5—Service instance spanning two Bridges protected by Up MPs

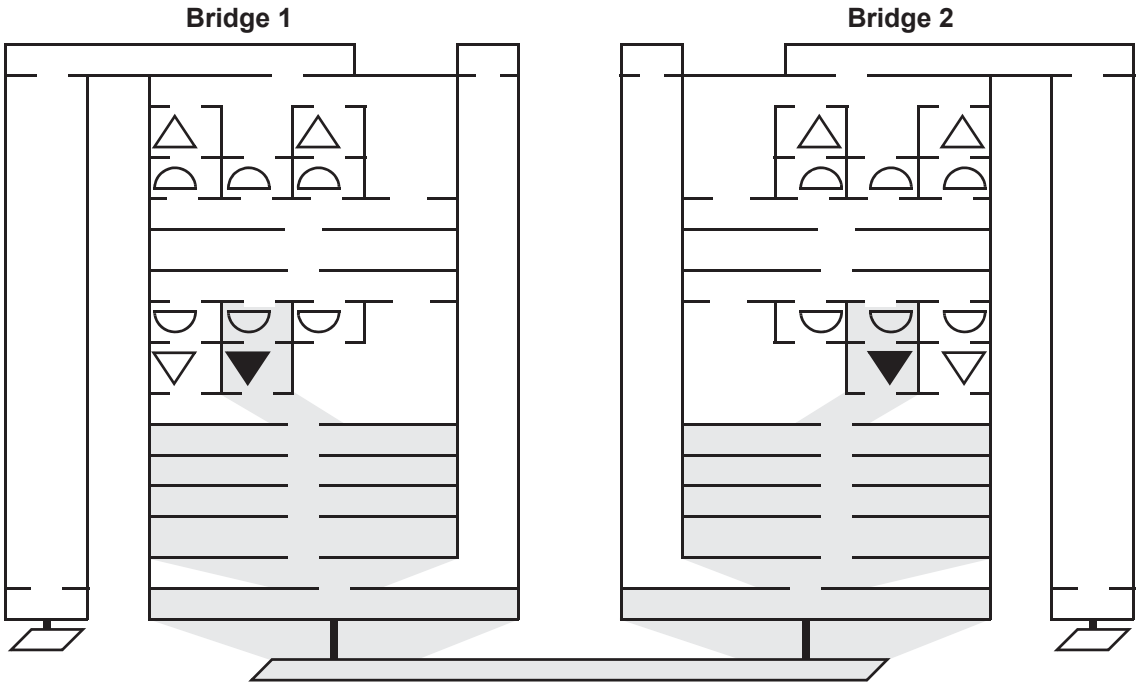


Figure 22-6—Service instance spanning two Bridges protected by Down MPs

22.1.5 Multiple VID service instances

A service instance can be implemented using multiple VIDs. It is always the case that the VLAN tag uniquely determines the VLAN service instance for a given frame. A VID-based MA or a PBB-TE MA with multiple VIDs does not require any more MIPs or MEPs than the corresponding MA with a single VID. All of the VIDs belonging to a given VID or TESI share the same MA. That is, one MAID is used for all CFM PDUs on the various VIDs in the same VID or TESI and Maintenance Domain. The choice of VID used to tag a given CFM PDU depends on the OpCode and the ESP, as specified in Clause 20.

22.1.6 Untagged CFM PDUs

A MEP placed anywhere below the Support of the EISS entity (6.9) or the Bridge Port connectivity entity (8.5.1) differs in three important respects from a MEP placed above the Support of the EISS entity:

a) The lower position would not have the Queuing entities available to it. For example, the reflection of a high-speed stream of LBMs (as LBRs) could seriously disrupt the flow of data frames, and thus bring into question the utility of the Queuing entities, CFM, or both.
b) A MEP in the lower position is necessarily VLAN untagged; the VLAN tagging functions are performed in the Support of the EISS entity.
c) A MEP in the lower position protects all data passing through the Bridge Port or if it is associated with a backbone service instance only data with this instance as specified in (26.8); it does not separately protect the different VLANs.

Point c) above does not mean that the lower position is the only one that can protect all of the traffic on a single link. MEPs placed above the Queuing entities can be associated with a VLAN whose VID is the PVID, for which this Bridge Port belongs to the untagged set. That VID can be statically configured in the member set to not be allowed to pass through the Frame filtering entity (8.6.3). MEPs so configured can then transmit and receive only untagged frames, and thus protect all of the data on the link. Their untagged CFM PDUs can be visible to complex “links” such as PBNs, even though the C-VLAN-tagged CFM PDUs are not visible inside the PBN.

The option to create MEPs below the Bridge Port connectivity entity for VID identified service instances cannot be omitted, however, because of considerations given in 22.1.8. This subclause also explains why only MEPs, and not MHFs, can be placed below the Bridge Port connectivity entity.

22.1.7 MPs and non-VLAN-aware Bridges

The positioning of MPs in Bridges that are not VLAN aware (i.e., MAC Bridges) is illustrated in Figure 22-7. Because there are no VLANs, no EISS Multiplex Entity is needed. However, the Up MPs are still above the Port filtering entities, so the transformation introduced in 22.1.2 is still retained.

Down MPs can be placed either above or below the Queuing entities and Bridge Port connectivity in Figure 22-7; the difference between the two locations is that:

a) In the upper location, frame queues are available to CFM, so that CFM frames and data frames can be scheduled appropriately for output, and
b) Placing a Down MEP in the lower location protects the LLC path used by the Higher Layer Entities, e.g., BPDUs, as well as the normal data forwarding path.

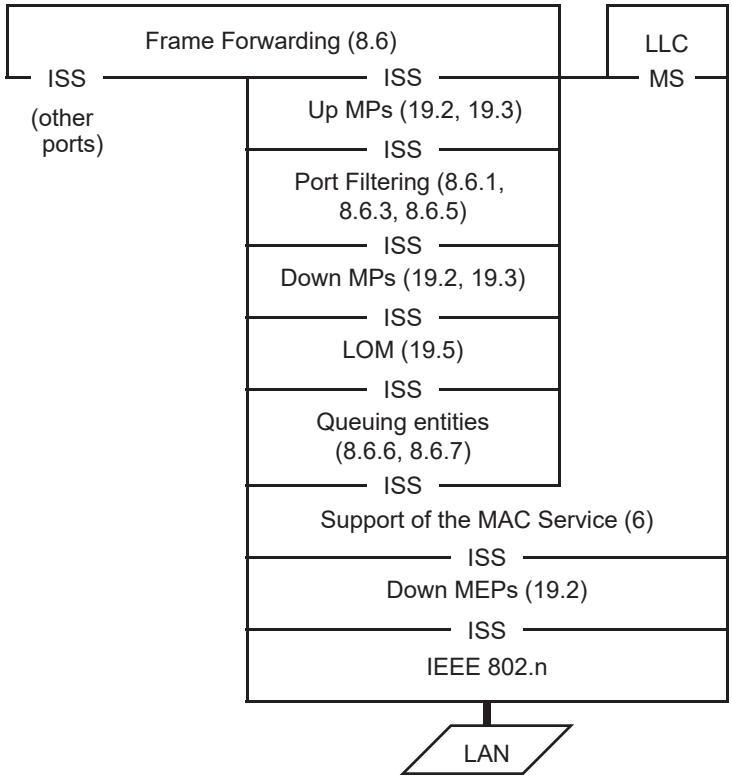


Figure 22-7—MP placement in a non-VLAN-aware Bridge Port

22.1.8 MPs and other standards

The relationship of MPs and the shims defined by two other standards, IEEE Std 802.1AX (Link Aggregation) and IEEE Std 802.1AE (MAC Security), is illustrated in Figure 22-8. This figure shows Down MEPs positioned both above and below Link Aggregation and illustrates a number of points.

MPs could, in theory, be placed either above or below the MAC Security shim. No loss of data integrity beyond the protected link would be incurred by placing CFM below MAC Security; the only attacks that could be generated would be variants of a denial of service attack. However, there are several reasons for restricting MPs to positions above the MAC Security shim:

a) The denial of service attacks available by the introduction of bogus CFM PDUs have more potential for disrupting management operations, in more complex ways, than do attacks based on other unprotected protocols, namely those defined by IEEE Std 802.3. For example, bogus cross connect CCMs could be introduced, leading to undesirable interactions between different providers' management systems.
b) MAC Security ensures that all data frames are legitimate, in the sense that they were last transmitted by a trusted device. Allowing the introduction of unprotected CFM PDUs violates the principle that data frames and CFM PDUs follow the same paths, distinguished only by the CFM protocol encapsulation.
c) Allowing the CFM and MAC Security shims to be interchanged by management operations could significantly complicate the implementation of a Bridge, with no commensurate benefit to the user.

As described in 22.1.6, placing an MP below the Queuing entities, whether above or below the Link Aggregation shim, is not desirable, as that MP is not able to use the Queuing entities. For this reason, it is preferable to use a Down MEP that is attached to a specific VID, and is thus above the Queuing entities, to protect the link.

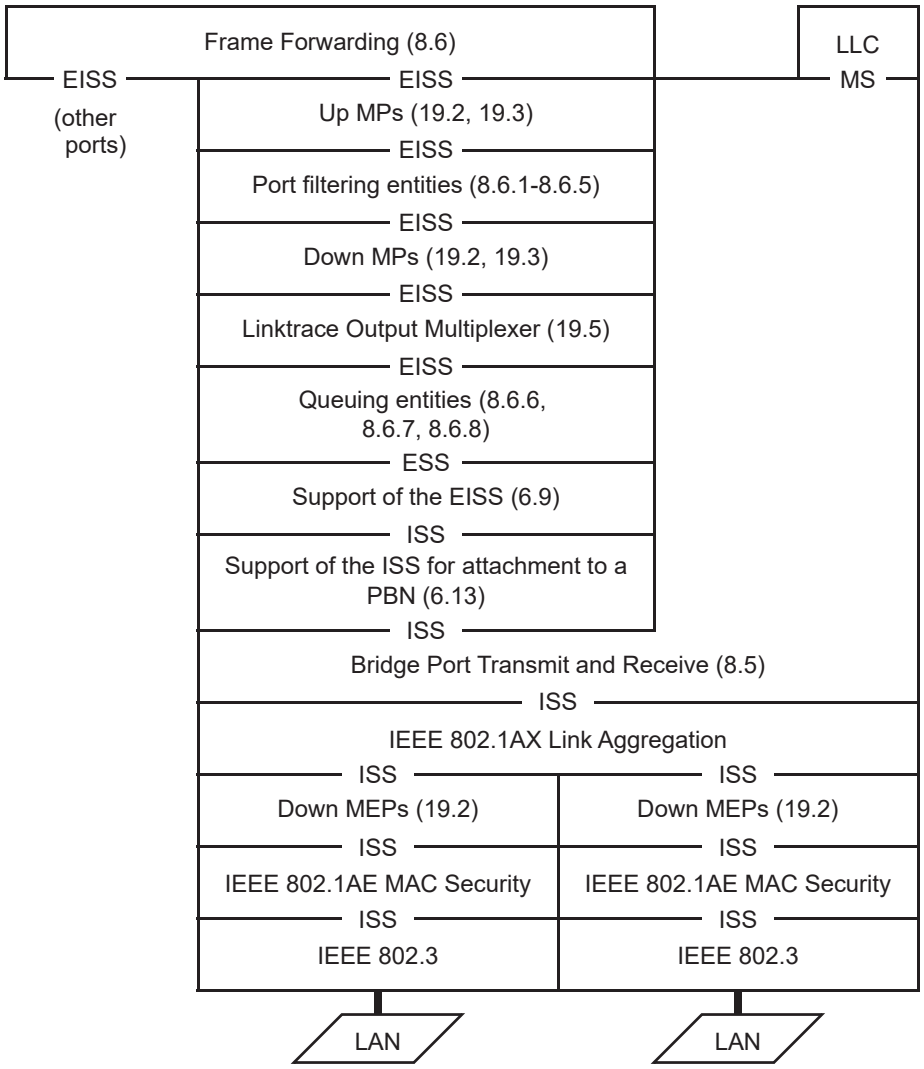


Figure 22-8—MP placement relative to other standards

When Link Aggregation is employed, Down MEPs attached to no VID can be useful for protecting the individual IEEE 802.3 LANs. The method used in Link Aggregation to select the outgoing IEEE 802.3 link is undefined. It is not necessarily possible for an MP above the Queuing entities to protect all of a Bridge Port's data; CCM PDUs could take one IEEE 802.3 link, and data frames another. Therefore, provision is made in this standard for configuring Down MEPs in an MA attached to no VID below the Bridge Port connectivity entity, and below Link Aggregation, when employed. The following considerations are important when configuring Down MEPs:

d) It is best to disable the Bridge Port before issuing a high-speed stream of LBRs (relative to the physical link speed), either from or toward a Down MEP attached to no VID; otherwise, the Queuing entities might be unable to achieve any guarantees for throughput or latency.

e) The rate of CCMs generated by Down MEPs attached to VIDs should be taken into account when configuring the Queuing entities to achieve particular guarantees for throughput or latency.

f) If Link Aggregation is present, Down MEPs attached to no VID should be configured below Link Aggregation.

g) The creation of MHFs below Link Aggregation presents two problems that preclude it from this standard:
   1) IEEE Std 802.3 provides no means for Link Aggregation to use a destination MAC address to direct a CFM PDU down the correct link to reach a particular MP at one or the other end of that link.
   2) The utility of isolating the short segment between the Port filtering entities and the links being aggregated, which is completely internal to a Bridge, is very limited, especially considering the wide range of methods employed for implementing Link Aggregation.

22.1.9 CFM and IEEE 802.3 OAM

The following differences between CFM and the IEEE Std 802.3 specification of Operations, Administration, and Maintenance (OAM) are relevant to making a decision whether to employ one, the other, or both of these protocols.

a) IEEE 802.3 OAM has provision for a loopback mode in which all frames are returned to the sender. CFM does not.

NOTE—IEEE 802.3 OAM confines loopbacked frames to the individual IEEE 802.3 LAN, effectively disabling any attached Bridge Port. Use of simple frame loopback through a Bridged Network could be expected to seriously impact the operation of the network.

b) IEEE 802.3 OAM has provision for acquiring statistics from a remote interface. CFM does not.
c) IEEE 802.3 OAM has provision for generating error conditions when configured thresholds are exceeded for parameters such as the number of frames received with Cyclic Redundancy Check (CRC) errors. CFM does not.
d) IEEE 802.3 OAM has provision for organizations other than IEEE 802 to define both new TLVs and new operation codes using OUIs/CIDs. CFM allows only TLVs to be defined using OUIs/CIDs.
e) IEEE 802.3 OAM performs a continuity check once per second. CFM can be programmed to perform the continuity check over a wide range of intervals.
f) IEEE 802.3 OAM is defined only for IEEE 802.3 media. CFM can be used over any medium, or bridged network, that can carry IEEE 802 frames.
g) IEEE 802.3 OAM protects a single link. CFM can protect a single link or a network of bridged networks, over multiple nested ranges.
h) CFM can protect the connectivity of shared media. IEEE 802.3 OAM has no such capability.
i) CFM can perform in-band loopback tests at any rate up to the physical line rate, during normal operations. IEEE 802.3 OAM has no such capability.
j) CFM can perform Linktrace functions through a Bridged Network. IEEE 802.3 OAM has no such capability.
k) CFM can detect unintentional connectivity, as well as lack of connectivity. IEEE 802.3 OAM cannot.

22.2 Maintenance Entity creation

MPs are created using the managed objects described in 12.14. Before a MEP or MHF can be created, either an entry in the Default MD Level managed object, or the Maintenance Domain and MA to which the MEP or MHF belongs, are created. In this context, a Default MD Level managed object, Maintenance Domain, or an MA are strictly managed objects in a single Bridge. In order to realize the network-wide definitions of Maintenance Domains and MAs given in 18.1 and 18.2, the Bridges in a Maintenance Domain are configured with identical information in these managed objects. During transitional periods when this information is changing, Fault Alarms will likely be generated.

NOTE—The correct operation of CFM does not depend on the configuration restrictions in this subclause. Rather, violating these restrictions is likely to generate Fault Alarms that might or might not be erroneous. In other words, if no Fault Alarms are generated, then all monitored MAs have connectivity. If any Fault Alarm is generated, then either

connectivity has been lost or the network is improperly configured. Determining which of these two is the cause of a Fault Alarm depends on the intentions of the operators and is therefore beyond the scope of this standard.

22.2.1 Creating Maintenance Domains and MAs

The operator creates either a Default MD Level managed object or a Maintenance Domain managed object in a Bridge for every Maintenance Domain whose CFM PDUs can pass through that Bridge and are to be processed. The operator can also create a MA managed object in a Bridge for some or all of the MAs whose CFM PDUs can pass through that Bridge and are to be processed. Whether a service instance can pass through a Bridge depends on the following:

a) Enable Ingress Filtering per-Bridge Port parameter (8.6.2).
b) Static Filtering Entries (8.8.1).
c) Static VLAN Registration Entries (8.8.2).
d) PIP configuration parameters (6.10).
e) CBP configuration parameters (6.11).
f) Dynamic VLAN Registration Entries (8.8.5).
g) Operation of MSTP (Clause 13), which in turn, can be affected by the state of the MAC_Operational parameters (IEEE Std 802.1AC) of the ISSs in the Bridge Port.

The first five of these methods are altered only by modifying managed objects and can therefore be considered static for the purposes of configuring CFM. The last two methods are dynamic, in that they depend not only on configuration, but on protocols that respond to network events, such as the addition or loss of a link or Bridge. For example, a VLAN can pass through a Bridge unless there is a Static VLAN Registration Entry prohibiting its VID from passing through every Bridge Port, and Ingress Filtering is enabled on every Bridge Port. If a Bridge's Maintenance Domain requires only insignificant resources to support MHF configuration, then the most reliable network is one that assumes that all service instances will require MHFs at some MD Level higher than that of that Maintenance Domain.

22.2.2 Creating MEPs

There are four kinds of Maintenance Association managed objects: those that are attached to one or more specific VIDs in the Bridge, those that are attached to no VID, those that are attached to an I-SID, and those that are attached to a TESI or ECMP path.

Once the appropriate Maintenance Domain and MA have been created, a MEP can be created, modified, or deleted using the MA managed object defined in 12.14.6. MEPs are always created explicitly. MEP creation is controlled by creating a Maintenance association Endpoint managed object using the following parameters:

a) Whether the MA to which the MEP belongs is associated with specific VID(s), I-SID, TESI, or ECMP path, and if so, which parameters [item b) in 12.14.6.1.3], including a specification of the MA's Primary VID [item d)in 12.14.7.1.3].
b) Whether the MEP is a Down MEP (pointing away from the MAC Relay Entity), or an Up MEP, (pointing toward the MAC Relay Entity) [item c) in 12.14.6.3.2].

Given those two values in the MEP managed object, Table 22-1 shows where, in Figure 22-9, the MEP is created. In Figure 22-9, which shows a PNP or a CNP, the VID selects which of the MEP positions is selected for Table 22-1 column 3 values 1 and 4. Only one row of MEPs is shown in positions 1, 4, and 5, even though up to eight rows can exist at each of these points. Because the MEPs are always placed in order by MD Level, with the highest MD Level nearest the MHFs, at the center of each stack, there is thus no ambiguity. The third column, starting from the left, in the EISS Multiplex Entity depicted in Figure 22-9

corresponds to an ESP-VID or SPBM VID. Only MIPs can be placed in this column for a PNP. MEPs can be created on a CBP and PIP as shown in Figure 26-2.

Table 22-1—MEP creation

MA has VID [item b) in 12.14.6.1.3]	MEP direction [item c) in 12.14.7.1.3]	Position of MEP in Figure 22-9
Yes	Up	1
	Down	4
No	Up	disallowed
	Down	5

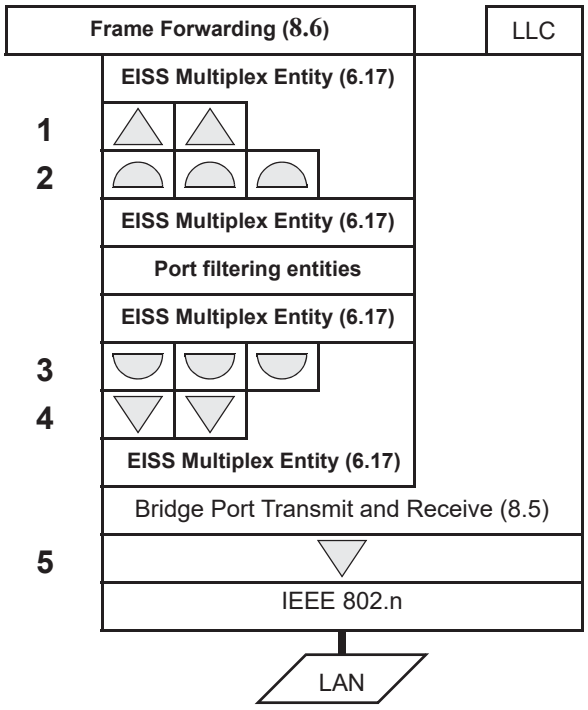


Figure 22-9—Creating MEPs and MIPs

If any MEPs are configured on an MA, then in any given Bridge, either all of those MEPs are Up MEPs or all of them are Down MEPs; a Bridge refuses to create an Up (Down) MEPs if a Down (Up) MEP already is configured in that MA in that Bridge. An MA can be configured with Up MEPs in one Bridge and Down MEPs in another Bridge or Station. Any given VID can be configured on any number of MAs (including zero) containing either Down MEPs or no MEPs at all, plus zero or one MA containing Up MEPs. No VID can be configured on more than one MA on which are configured Up MEPs.

These restrictions, along with the configuration errors in 22.2.4, enable MEPs to be configured so that they bound an MA, no matter what action is taken by the spanning tree protocols within a Maintenance Domain.

22.2.3 Creating MIPs

Managed objects control the creation of MIPs, but indirectly, rather than explicitly, as for MEPs. Every MA defined in a Bridge can cause the management entity to create MIPs on every Bridge Port. On each Bridge Port, the following conditions trigger the management entity to reevaluate the creation of MIPs for a given VID (or list of VIDs) or I-SID *x* on that port:

a) The Bridge is initialized.
b) A MEP is created or deleted on VID(s) or I-SID *x* on that Bridge Port.
c) An Up MEP is created or deleted on VID(s) *x*, which is (are) not allocated to a TESI, on any Bridge Port or an Up MEP is created or deleted on I-SID *x*.
d) A change occurs in whether VID(s) or I-SID *x* can or cannot pass through the Bridge Port (22.2.1).
e) A change occurs in the Default MD Level managed object (12.14.3).
f) A change occurs in a Maintenance Association managed object associated with VID(s) or I-SID *x*.

A MIP for VID-based service instances and TESIs is created by creating a pair of MHFs in positions 2 and 3 in Figure 22-9. MIPs associated with I-SIDs are created on the two sides of the multiplexed SAPs in the Backbone Service Instance Multiplex Entity as depicted in Figure 26-2. MAs that are associated with no VID are not considered in this subclause. For a given VID on a given Bridge Port, and in the absence of any of the configuration errors in 22.2.4, there are at most two MAs at each MD Level that can affect MIP creation, plus at most one entry in the Default MD Level managed object. If one or more of the configuration errors in 22.2.4 are present, this standard does not specify what MIPs the Bridge creates.

When required, the Maintenance Entity performs the MIP evaluation on each Bridge Port for each VID. For each Bridge Port *p* and service identifier *x*, which can be a list of VIDs, or an I-SID, the Maintenance Entity creates a list of active MD Levels. This list contains the following:

g) MD Level of each of the MAs (if any) that monitors service *x* and has a MEP configured on Bridge Port *p*.
h) MD Level of each of the MAs (if any) that monitors a service *x*, and has at least one Up MEP configured on some Bridge Port in this Bridge other than Bridge Port *p*.
i) MD Level of each of the MAs (if any) that monitors service *x* and has no MEPs configured on any Bridge Port in this Bridge.
j) MD Level of the entry in the Default MD Level managed object (12.14.3) for service *x*.

Exactly one MD Level *d* in this active list is eligible for MIP creation. It is the lowest MD Level in the list of active MD Levels such that there is no MEP configured on Bridge Port *p* and service *x* at MD Level *d* or at any higher MD Level. This is the lowest MD Level in the list, if there is no such MEP configured. The Maintenance Entity then uses Table 22-2 to determine whether the MIP is to be created.

Table 22-2—MIP creation

Enumeration [item d) in 12.14.3.1.3, item c) in 12.14.6.1.3, or item c) in 12.14.6.1.3]	A MEP is configured on Bridge Port *p*	MIP created
defMHFnone:	—	No
defMHFexplicit	False	No
	True	Yes
defMHFdefault	—	Yes

The enumeration controlling whether the MIP is created is taken from:

k) The Maintenance Association managed object [item c) in 12.14.6.1.3] for the MA that monitors service *x*, and has at least one Up MEP configured on some Bridge Port in the Bridge [see item h)]; or

l) That MA's Maintenance Domain managed object [item c) in 12.14.5.1.3], if that MA exists, but its Maintenance Association managed object contains the value defMHFdefer; or

m) The Default MD Level managed object [item d) in 12.14.3.1.3] if no such MA exists [see item j)].

The enumerated values used in the managed objects item d) in 12.14.3.1.3, item c) in 12.14.5.1.3, and item c) in 12.14.6.1.3 to control the creation of a MIP for a service instance identified by the parameter *x* on a Bridge Port are as follows:

n) **defMHFnone**—No MHFs can be created for this VID(s) or I-SID (the default value).

o) **defMHFdefault**—MHFs can be created for this VID(s) or I-SID on any Bridge Port through which the VID(s) or I-SID can pass where:

   1) There are no lower active MD levels, or

   2) There is a MEP at the next lower active MD level on the port.

p) **defMHFexplicit**—MHFs can be created for this VID(s) or I-SID only on Bridge Ports through which this VID(s) or I-SID can pass, and only if there is a MEP at the next lower active MD level on the port.

q) **defMHFdefer**—In the Maintenance Association managed object [item c) in 12.14.6.1.3] only, the control of MHF creation is deferred to the corresponding variable in the enclosing Maintenance Domain [item c) in 12.14.5.1.3].

22.2.4 CFM configuration errors

While making the MIP creation evaluation described in 22.2.3, or whenever a MEP is created or deleted, the management entity can encounter errors in the configuration. Because of this, the Management entity maintains a Configuration Error List managed object (12.14.4) that lists, for every VID or I-SID, the Bridge Ports that have MIP configuration errors. Every time the MIP creation evaluation is performed or a MEP is created or deleted, this list is updated to reflect which Bridge Ports and VIDs are in error and which are not. A Bridge Port is placed in the list if and only if one of the following errors occurs:

a) **CFMleak**—MA *x* is associated with a specific VID list or I-SID, one or more of the VIDs or I-SID in MA *x* can pass through the Bridge Port, no Up MEP is configured for MA *x* on the Bridge Port, no Down MEP is configured on any Bridge Port for MA *x*, and some other MA *y*, at a higher MD Level than MA *x*, and associated with at least one of the VID(s) or the I-SID also in MA *x*, does have a MEP configured on the Bridge Port.

b) **ConflictingVIDs**—MA *x* is associated with a specific VID list or I-SID, an Up MEP is configured on MA *x* on the Bridge Port, and some other MA *y*, associated with at least one of the VID(s) or I-SID also in MA *x*, and at the same MD Level as MA *x*, also has an Up MEP configured on some Bridge Port.

c) **ExcessiveLevels**—The number of different MD Levels at which MIPs are to be created on this port exceeds the Bridge's capabilities (see 22.3).

d) **OverlappedLevels**—A MEP is created for one VID or I-SID at one MD Level, but a MEP is configured on another VID or I-SID at that MD Level or higher, exceeding the Bridge's capabilities (see 22.3).

A Bridge uses detection of the ExcessiveLevels error to refuse an operation on a managed object and thus avoids adding Bridge Ports to the error lists. This is because this incremental operation is known to be the one that exceeds the capabilities of the Bridge. However, a Bridge uses only the detection of the ExcessiveLevels error to refuse an operation on a managed object. That is because the other errors can arise as a result of a management operation, e.g., the deletion of a Static VLAN Registration Entry, that has no

knowledge of CFM and cannot report the error. Furthermore, the root cause of either error might not be the last MA to be configured and could be under the control of another administration. Therefore, management operations that trigger errors other than ExcessiveLevels are performed, not rejected. The lists of Bridge Ports in error are maintained (12.14.4), so that the system administrator(s) can agree on a course of action, outside this standard, to correct the problem.

22.3 MPs, Ports, and MD Level assignment

It is possible to configure MPs at different MD Levels for different VIDs on a single Bridge Port. However, this imposes upon an implementation the burden to be able to configure up to 8189 MD Levels for the VIDs on a Port, 4094 for MHFs and 4095 for MEPs, each requiring 3 bits of storage. An implementation may not support different MD Levels for MIPs on different VIDs on a single Port, hence the ExcessiveLevels and OverlappedLevels error responses (22.2.4). At least one MD Level shall be supported for each port in a Bridge, such that MIPs can operate at that MD Level, and all CFM PDUs below that MD Level are filtered or processed, according to the configuration of MEPs on the port.

In Figure 18-7, the left-most Maintenance Entity at the lowest MD Level (0) has one MEP in the customer's equipment 1 and one in Provider Bridge 2. When Down MEPs are used in this manner to create a Maintenance Entity that interconnects two administrations, those administrations can agree upon a particular MD Level (and MAID and MEPIDs) to use. To enhance the chances for interoperability, the MD Level for Down MEPs should be the lowest not already in use by an existing MA, typically 0.

Assigning MD Levels with gaps between the levels used, as in Figure 18-7, can be wasteful of resources, especially MAC Address Registration Entries in the FDB. Minimizing the number of MD Levels, and concentrating the MD Levels used toward MD Level 0, minimizes the required resources, since CFM PDUs carrying higher MD Levels than those used in a Bridge are treated as ordinary multicasts by that Bridge. However, if one creates a Maintenance Domain at MD Level 0, and subsequently needs a level beneath that one, for example if a PBN is substituted for a physical connection, then the MD Level of the original Maintenance Domain might have to be changed. If there is another Maintenance Domain above the one at MD Level 0, that one would have to be changed, first, and so on. Similarly, if an existing Maintenance Domain at MD Level 3 is partitioned into several Domains, a new Maintenance Domain at MD Level 4 would be needed to ensure end-to-end connectivity across the extent of the old Maintenance Domain.

Such difficulties can be avoided in several ways:

a) The MD Levels of different Maintenance Domains can be insulated from each other by VLAN tags. Appropriate placement of the MEPs in Bridge Ports can ensure that the tags insulate the MD Levels, and that no reconfiguration will be necessary.
b) If it is expected that an additional MD Level will be needed because a physical link will likely become virtualized, MD Level 0 can be left vacant.
c) If it is expected that an additional MD Level will be needed because a Maintenance Domain will likely be partitioned, a gap can be left between that Maintenance Domain's MD Level and the lowest MD Level offered to a customer of that Maintenance Domain.

See J.2 for a description of an MD Level assignment plan that can be used in the most general case.

22.4 Stations and CFM

Stations, as well as Bridges, can implement CFM. For the purposes of CFM, and for no other purposes, a Station is modeled as a Bridge, with the following exceptions:

a) This standard defines no entities above the layer of Down MPs in Figure 22-8. In particular, a Station has no Port filtering entities, Up MPs, or Forwarding Process. A CFM-capable Station is therefore a set of one or more disconnected Bridge Ports.
b) A Station shall not support the creation of MIPs or Up MEPs. Only Down MEPs can be implemented in a Station.
c) CFM PDUs not processed and not discarded by a MEP shall be ignored, and not processed, by the Station.
d) A Station shall create no entries in the Configuration Error List managed object (12.14.4) except for CFMleak errors.

22.5 Scalability of CFM

CFM can create a considerable load on the resources of a Bridge. Ideally, a Bridge has the capability to reflect LBMs as LBRs at line rate, so that the capacity and reliability of a network can be tested. The total load imposed by LBMs, LBRs, LTMs, and LTRs cannot be predicted, as these are all under the control of the system administrator, and any number of streams of these PDUs can be generated.

The load imposed by CCMs is more regular, so reasonable predictions of the load they impose can be made. Based on a figure of 109 octets as the minimum frame size, from the start of the destination MAC address of one frame to the start of the destination MAC address of the next frame,[38] Table 22-3 shows the load that is imposed by CCM transmission and reception upon a Bridge Port with a single configured MEP, as a function of the CCM transmission interval, the number of MEPs in the MA, and the speed of the link. One row in the table shows the number of CCMs per second transmitted or received. The number in each of the other rows is the fraction of the total bandwidth required by those CCMs. Table 22-4 extends this calculation by multiplying all numbers by 1000, for the case where 1000 VIDs, each with a MEP, are configured on the Bridge Port, again with the specified transmission interval and average number of MEPs per MA.

Counting 4094 allowed VIDs in a VLAN tag, three kinds of MEPs, Up VID MEPs, Down VID MEPs, and Down no-VID MEPs, and eight MD Levels, a single Bridge Port with no Link Aggregation can, in theory, support 65 504 MEPs and 8188 MHFs.

Table 22-3—Bandwidth required for CCMs for 1 MA

Transmit interval	**3.3 ms**		**10 ms**		**1 s**		**60 s**	
MEPs in each MA	**10**	**2**	**10**	**2**	**10**	**2**	**10**	**2**
CCM / s	**3000**	**600**	**1000**	**200**	**10**	**2**	**0.167**	**0.033**
10 Mb/s	26.160%	5.232%	8.720%	1.744%	0.087%	0.017%	0.001%	0.000%
100 Mb/s	2.616%	0.523%	0.872%	0.174%	0.009%	0.002%	0.000%	0.000%
1 Gb/s	0.262%	0.052%	0.087%	0.017%	0.001%	0.000%	0.000%	0.000%
10 Gb/s	0.026%	0.005%	0.009%	0.002%	0.000%	0.000%	0.000%	0.000%
100 Gb/s	0.003%	0.001%	0.001%	0.000%	0.000%	0.000%	0.000%	0.000%

[38] First TLV Offset = 70, 12 for MAC addresses, 6 for Type and fixed header, 1 for End TLV, 20 for inter-frame gap and preamble.

Table 22-4—Bandwidth required for CCMs for 1000 MAs

Transmit interval	3.3 ms		10 ms		1 s		60 s	
MEPs in each MA	10	2	10	2	10	2	10	2
CCM / s	3 000 000	600 000	1 000 000	200 000	10 000	2000	167	33
10 Mb/s	> 100%	> 100%	> 100%	> 100%	87.200%	17.440%	1.453%	0.291%
100 Mb/s	> 100%	> 100%	> 100%	> 100%	8.720%	1.744%	0.145%	0.029%
1 Gb/s	> 100%	52.320%	87.200%	17.440%	0.872%	0.174%	0.015%	0.003%
10 Gb/s	26.160%	5.232%	8.720%	1.744%	0.087%	0.017%	0.001%	0.000%
100 Gb/s	2.616%	0.523%	0.872%	0.174%	0.009%	0.002%	0.000%	0.000%

22.6 CFM in Provider Bridges

The S-VLAN component of a Provider Bridge is, for the purposes of this standard, an example of a VLAN Bridge. Fortunately, the many combinations possible when configuring CFM on Customer Bridges and Provider Bridges, connected using Port-based, C-tagged, or Remote Customer Service Interfaces (RCSIs), can be simplified.

22.6.1 MPs and C-VLAN components

When a C-VLAN component is integrated into a Provider Edge Bridge to form a C-tagged service interface, there is little justification for making all possible CFM entities manageable. Subclause 15.4 describes a C-tagged service interface, illustrated in Figure 15-4. Figure 22-10 recasts Figure 15-4, illustrating the minimum set of CFM functions that a C-tagged service interface is required to support, if its Provider Bridge supports CFM. Almost all of the CFM components have been removed from the C-VLAN component. As a result, the transformations made in 22.1.2 and 22.1.3 are unnecessary, and the subclause references collapse to match those in Figure 15-4. The S-VLAN component contains almost the full suite of CFM entities. One set of shims has been moved from the CNP to the CEP, however.

The managed objects in 12.14 support the creation of up to eight MEPs below the Bridge Port Transmit and Receive process (8.5). These MEPs belong to MAs associated with no VID. A MEP in this position would be of little use in a CNP, since there is no need to pair it with a MEP in the PEP to protect an Internal LAN. However, a MEP attached to no VID in the CEP could be used to protect the LAN to the customer equipment.

In order to support protection of the CEP's LAN, while maximizing interoperability, whenever (Down) MEPs are created (12.14.6.3) in an MA associated with no VID, a Provider Edge Bridge shall allow those MEPs to be created using the interface number [item d) in 12.14.6.3.2] for a CEP.

22.6.2 Maintenance C-VLAN on a Port-based service interface

Assume that a customer's C-VLAN Bridge is attached to an S-VLAN Bridge as in Figure 22-4, and that the customer wants to pair a Down MEP in the C-VLAN Bridge with a similar Down MEP in the C-VLAN Bridge on the other side of the PBN, thus creating an MA to provide end-to-end protection of the service instance offered by the Provider. In order to obtain the advantage of inserting the CFM PDUs above the

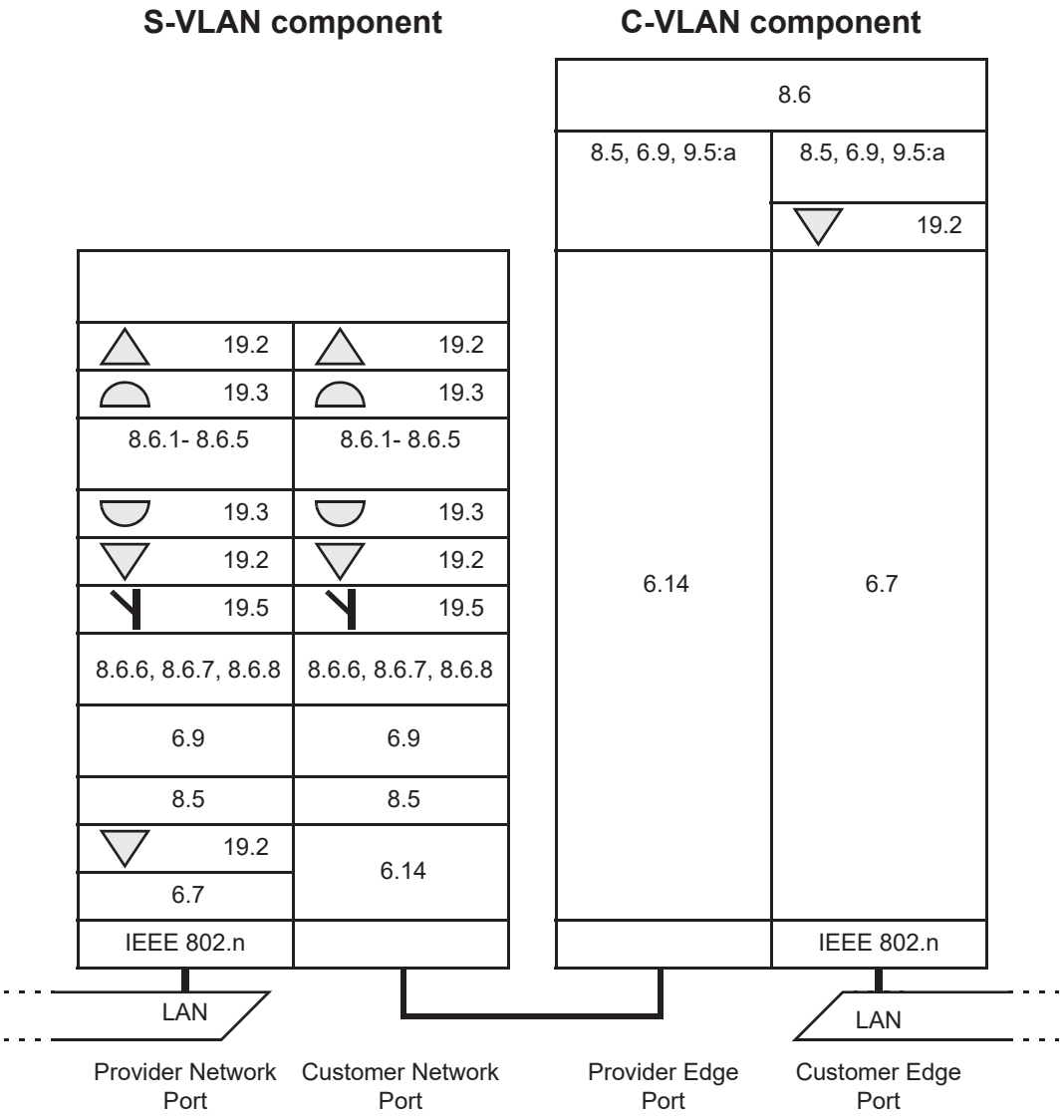


Figure 22-10—CFM in a Provider Edge Bridge C-tagged service interface

Queuing entities, the customer would not use MEPs below the Bridge Port Transmit and Receive process (8.5). The customer could create one MA for each C-VID. However, this would have drawbacks in that:

a) The extra MAs beyond the first MA would provide very little protection on a Port-based service.
b) Each extra MA would add to the overhead of CFM PDUs.
c) The C-tagged CFM PDUs would not be detected by any of the CFM entities in any Provider Bridge, so no MIPs would be present in the customer's MAs.

If the customer, instead, creates an MA on only one C-VLAN, the Maintenance C-VLAN, and configures the two C-VLAN Bridges to pass the Maintenance C-VLAN across the PBN untagged, then:

d) The service instance is protected.
e) The provider can configure a MIP on the S-VLAN carrying the customer's service instance that is visible in the customer's MA.

22.6.3 Maintenance C-VLAN on a C-tagged service interface

Assume that a customer's C-VLAN Bridge, illustrated by Figure 22-4 (less, of course, the box for "Support of the ISS for attachment to a PBN (6.13)"), is attached to a Provider Edge Bridge as in Figure 22-10. Assume that the customer has purchased several service instances, which have C-tagged service interfaces to other of the customer's C-VLAN Bridges at several different locations. Let us further suppose that the customer wants to pair Down MEPs in the C-VLAN Bridge to create MAs to provide end-to-end protection of the service instances. In order to obtain the advantage of inserting the CFM PDUs above the Queuing entities, the customer would not use MEPs below the Bridge Port Transmit and Receive process (8.5). The customer could create one MA for each C-VID.

There would be more justification in creating an MA per C-VLAN than for the Port-based service instance described in 22.6.2. However, if the customer is reasonably confident that the provider will carry each C-VLAN in the correct S-VLAN, then the customer can create multiple Maintenance C-VLANs, one per provider service instance (S-VLAN), and thus one per PEP in the C-VLAN component. By configuring each of these PEPs to pass that one C-VLAN untagged to the corresponding CNP in the S-VLAN component, the CFM PDUs in that one customer MA are visible to the S-VLAN component. The provider can configure a MIP for that S-VID that is visible to the customer's MA. The customer can have one MA protecting each service instance.

22.6.4 MPs and Port-mapping S-VLAN components

When a Port-mapping S-VLAN component is used to provide RCSIs there is little justification for making all possible CFM entities manageable. The other Provider Bridge components can provide the necessary MPs for service OAM. There is one MP that can only be provided by the Port-mapping S-VLAN component and that is the point below the Bridge Port Transmit and Receive process (8.5) on the RCAP. This MP can be used to protect the LAN to the neighboring PBN.

Figure 22-11 extends Figure 22-10, showing the minimum set of CFM entities required for a C-tagged RCSI, if the Provider Bridge supports CFM. The S-VLAN component and C-VLAN component support the same set of CFM entities as in Figure 22-10. The Port-mapping S-VLAN component that provides the RCSIs supports at least one more CFM entity, as shown, that can protect the LAN to the neighboring PBN.

Similarly, in the case of a Port-based RCSI or an internal PNP the required service CFM entities can be provided by the S-VLAN component. Thus the only CFM entity required from the Port-mapping S-VLAN component is the one shown in Figure 22-11 which is independent of the number and type of internal Ports provided.

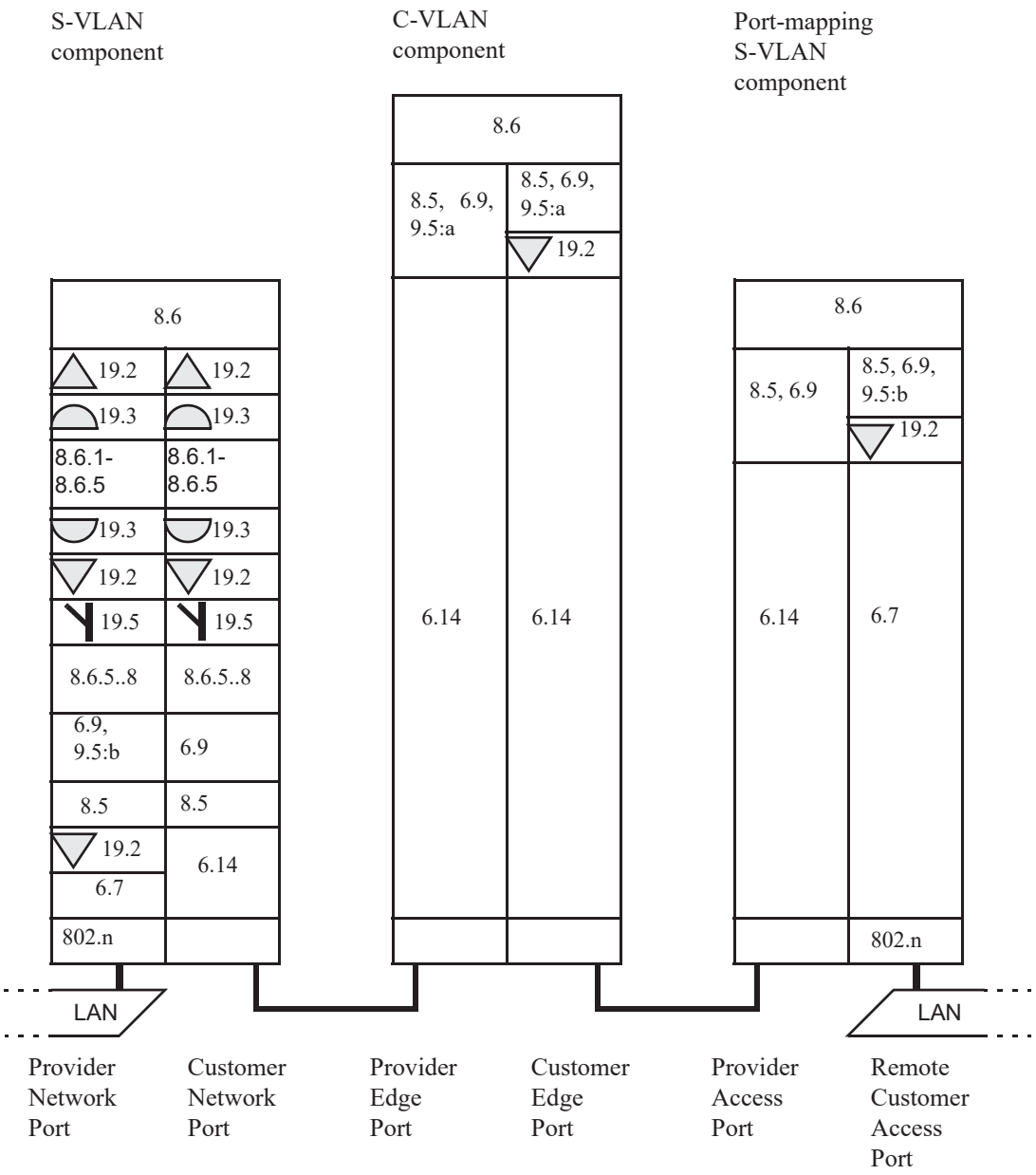


Figure 22-11—CFM in a Provider Edge Bridge C-tagged RCSI

22.7 Management Port MEPs and CFM in the enterprise environment

Figure 22-12 illustrates the placement of Management Port MEPs. It is similar to the CFM Port illustrated in Figure J-1. However, the Management Port MEPs are configured explicitly for the Management Port. They do not represent information for any other Bridge Port in their CFM PDUs. Therefore, there is only one MEP for each MA. Furthermore, there can be no MHFs configured on a Management Port, because there can be no MEP further along the path to terminate the MA.

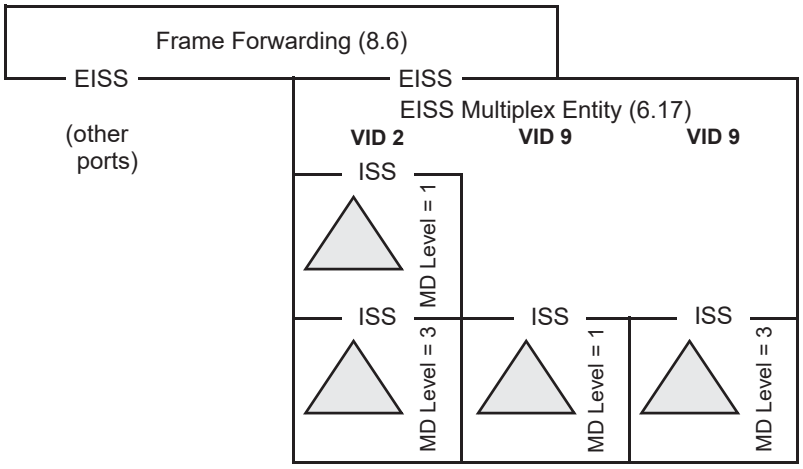


Figure 22-12—Up MEPs in a Management Port

NOTE—The fact that a CFM Port could be configured on a Management Port, and thus instantiate MHFs on the Management Port, does not contradict the preceding paragraph. Those MHFs are configured on a Bridge Port, and instantiated on the Management Port (CFM Port), not configured on the Management Port.

Although this standard uses the terminology of Provider Bridges and describes the functions of CFM in terms of Provider Bridges, it can be applied to any Bridge, whether a Provider Bridge, C-VLAN Bridge, or MAC Bridge. The normative definitions and functions specified by this standard do not depend on, for example, whether the VLAN tag used to associate frames with VLANs use the customer format or the provider format. Certainly, no business relationships are required to implement this standard.

Given that both the users and the providers of an enterprise network are, by definition, all members of the same company, the utility of CFM in the enterprise environment is less than in the provider/customer environment. The network administrator of an enterprise network can find a number of uses for CFM, however.

The default values for MEP and MIP configuration make CFM easy to configure for the typical enterprise network. Figure 22-13 illustrates two Bridge Ports, the Management Port, and one Bridge Port connected to a LAN, using the default configuration as follows:

a) A single Maintenance Domain can be configured at MD Level 0.
b) An MA for each VID is configured in each Bridge.
c) A single MEP for each VID is configured on a Management Port in each Bridge. Typically, this is a port with no external interface, often the one used to manage the Bridge.
d) Through the Maintenance Domain managed object previously created, it is easy to define a MIP on every Bridge Port on every VID.

This simple configuration enables the administrator to use LBMs and LTMs to diagnose network faults among the Bridges of the network. In addition, specific high-priority VLANs, e.g., a VLAN interconnecting key routers and file servers for a large enterprise, could be explicitly monitored via CFM.

In a large enterprise, separate Maintenance Domains can be established, along with an accompanying enterprise-wide Maintenance Domain at a higher MD Level, in order to define and enforce separate spheres of responsibility for separate network administrations, e.g., in different departments in a university. The boundaries between Maintenance Domains might well coincide with administratively imposed boundaries between MSTP Regions.

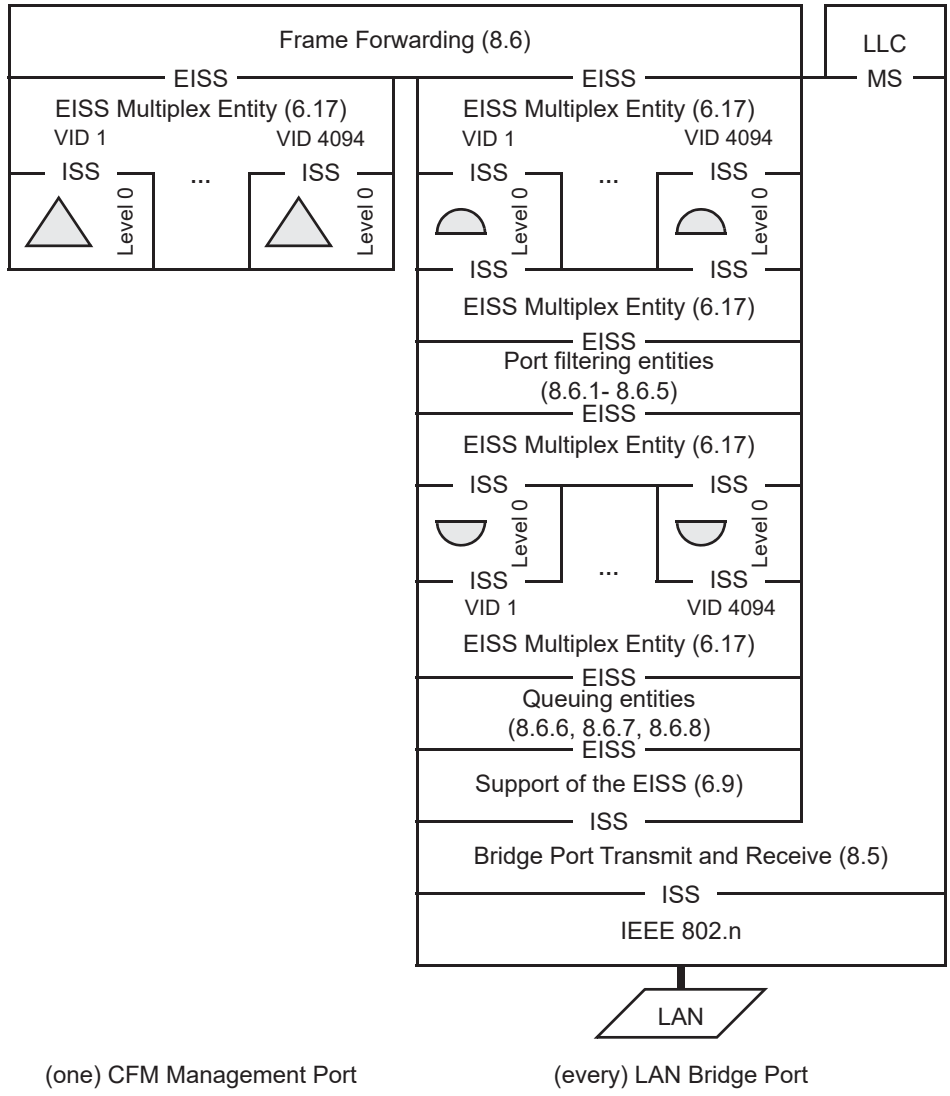


Figure 22-13—CFM in the enterprise environment

22.8 Implementing CFM on Bridges that implement earlier revisions of IEEE Std 802.1Q

It might or might not be easy to implement CFM in a VLAN Bridge that implement earlier revisions of IEEE Std 802.1Q. The problems are best illustrated by a three-port Bridge as illustrated in Figure 22-14. Each of the three Bridge Ports A, B, and C is configured with MEPs and MIPs at the MD Levels shown in the figure.

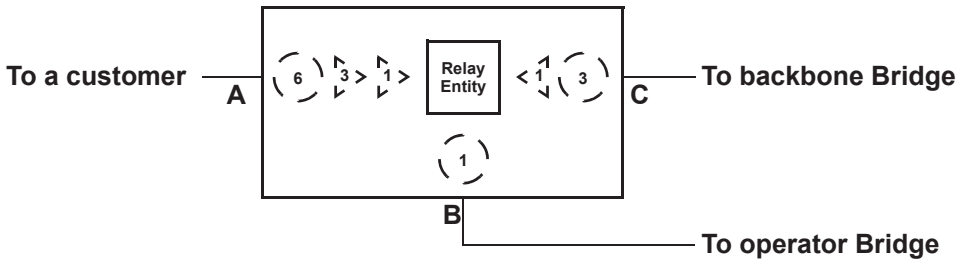


Figure 22-14—CFM in the enterprise environment

If a CCM at MD Level 3 enters the Bridge from Bridge Port C, that CCM will be passed to both of the other Bridge Ports A and B. It will not exit Bridge Port A, however, because there is a MEP at MD Level 3 on that Bridge Port. It will, however, pass through Bridge Port B to the other operator Bridge. One can easily imagine configuring MAC Address Registration Entry in the Bridge for the MD Level 3 group address shown in Table 8-18 that permits that group address to pass through the Bridge Ports B and C, but not through Bridge Port A, and also sends the CCM to a CFM module in the Bridge's Higher Layer Entities, perhaps residing on the Management Port of 22.7, for processing. It is precisely so that MAC Address Registration Entries can be used in this manner that CCMs and LTMs are required to use the group addresses in Table 8-19 and Table 8-18.

A potential problem for some implementations can be seen if readers ask what happens if that same CCM at MD Level 3 enters from Bridge Port A. In that case, the CCM does not exit either of Bridge Ports B or C, because Bridge Port A has a MEP at MD Level 3 to stop it; MAC Address Registration Entries prevent frames from leaving a Bridge Port, not from entering one. Many Bridges have the ability to filter incoming frames based on the destination MAC address and/or the contents of the frame; either facility will enable this CCM to be stopped. In order to support both a Down MEP attached to no VID, and a Down MEP attached to a tagged VID at a lower MD Level than the no-VID MEP, the Bridge filters frames based on both the MAC address and whether the frame is tagged.

23. MAC status propagation

Individual LANs, each operating its own MAC and media access method-specific procedures, can be connected by one or more TPMRs to form a composite LAN that is transparent to other Bridges and stations and their configuration protocols. The MAC Status Protocol (MSP) ensures that changes in the connectivity provided by the composite LAN results in changes in the MAC_Operational status parameter (IEEE Std 802.1AC) at each of the attached Bridges and stations, just as if they were connected to an individual LAN.

NOTE 1—MSP is designed only for use with point-to-point LANs.

MAC_Operational provides rapid notification of connectivity failures and prompts the necessary initial protocol behavior to ensure that new connectivity has not caused an instantaneous data loop. If this MAC status parameter were not propagated by a TPMR, Bridge protocols would have to rely on periodic transmissions to detect connectivity changes. On their own these periodic transmissions take longer to detect failures, and cannot detect the possibility of data loops until they have been created, as illustrated by the following examples.

Figure 23-1 shows a TPMR connecting two Bridge Ports.

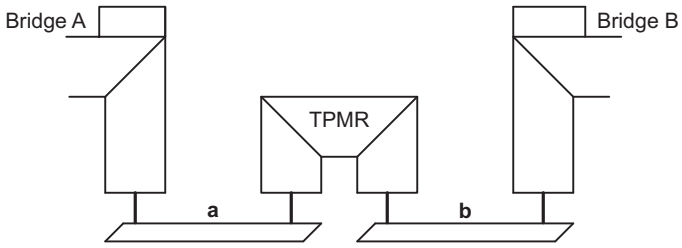


Figure 23-1—TPMR connecting two Bridge Ports

Assume that Bridge A is the spanning tree Designated Bridge for the LAN that comprises the individual LANs **a** and **b** and the TPMR, and that Bridge B's spanning tree Root Port is shown. If **a** fails and the TPMR does not propagate MAC_Operational, Bridge B will not reselect its Root Port until it has timed out the last BPDU from A.

Figure 23-2 shows a link that uses two TPMRs, perhaps because LAN **c** uses a non-IEEE-802 technology together with an appropriate convergence function.

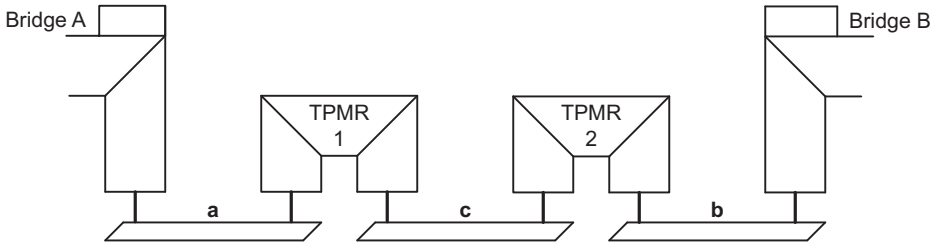


Figure 23-2—TPMR chain connecting Bridge Ports

Without MAC_Operational propagation, failure of **c** will not be immediately visible to either Bridge. Worse, if **c** fails and is restored after a while, both A and B will believe themselves to be Designated Bridge for the composite LAN, and will forward frames until one receives a BPDU from the other, even if a data loop has been created.

When working correctly the MAC Service provides bidirectional connectivity or no connectivity at all. MAC_Operational is TRUE for each of two peers connected to the same LAN if they can communicate, and FALSE for either or both if they cannot. Protocols, such as the spanning tree protocols, that make use of MAC_Operational to detect new connectivity and initialize state machines rely on the last peer that sees MAC_Operational transition TRUE to enforce any necessary behavior after a connectivity change. For example, it is the last of two connected Bridge Ports to be powered on that enforces the necessary delay prior to setting operEdge TRUE (13.27).

NOTE 2—MAC_Operational being TRUE within a single station does not guarantee connectivity to any peer. Even if connected by a point-to-point LAN, the peer could have just reinitialized. It is not possible, given only the use of the LAN medium for communication, to arrange for two peers to transition MAC_Operational at exactly the same time.

This clause defines media-independent propagation of MAC status between TPMRs and to attached stations, as follows. It:

a) Models MAC status propagation within the Bridge architecture used to describe a TPMR (23.1).
b) Provides an overview of MSP (23.2).
c) Specifies state machines for MSP operation (23.3–23.9).
d) Specifies the addressing, protocol identification, format, encoding, and validation of MAC Status Protocol Data Units (MSPDUs, 23.13–23.16).

The term *MAC status propagation* (3.154) describes the overall process of communicating a MAC_Operational parameter value through one or more TPMRs. MSP can use *link status notification*[39] (3.123) between some Bridges and end stations and *MAC status notification* (3.153) between others. These two notification methods differ, as follows:

e) Link status notification uses frames to convey information about MAC_Operational. It does not interrupt or prevent other communication between adjacent Bridges. However, it requires both the source and destination of the notification to implement additional protocol. Since it does not prevent communication it cannot, by itself, prevent loops caused by new connectivity.
f) MAC status notification uses a layer management interaction with the local MAC Entity to change MAC_Operational for a peer user of the MAC Service provided by an individual LAN. It is equivalent to bringing a link down, and is generally effective for MACs with specific point-to-point support. It also interrupts all other communication, including the use of in-band management to rectify an underlying problem.

Where management of a TPMR is permitted through one of its ports, the failure of an individual LAN not in the communication path does not cause MAC status propagation to prevent management connectivity. In Figure 23-2, for example, the failure of LAN **b** does not prevent connectivity to TPMR 2 from Bridge A. When **b** recovers, MAC_Operational for Bridge A's Port is "blipped," i.e., taken FALSE for a brief period and allowed to return TRUE, thus meeting the requirement for transition when connectivity changes.While this slows the recognition of newly available connectivity, that is rarely an issue since several seconds hysteresis should be applied to any MAC_Operational status transition to prevent higher layer protocols "flapping."

[39] The use of the term link status notification in this standard is not to be confused with the term used in SNMP to refer to a type of trap notification.

23.1 Model of operation

The model of operation presented in this clause allows the description of MSP functionality to be consistent with that of the general Bridge architecture and operation (8.2, 8.3). Implementations of a TPMR may adopt any internal model of operation compatible with the externally visible behavior specified.

The additional entities that model MSP operation, and their relationship to the other processes and entities that model the operation of a TPMR are illustrated in Figure 23-3. They comprise the following:

a) A MAC Status Shim (MSS, 23.1.1) for each Port, which allows MSP to control the value of MAC_Operational presented to the TPMR Port connectivity function (8.5.2) and hence to the frame transmission and reception functions of the MAC Relay Entity, Higher Layer Entities, and MAC Status Propagation Entity (MSPE).

b) The MSPE, which implements MSP, controlling each MSS to ensure that frames are not forwarded by the MAC Relay Entity until status propagation is complete, transmitting and receiving frames to support link status notification, and controlling the individual LAN's MAC to provide MAC status notification.

NOTE—In a TPMR the priority signaling functions shown in Figure 23-3 are provided by 6.20 Support of the ISS with signaled priority.

MSPDUs are sent to a standard group address. They are received by the MSPE, but are forwarded by the MAC Relay Entity (like any other frame) in order to communicate without a delay in each TPMR. The MSPE attaches to each Port by a TPMR Port connectivity function (8.5.2) that allows it to transmit to and receive from the attached individual LAN only, as shown in Figure 23-3.

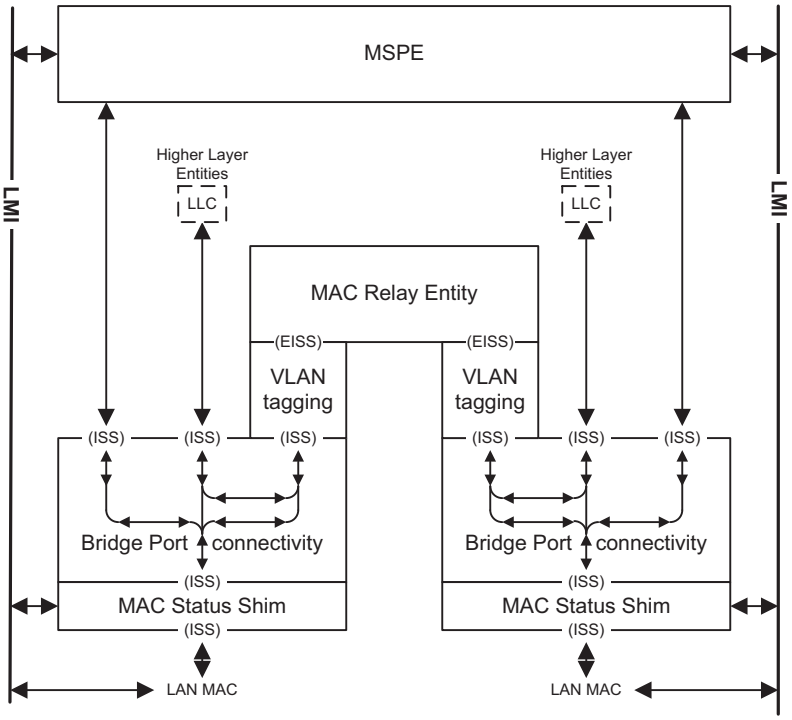


Figure 23-3—MSSs and the MSPE

23.1.1 MAC Status Shim (MSS)

The MSS allows MSP to control the transmission and reception of frames through a Port by all the entities (including the MAC Relay Entity) supported by the TPMR Port Connectivity function (8.5.2). Each transmit request from the latter at the MSS's upper ISS-SAP results in a corresponding transmit request at the lower ISS-SAP supported by the LAN MAC and each receive indication from the lower ISS-SAP results in a corresponding receive indication at the upper ISS-SAP, without omission or duplication, and with identical parameters, if and only if MAC_Operational for the upper ISS-SAP is TRUE.

The values of the MAC status parameters presented at the upper ISS-SAP are determined as follows:

— **MAC_Enabled**: The value of this parameter is FALSE if the value of STM's disableMSS variable is TRUE. Otherwise, the value of this parameter is TRUE. STM communicates the value of its disableMSS variable using a Layer Management Interface (LMI).
— **MAC_Operational**: The value of this parameter is TRUE if and only if the MSS's MAC_Enabled parameter is TRUE and the value of the MAC_Operational parameter provided by the LAN MAC at the lower ISS-SAP is TRUE.

The MSPE uses the LMI to control and receive status from each MSS and individual LAN MAC, allowing generic management requests and indications to be tailored to the requirements of different MACs, as well as providing a way for one MSS to propagate status to another (via the MSPE), even though MAC_Operational for the MSS's upper ISS-SAP is FALSE.

23.1.2 Relationship of CFM to the MSS

MEPs may be placed above or below the MSS. A MEP placed in the lower position and partnered with another MEP so that the pair spans a chain of TPMRs would obscure the LAN MAC's MAC_Operational parameter and interfere with the operation of MSP. For this reason, MEPs that protect individual LANs should be placed below MSS, and MEPs that protect chains of TPMRs should be placed above MSS.

23.2 MAC Status Protocol (MSP) overview

This clause provides examples of MSP operation as time sequence diagrams that show the following:

a) Exchange of MSPDUs transmitted and received to support link status notification.
b) The values of MAC_Operational and MAC_Enabled provided by the following:
    1) Each MSS, at its upper ISS-SAP, to the TPMR Port connectivity function.
    2) Each LAN MAC to the MSS, at the latter's lower ISS-SAP.

The value of MAC_Operational provided by the MSS is TRUE if, and only if the MSS' MAC_Enabled is TRUE and the value of MAC_Operational provided to the MSS by the LAN MAC is TRUE. The latter can be TRUE only if MAC_Enabled is TRUE for both the LAN MAC and its peer in the other station connected to the LAN. The MSPE can use the LMI to disable the MSS in order to prevent communication until MAC status propagation has occurred, and to disable the LAN MAC in order to provide MAC status notification to a peer service user. This clause uses the symbols defined in Table 23-1 to show combinations of the MAC status parameter values for each Port.

Table 23-1—Time sequence diagram symbols

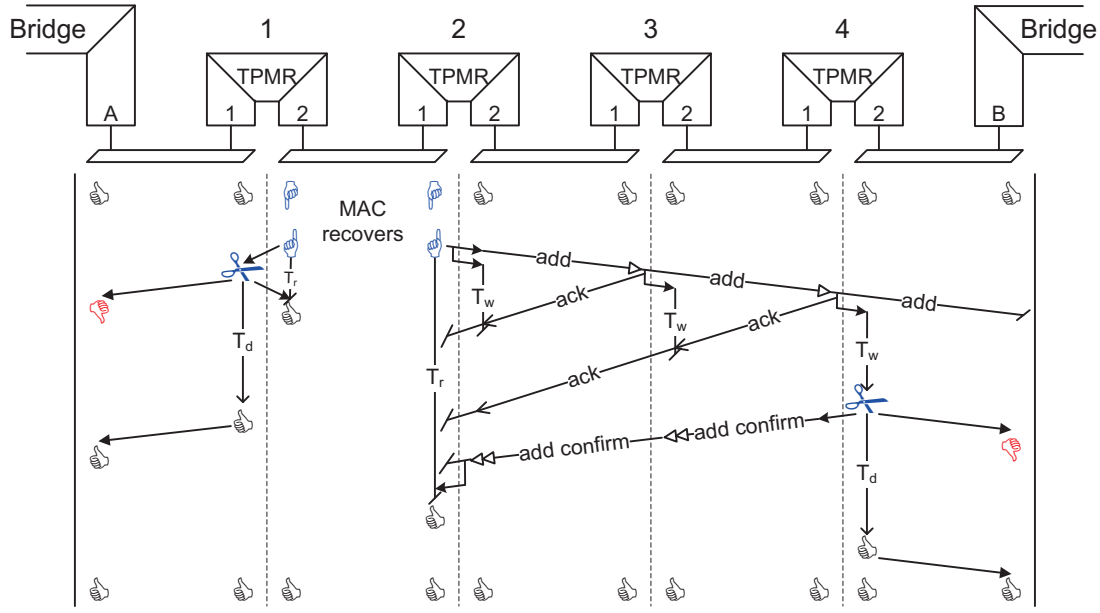
MSS	**MAC_Operational**	T	F	F	F	F
	MAC_Enabled	T	T	F	F	—
LAN MAC	**MAC_Operational**	T	F	F	T	F
	MAC_Enabled	T	T	T	T	F

T = TRUE, F = FALSE, — = either TRUE or FALSE

Throughout this protocol description, the term *LAN* is used to refer to individual LANs connecting adjacent TPMRs or a TPMR and an adjacent Bridge. A *chain* is a series or part of a series of TPMRs connected by LANs, and a *link* is the connectivity provided by a chain between non-TPMR devices that communicate at a higher (sub) layer and perceive the entire link as a single transparent LAN.

The number of TPMRs in the following examples is deliberately high, four where one or two might be more common, in order to show all the necessary aspects of protocol behavior.

Signaling the addition of new or restored connectivity is considered first, as it is more difficult than signaling failure. Figure 23-4 shows the response to a new or recovered LAN connection in a link between two Bridges that do not implement MSP—and thus require MAC status notification.



Timers: Tr : linkNotifyWhen (‘retry timer’) Tw : macNotifyWhen (‘wait timer’) Td :macNotifyWhile (‘down timer’)

Figure 23-4—Adding connectivity

Before the LAN that connects TPMR 1 to TPMR 2 is MAC_Operational, each MSPE disables its MSS ( ). This allows the MSPE to intercept the new connectivity as the LAN MAC asserts MAC_Operational ( ). TPMR 2 propagates the new status to its other Port, transmitting an *add* MSPDU. TPMR 2 does not necessarily know that TPMR 3 implements MSP (or indeed is a TPMR) but uses the default MSP

configuration—waiting before resorting to MAC status notification and starting a linkNotifyWhile timer (as do TPMRs 3 and 4) on receipt of the *add* (which is forwarded by the Relay Entity). Each TPMR responds to the *add* with an *ack* that clears the timer, but the Bridge at the end of the chain does not (as it does not implement MSP). When TPMR 4's timer expires, its MSPE disables the LAN MAC (✂), ensuring that MAC_Operational becomes FALSE (👎) for the Bridge's Port, and starts a macNotifyWhile timer. When that timer expires, the MSPE reenables the LAN MAC so that the Bridge Port's MAC_Operational can become TRUE (👍) once more. As well as disabling the LAN MAC for its Port 2, TPMR 4 also transmitted an *add confirm* through Port 1, and receipt of this *add confirm* by TPMR 2 causes the latter to cancel its retry timer (linkNotifyWhen). The initial value of macNotifyWhile (MacNotifyTime) is sufficient for the *add confirm* to reach the TPMR 2, and for that TPMR's MSPE to enable the MSS, thus ensuring that there is connectivity between the Bridges connected by the link when they have both reported MAC_Operational TRUE to their local protocol clients.

In Figure 23-4 the MSP configuration of TPMR 2's Port 2 differs from that for Port 1 of TPMR 1. The latter is explicitly configured to use MAC status notification immediately without waiting to see if its peer implements MSP.

Figure 23-5 illustrates the operation of MSP when the connectivity provided by an individual LAN is lost. The MSPE for each of the TPMR ports directly attached to the failed LAN begins by disabling the MSS for that Port (👎) to ensure that connectivity does not 'flap'. Otherwise, the protocol proceeds as for connectivity addition, except that *loss* and *loss confirm* are used instead of *add* and *add confirm*, and the MSSs attached to the failed LAN are left disabled. The final state of the link components is the initial state assumed in Figure 23-4—both attached Bridges have seen MAC_Operational transition to indicate that the connectivity has changed, and the TPMRs in each of the two chains can be reached and managed (if their individual configuration permits) through the attached Bridge Ports.

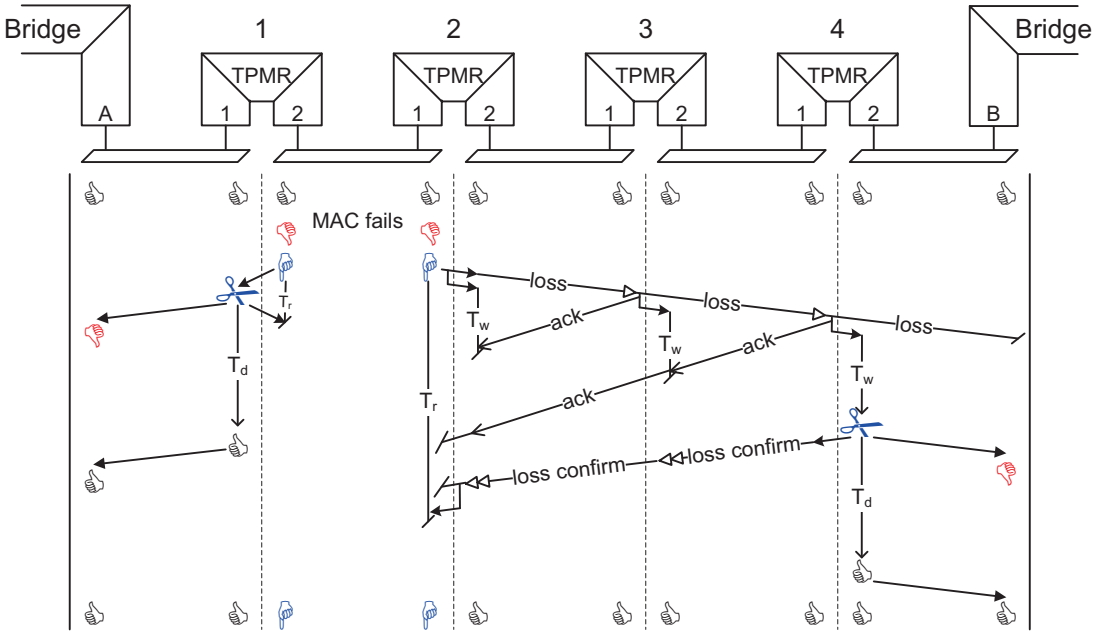


Figure 23-5—Losing connectivity

In the examples above, if an *add*, or *loss* is lost then the TPMR Port that transmitted or relayed that MSPDU will revert to using MAC status notification, as will a TPMR that fails to receive the *ack* from the next (or a subsequent) TPMR in the chain. If the MSPDU is lost on a LAN removed from the TPMR that initiated the link status notification, then that notification will be retried on expiry of the linkNotifyWhen timer, which also serves to protect against the loss of an *add confirm* or *loss confirm*.

Loss of a frame due to physical corruption is rare in LAN technologies, and frame losses due to buffer overrun are not expected when connectivity is being added (as the link is not usable prior to the addition) nor when a loss of connectivity is being signaled (as that connectivity loss will have prevented other frames from being added to the link). The loss of an MSPDU is most likely to be due to failure of one of the LANs, or to interruption of a TPMR's relay functionality by another MSS whose MSPE is also waiting for confirmation that a connectivity change that it has detected has been propagated to the end of the link. MSP does not, and cannot, ensure that information about each and every connectivity change reaches both ends of the link. Unless link status notification or MAC status notification is disabled or the individual LANs fail to report MAC_Operational correctly, MSP does ensure that any change in connectivity is accompanied by one or more notifications at each end of the link, and that a continuous period during which MAC_Operational is reported TRUE at both ends of the link provides unchanged connectivity from 1 second after the start of the period to 1 second before the end. This guarantee meets the requirements implicit in the initial transmission and retransmission strategies of well designed protocols. Protocol clients of the MAC Service should not use the difference between *loss* and *add* MSPDUs to take different actions on receipt, though the distinction can be useful to a network administrator when investigating connectivity changes.

Figure 23-6 provides a common example of simultaneous change. TPMR 2 is powered on and initializes both its ports. When the LAN MAC becomes operational, each Port attempts to send a notification through the other, but cannot as they are both waiting for the connectivity addition to be confirmed. However, in this eventuality, each Port can provide the other with the confirmation required, because the peer system for each of the individual LANs will also have seen the initial MAC_Operational transition and will have initiated a notification toward its end of the link.

NOTE—The SNM state machine transition direct from SNM:LINK_NOTIFICATION to SNM:MAC_NOTIFYING supports this behavior (see Figure 23-11).

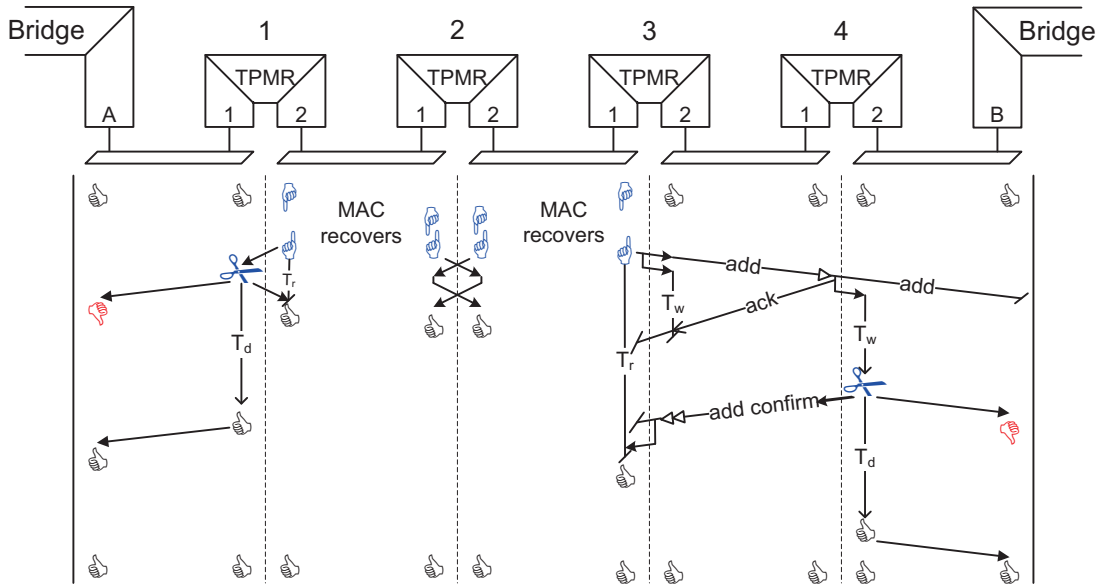


Figure 23-6—TPMR recovery

If the individual LAN that recovers (or loses) connectivity is at the end of the link, MSP ensures that the other end of the link is also aware of the status change as illustrated in Figure 23-7. This figure also shows the effect on MSP of including two nonstandard relays in the chain. Provided they (and their attached LANs) never fail, MSP can continue to operate as intended.

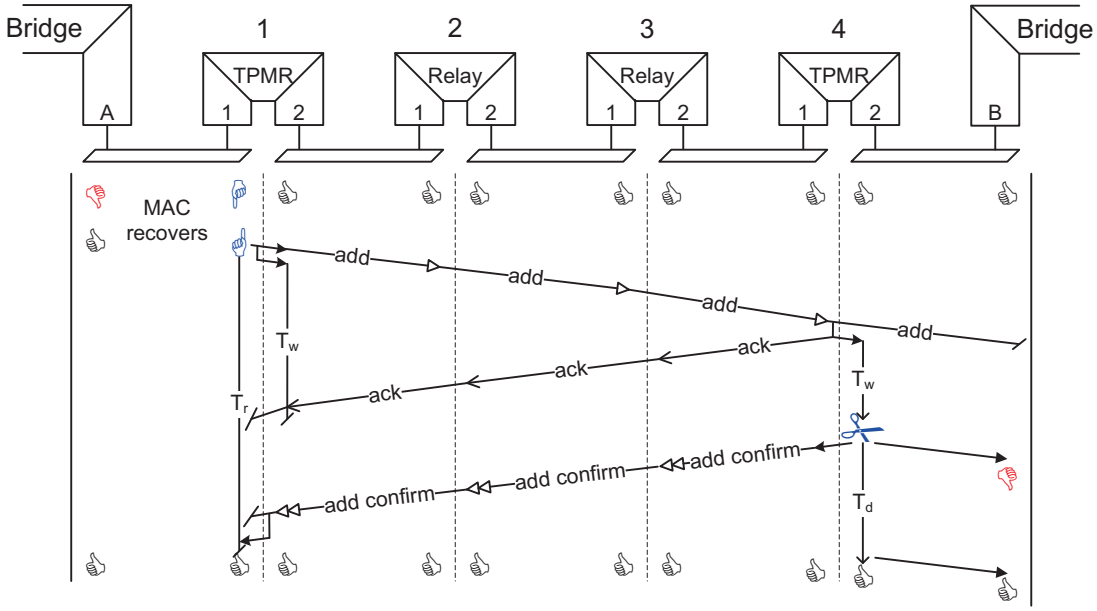


Figure 23-7—Notification from one end of the link to the other

If TPMR 4 is configured to use MAC status notification immediately, it does not return an *ack* as the *add confirm* can be sent almost immediately (see Figure 23-8).

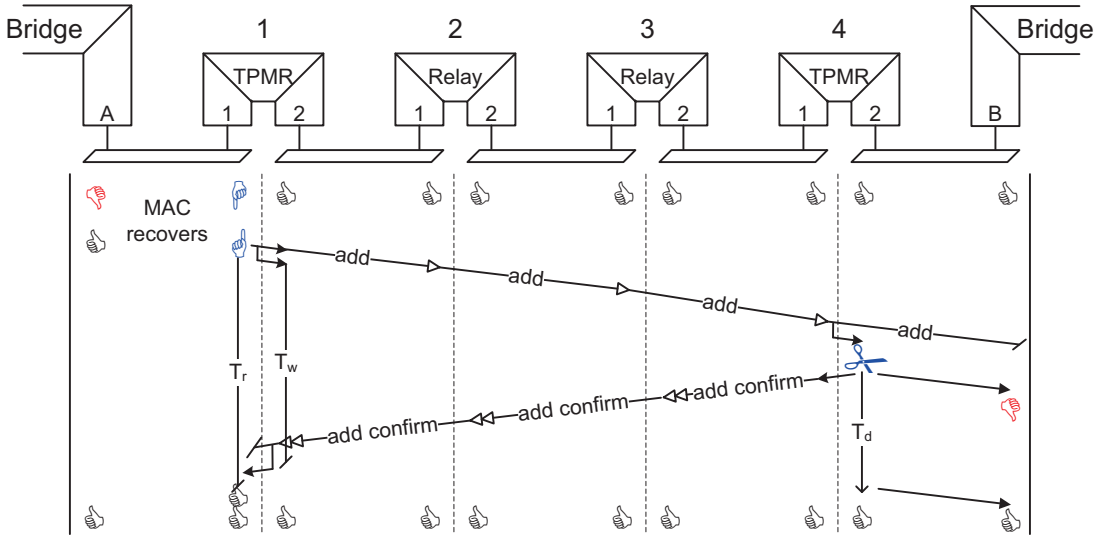


Figure 23-8—Immediate MAC status notification at the end of a link

23.3 MSP state machines

The operation of the MSPE is represented by an instance of each of the following for each Port of the TPMR:

a) A Status Transition state machine (STM, 23.8)
b) A Status Notification state machine (SNM, 23.9)
c) A Receive Process (23.10)
d) A Transmit Process (23.11)

Figure 23-9 shows the state machine variables that are used to communicate between these machines and processes, and that support management control over their operation. Variables prefixed with 'r.' are those of the corresponding state machines of the other Port of the TPMR.

The notational conventions used in Figure 23-9 and in the specification of the state machine are identical to those used in the specification of MSTP (Clause 13) and RSTP and are defined in Annex E.

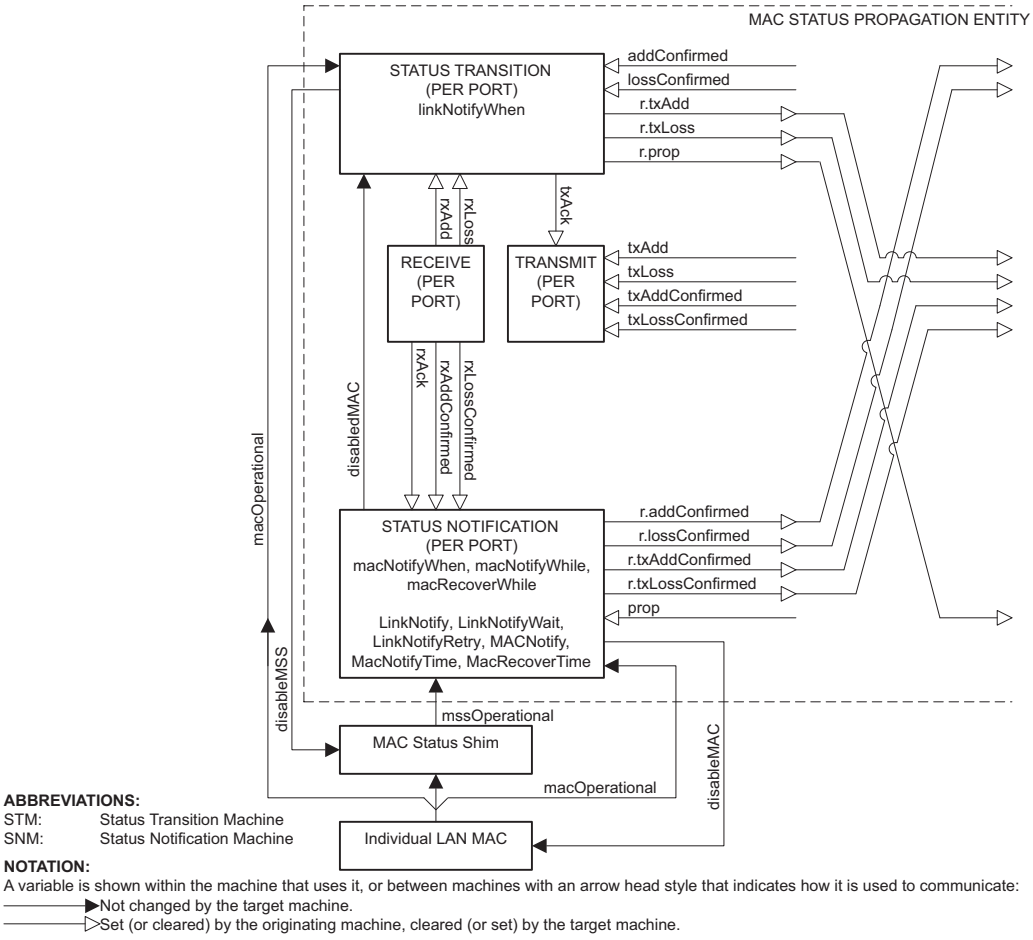


Figure 23-9—MSPE state machine overview

Port 1's STM monitors MAC_Operational transitions for its own LAN, and tells Port 2's Transmit process to send *add* or *loss* link notifications and Port 2's SNM to monitor the progress of status notification, using MAC status notification if necessary. Port 2's SNM receives the *ack* that indicates that it should wait for link status notification to complete, and the *add confirm* or *loss confirm* that indicates that completion. Whether

link status or MAC status notification is used, Port 2's SNM tells Port 1's STM when the notification has been confirmed, so the latter does not have to retry the notification. Port 1's SNM provides the same service to Port 2's STM.

A *loss* or *add* notification that is received from Port 1's own LAN is handled by its STM, which propagates the notification to Port 2's SNM (in the same way as a local MAC_Operational transition) while transmitting an *ack* on Port 1's LAN. Similarly Port 2's STM transmits an *ack* for a link status notification received on its own LAN, and propagates the notification to Port 1's SNM.

23.4 State machine timers

Timers are implemented by variables that are decremented on each timer tick, with timer expiry occurring when they reach zero.

23.4.1 linkNotifyWhen

Causes a link status notification to be sent on each expiry until the original status transition is confirmed.

23.4.2 linkNotifyWhile

Started when a change is first propagated through the Port, on expiry allows MAC status notification.

23.4.3 macNotifyWhile

Sets the time for which the MAC is disabled for MAC status propagation.

23.4.4 macRecoverWhile

Sets the time for which the MAC is permitted to be nonoperational, after being disabled, before the link is reported as lost.

23.5 MSP performance parameters

These parameters are not modified by the operation of MSP but are treated as constants by the state machines. They can be managed independently for each TPMR Port—default values and permissible ranges are specified in Table 23-2.

Table 23-2—MSP performance parameters

Parameter	Recommended or default value	Permitted range
LinkNotify	TRUE	TRUE or FALSE
LinkNotifyWait	0.4 s	0.2–1.0 s
LinkNotifyRetry	1.0 s	0.1–1.0 s
MACNotify	TRUE	TRUE or FALSE
MACNotifyTime	0.2 s	0.01–0.5 s
MACRecoverTime	0.1 s	0.02–0.5 s

23.5.1 LinkNotify

TRUE if the Port uses link status notification to propagate MAC status, and will wait to allow link status notification to succeed before using MAC status notification.

NOTE—If LinkNotify is FALSE, the TPMR still forwards *loss* and *add* notifications transmitted by other TPMRs prior to using MAC status notification, but the TPMR will not originate link status notifications.

23.5.2 LinkNotifyWait

The initial value of the linkNotifyWhile timer.

23.5.3 LinkNotifyRetry

The initial value of the linkNotifyWhen timer of the other TPMR Port.

23.5.4 MACNotify

TRUE if the Port uses MAC status notification.

23.5.5 MACNotifyTime

The initial value of the macNotifyWhile timer.

23.5.6 MACRecoverTime

The initial value of the macRecoverWhile timer.

23.6 State machine variables

23.6.1 BEGIN

This is a Boolean variable controlled by the system initialization process. A value of TRUE causes all TPMR state machines to continuously execute their initial state. A value of FALSE allows all state machines to perform transitions out of their initial state, in accordance with the relevant state machine definitions.

23.6.2 addConfirmed

Set by the other Port's SNM to tell STM that the addition has been confirmed. Cleared by STM.

23.6.3 disableMAC

Set by SNM to instruct the individual LAN MAC (via an LMI) to disable itself in a way that will cause MAC_Operational to be FALSE for the peer user of the MAC Service provided by that LAN.

NOTE—The state machines do not assume that a client of the MAC can tell whether the MAC is not operational because that client has disabled it, or whether some other client has disabled it.

23.6.4 disabledMAC

Set by the SNM when it has set disableMAC and for MACRecoverTime after disableMAC has been reset, so that the STM does not conclude that a loss notification should be sent through the other TPMR Port.

23.6.5 disableMSS

Set (or reset) by the STM to instruct the MSS (via an LMI) to set its MAC_Enabled status parameter to FALSE (correspondingly, TRUE).

23.6.6 lossConfirmed

Similar to addConfirmed but confirms a loss.

23.6.7 macOperational

The value of MAC_Operational for the individual LAN MAC.

23.6.8 mssOperational

The value of MAC_Operational provided by the MSS to the TPMR Port's Bridge transmit and receive function.

23.6.9 prop

Set by the other Port's STM to Add or Loss to notify SNM that a change is being propagated through the Port. Reset by SNM to None.

23.6.10 rxAck

Set by the Receive process to tell SNM that an acknowledgment has been received. Cleared by SNM.

23.6.11 rxAdd

Set by the Receive process to tell STM that an *add* notification is being propagated through the TPMR. Cleared by STM.

23.6.12 rxAddConfirm

Set by the Receive process to tell SNM that an *add confirm* has been received. Cleared by SNM.

23.6.13 rxLoss

Similar to rxAdd, but for a *loss*.

23.6.14 rxLossConfirm

Similar to rxAddConfirm, but for a *loss confirm*.

23.6.15 txAck

Set by the STM to instruct the Transmit process to send an acknowledgment. Cleared by the Transmit process.

23.6.16 txAdd

Set by the other Port's STM to cause transmission of an *add* notification. Cleared by the Transmit process.

23.6.17 txAddConfirm

Set by the other Port's SNM to cause transmission of an *add confirm* (through this Port) confirming that a received *add* message has been acted upon. Cleared by the Transmit process.

23.6.18 txLoss

Similar to a txAdd but causes a *loss* message to be transmitted.

23.6.19 txLossConfirm

Similar to a txAddConfirm but causes a *loss confirm* message to be transmitted.

23.7 State machine procedures

No procedures are defined beyond those represented in the state machines.

23.8 Status Transition state machine (STM)

The STM shall implement the function specified by the state diagram in Figure 23-10 and the attendant definitions contained in 23.4 through 23.7.

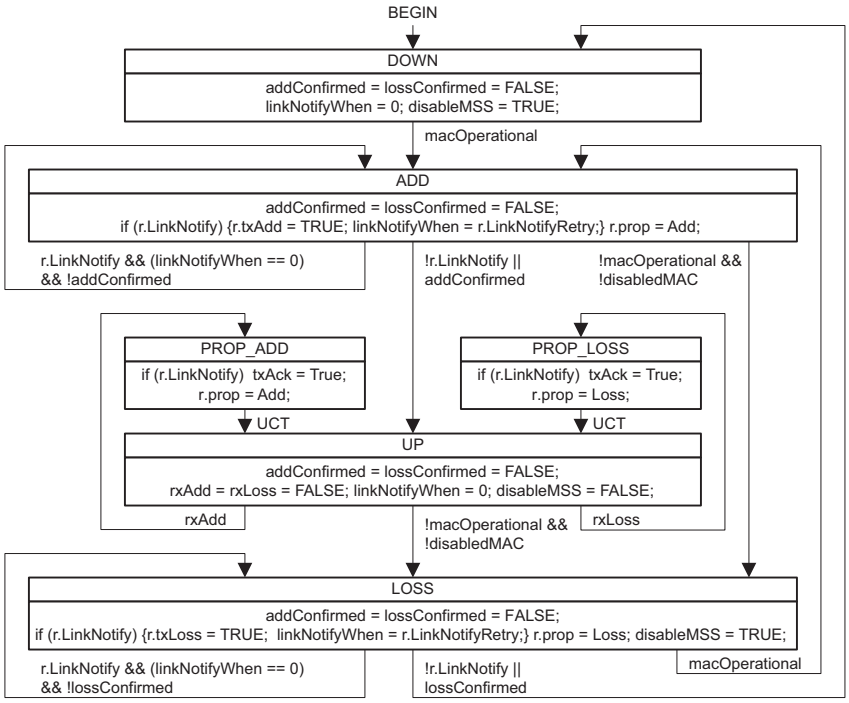


Figure 23-10—Status Transition state machine (STM)

23.9 Status Notification state machine (SNM)

The SNM shall implement the function specified by the state diagram in Figure 23-11 and the attendant definitions contained in 23.4 through 23.7.

23.10 Receive Process

The Receive Process shall receive and validate MSPDUs as specified in 23.16.

23.11 Transmit Process

The Transmit Process shall transmit and encode MSPDUs as specified in 23.13 through 23.15. If the Transmit Process is instructed to transmit an MSPDU before it has had the opportunity to transmit a prior MSPDU, that prior MSPDU shall be discarded and not transmitted. If the MAC_Operational status provided by the MSS for the Port is FALSE, the MSPDU shall be discarded and not transmitted.

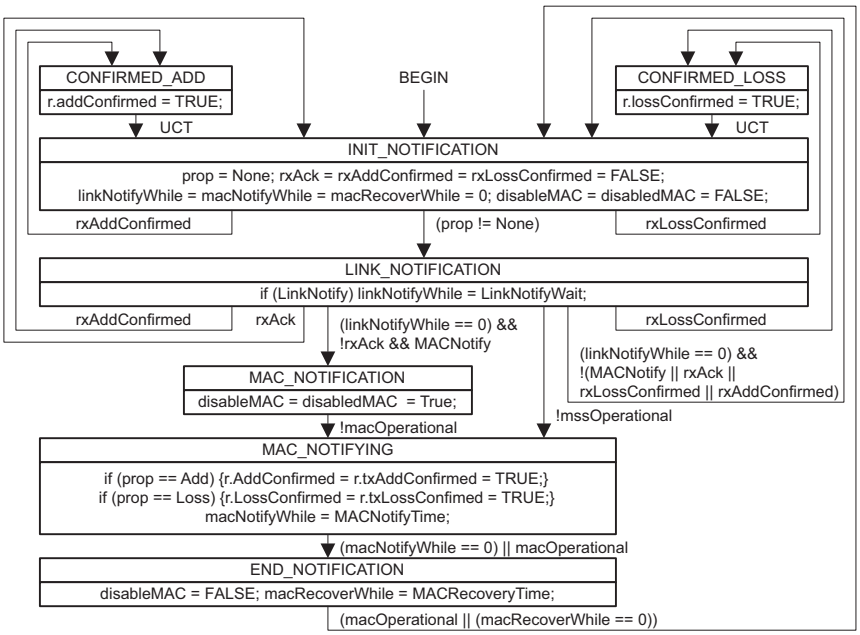


Figure 23-11—Status Notification state machine (SNM)

23.12 Management of MSP

An implementation of MSP in a TPMR:

a) May allow the performance parameters (23.5) to be read by management.
b) May allow the performance parameters (23.5) to be modified by management.
c) May maintain each of the following counts for one or both ports of the TPMR:
   1) acksTransmitted: The number of *acks* transmitted (23.6.15) by the Port's Transmit Process as a consequence of txAck being set.
   2) addNotificationsTransmitted: The number of *adds* transmitted (23.6.16) by the Port's Transmit Process as a consequence of txAdd being set.
   3) addConfirmationsTransmitted: The number of *add confirms* transmitted (23.6.17) by the Port's Transmit Process as a consequence of txAddConfirm being set.
   4) lossNotificationsTransmitted: The number of *loss*es transmitted (23.6.18) by the Port's Transmit Process as a consequence of txLoss being set.
   5) lossConfirmationsTransmitted: The number of *loss confirms* transmitted (23.6.19) by the Port's Transmit Process as a consequence of txLossConfirm being set.
   6) acksReceived: The number of *acks* received (23.6.10) by the Port's Transmit Process.
   7) addNotificationsReceived: The number of *adds* received (23.6.11) by the Port's Receive Process.
   8) addConfirmationsReceived: The number of *add confirms* received (23.6.12) by the Port's Receive Process.
   9) lossNotificationsReceived: The number of *loss*es received (23.6.13) by the Port's Receive Process.
   10) lossConfirmationsReceived: The number of *loss confirms* received (23.6.14) by the Port's Receive Process.
   11) addEvents: The number of transitions to STM:ADD directly from STM:DOWN or STM:LOSS (23.8).

12) lossEvents: The number of transitions to STM:LOSS directly from STM:UP or STM:ADD (23.8).
13) macStatusNotifications: The number of transitions to SNM:MAC_NOTIFICATION (23.9).

23.13 MSPDU transmission, addressing, and protocol identification

MSPDUs are transmitted and received using the service provided by an LLC entity that uses, in turn, a single instance of the MAC Service provided at an MSAP. In a TPMR the MSPE transmits and receives the MSPDUs, and the MSAP is provided by the TPMR Port connectivity function as illustrated in Figure 23-3. Each MSPDU is transmitted as a single MAC Service request, and received as a single MAC Service indication, with the following parameters:

a) destination address (23.13.1)
b) source address (23.13.2)
c) MSDU
d) priority (23.13.3)

The MSDU of each request and indication comprises an number of octets that provide EtherType protocol identification (23.13.4) followed by the MSPDU proper (23.15).

NOTE 1—For the purposes of this standard, the term “LLC entity” includes entities that support protocol discrimination using the EtherType field as specified in IEEE Std 802.

NOTE 2—The complete format of an MSP frame “on the wire” or “through the air” depends not only on the MSPDU format, as specified in this clause, but also on the media access method-dependent procedures used to support the MAC Service.

23.13.1 Destination MAC Address

The destination address for each MAC Service request used to transmit an MSPDU shall be the group address identified in Table 8-1 and Table 8-2 as “Nearest non-TPMR Bridge group address”[40].

23.13.2 Source MAC Address

The source address for each MAC Service request used to transmit an MSPDU shall be an individual address associated with the MSAP at which the request is made.

23.13.3 Priority

The priority associated with each MAC Service request should be the default associated with the MSAP. Transmitted MSPDUs are not VLAN tagged or priority tagged.

23.13.4 EtherType use and encoding

All MSPDUs are identified by the EtherType specified in Table 23-3.

Table 23-3—MSP EtherType assignment

Assignment	Value
MAC Status Protocol EtherType	22-E2

[40] This address was originally assigned by IEEE Std 802.1X-2001 and was identified as an S-VLAN component Reserved Address (Table 8-2) by the IEEE Std 802.1ad amendment to IEEE Std 802.1Q-2005. This standard identifies it as the “nearest non-TPMR Bridge group address,” to be filtered by all relay functions above the sublayer specified for TPMRs (see Table 8-1 and Table 8-2).

23.14 Representation and encoding of octets

All MSPDUs consist of an integral number of octets, numbered starting from 1 and increasing in the order that they are put into a MAC frame. The bits in each octet are numbered from 1 to 8, where 1 is the low-order bit. When consecutive octets are used to encode a binary number, the lower numbered octet contains the more significant bits of the binary number.

When the encoding of (an element of) an MSPDU is represented using a diagram in this clause, the following representations are used:

a) Octet 1 is shown toward the top of the page, higher numbered octets being toward the bottom.
b) Where more than one octet appears on a given line, octets are shown with the lowest numbered octet to the left, higher numbered octets being to the right.
c) Within an octet, bits are shown with bit 8 to the left and bit 1 to the right.

23.15 MSPDU structure

The MSPDU comprises the octets following the MSP EtherType. All MSPDUs comprise a Protocol Version (23.15.1) and a Packet Type (23.15.2). See Figure 23-12.

	Octet
Protocol Version (23.15.1)	1
Packet Type (23.15.2)	2

Figure 23-13—MSPDU structure

23.15.1 Protocol Version

The MSP Protocol Version is encoded in all MSPDUs as a single octet, representing an unsigned binary number. Its value identifies the version of MSP supported by originator of the MSPDU. An implementation conforming to this specification shall encode the value 0000 0000 in this field. All other values are reserved.

NOTE—TPMRs that relay an MSPDU do not change its Protocol Version.

23.15.2 Packet Type

The MSP Packet Type is encoded as a single octet, representing an unsigned binary number. Table 23-4 lists the Packet Types specified by this standard, and the state machine variables set to indicate reception and transmission of MSPDUs of that type. All other possible values of the Packet Type field are reserved and shall not be used.

Table 23-4—MSP Packet Types

Packet Type	Value	Transmission	Reception
MSP-Add	0	txAdd (23.6.16)	rxAdd (23.6.11)
MSP-Loss	1	txLoss (23.6.18)	rxLoss (23.6.13)
MSP-Add Confirmed	2	txAddConfirm (23.6.17)	rxAddConfirm (23.6.12)
MSP-Loss Confirmed	3	txLossConfirm (23.6.19)	rxLossConfirm (23.6.14)
MSP-Ack	4	txAck (23.6.15)	rxAck (23.6.10)

23.16 Validation of received MSPDUs

To ensure that backward compatibility is maintained for future versions of this protocol, the validation and protocol version handling for all MSPDUs, follows general rules developed for this and other protocols. A received MSPDU shall be processed as specified by Table 23-4 if and only if:

a) The destination MAC address is the group address specified (23.13.1); and
b) The MSPDU is identified by the MSP EtherType encoded as specified in 23.13.4; and
c) The received MSPDU contains at least two octets, i.e., at least the Protocol Version and Packet Type; and
d) The Packet Type is one of the values specified in Table 23-4.

Otherwise, the received MSPDU shall be discarded. No other checks shall be applied to received MSPDUs, in particular the value of the Protocol Version is not checked and MSPDUs of length greater than the minimum of two octets are accepted as valid.

23.17 Other MSP participants

An end station or non-TPMR Bridge attached to the end of a TPMR link can participate in link status notification, avoiding the need for the last TPMR in the chain to use MAC status notification and thus speeding the transition of the link to an operational state. Such a participant receives MSPDUs, but acts only on a received *loss* or *add*, notifying its protocol clients of the change in connectivity, and responding immediately by transmitting an *add confirm* or *loss confirm* as appropriate. There is no need for such a participant to transmit an *add*, *loss*, or *ack*, or act upon a received *ack*, *add confirm* or *loss confirm*, or to initiate MAC status notification.

24. Bridge performance

This clause specifies a set of parameters that represent the performance of a Bridge. These parameters have been selected to allow a basic level of confidence to be established in a Bridge, for use in an initial determination of its suitability for a given application. They cannot be considered to provide an exhaustive description of the performance of a Bridge. It is recommended that further performance information be provided and sought concerning the applicability of a Bridge implementation.

The following set of performance parameters is defined:

a) Guaranteed Port Filtering Rate, and a related time interval T_F , that together characterize the traffic for which filtering is guaranteed.
b) Guaranteed Bridge Relaying Rate, and a related time interval T_R.

24.1 Guaranteed Port Filtering Rate

For a specific Bridge Port, a valid Guaranteed Port Filtering Rate, in frames per second, is a value that, given any set of frames from the specific Bridge Port to be filtered during any T_F interval, the Forwarding Process shall filter all of the set as long as all of the following are true:

a) The number of frames in the set does not exceed the specific Bridge Port's Guaranteed Port Filtering Rate multiplied by T_F.
b) The Guaranteed Port Filtering Rate of each of the other Bridge Port(s) is not exceeded.
c) The Guaranteed Bridge Relaying Rate is not exceeded.
d) Relayed frames are not discarded due to output congestion (8.6.7).
e) The information upon which the filtering decisions are based has been configured in the FDB prior to the start of time interval T_F.

24.2 Guaranteed Bridge Relaying Rate

For a Bridge, a valid Guaranteed Bridge Relaying Rate, in frames per second, is a value that given any set of frames from the specific Bridge Port to be relayed during any T_R interval, the Forwarding Process shall relay all of the set as long as all of the following are true:

a) The number of frames in the set does not exceed the Bridge's Guaranteed Bridge Relaying Rate multiplied by T_R.
b) The Guaranteed Port Filtering Rate of each Bridge Port is not exceeded.
c) Relayed frames are not discarded due to output congestion (8.6.7).
d) The information upon which the forwarding decisions are based has been configured in the FDB prior to the start of time interval T_R.

24.3 RSTP performance requirements

This subclause places requirements on the performance of the Spanning Tree Protocol Entities of Bridges in a Bridged Network to ensure that RSTP operates correctly.

The delay between the occurrence of an external event and the action or actions mandated by the RSTP specification as a consequence of the event shall not exceed the Maximum RSTP processing delay specified in Table 24-1.

Table 24-1—Transmission and reception delays

Parameter	Absolute maximum value (s)
Maximum RSTP processing delay	1.0
Maximum BPDU transmission delay	0.2

External events subject to this provision of this specification shall include the following:

a) Transmission of a BPDU by another Bridge on a LAN to which the Bridge is attached.

Specified actions subject to this provision shall include the following:

b) Transmissions of BPDUs on all Ports mandated by the RSTP specification, with the exception of transmissions delayed by the Port Transmit state machine (13.34) to enforce transmit rate limits.
c) Ceasing to learn or forward frames.

The delay between internal timer related events and the transmission of all BPDUs on Ports mandated by the RSTP specification as a consequence shall not exceed the Maximum BPDU transmission delay specified in Table 24-1. Timer events subject to this provision of this specification shall include the following:

d) Decrementing of txCount by the Port Transmit machine, thus allowing a BPDU transmission if transmit rate limits were being enforced.
e) Expiry of the helloWhen timer (13.25.3).

25. Support of the MAC Service by PBBNs

A PBBN comprises a set of BEBs interconnected by some or all of the S-VLANs supported by a PBN (see Clause 16). Each BEB provides interfaces that encapsulate (or verify the encapsulation of) customer frames, thus allowing Customer MAC (C-MAC) addresses and VIDs to be independent of the Backbone MAC (B-MAC) addresses and VIDs administered by the PBBN operator and used to relay those frames across the backbone. The S-VLANs used to encapsulate customer frames are known as Backbone VLANs (B-VLANs), and the resources that support those VLANs are usually considered to be part of the PBBN.

NOTE 1—The term Customer used in the context of PBBs may refer to a first Provider who is purchasing service from a second Provider. The first Provider deploys a PBN or a PBBN within its domain. The second Provider deploys a PBBN within its domain. In this case, the first Provider is identified as a Customer with respect to the second Provider. The term Customer used here may alternatively refer to each of a pair of Providers communicating as peers.

Figure 25-1 shows peer BEBs within the MAC sublayer and their relationship to customer and backbone bridging functions. The right-most BEB shown is modeled as comprising two types of VLAN Bridge components, an I-component and a B-component, connected together. The two BEBs on the left of the figure each comprise a single VLAN Bridge component of different types. The left-most BEB has a single I-component, while the BEB just to the right of the left-most BEB has a B-component. A T-component may also be used in place of an I-component.

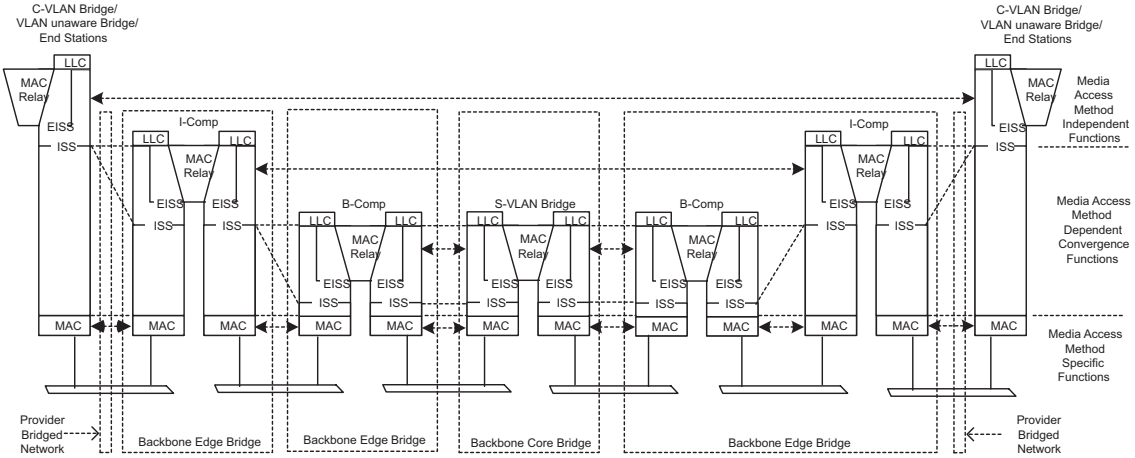


Figure 25-1—Internal organization of the MAC sublayer in a PBBN

Each I-component or T-component is responsible for encapsulating frames received from customers and assigning each frame to a backbone service instance. The backbone service instance consists of a set of BEBs that support a given customer's S-VLANs, and is uniquely identified within the PBBN by an I-SID. The customer frame is encapsulated by an I-TAG, which includes the I-SID, and a set of source and destination B-MAC addresses. The B-MAC addresses identify the BEBs of the backbone service instance where the customer frame will enter and exit the PBBN. If the I-component or T-component does not know which of the other BEBs provides connectivity to a given customer address, it uses a default encapsulating B-MAC address that reaches all the other BEBs in the backbone service instance. Each I-component learns the association between customer source addresses received (encapsulated) from the backbone and the backbone source address, so subsequent frames to that address can be transmitted to the correct BEB.

A PBBN or a series of PBBNs providing the MAC Service to attached end stations is typically modeled as a symmetric sequence of relay functions, as illustrated in Figure 25-1. The outermost peer relay functions are identified as I-components. The next peer relay functions in the sequence are identified as B-components.

Between the peer B-components are one or more S-VLAN relay functions. A B-component relay forms the service layer to an I-component relay. A B-component relay forwards frames taking into account the identity of a B-VLAN (B-VID), while an I-component relay forwards frames taking into account the identity of an S-VLAN (S-VID).

A single B-component is responsible for relaying encapsulated customer frames to and from I-components and T-components, either within the same BEB or externally connected, checking that ingress/egress is permitted for frames with that I-SID, translating the I-SID (if necessary) and using it to assign the supporting connection parameters (backbone addresses if necessary and VIDs) for the PBBN, and relaying the frame to and from the PNP(s) that provide connectivity to the other Bridges within and attached to the backbone. A B-component performs the same functions when relaying frames to and from another B-component when two PBBNs interconnect (26.6.2).

The number of I-components (zero or more), T-components (zero or more), and B-components (zero or one) within a given BEB is a direct consequence of the type and number of external interfaces supported by that BEB. The I-components, T-components, and B-component may be in the same BEB or may be in different BEBs. The types of BEBs may be classified as I-BEB, B-BEB, T-BEB, and ITB-BEB as depicted in Figure 25-2, where ITB-BEB covers all valid combinations of multi-component BEBs, e.g., IB-BEB.

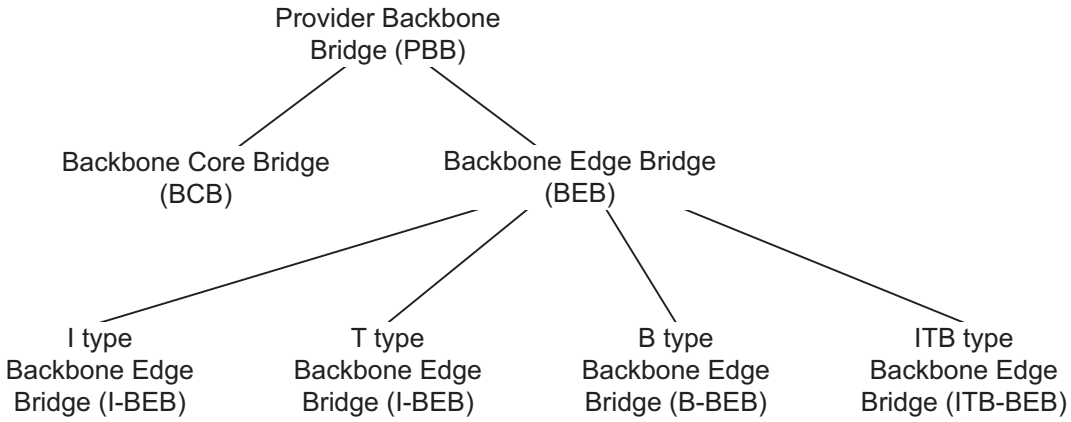


Figure 25-2—PBB terminology

This clause discusses the following aspects of PBBN service:

a) Service transparency (25.1)
b) Customer service interfaces (25.2, 25.3, 25.4, 25.5)
c) Service instance segregation (25.6)
d) Service instance and backbone service instance selection and identification (25.7)
e) Service priority and drop eligibility selection (25.8)
f) Service access protection (25.9)

NOTE 2—This standard makes use of the term *service* as defined by the OSI Reference Model (IS0/IEC 7498-1). In this sense, a service comprises a set of primitives and associated parameters, provided by one protocol layer in the architectural model to the protocol layer above, and the causal relationships between the primitives invoked by an upper layer protocol entity in one system with those resulting indications to a peer entity in another system. The term service used by backbone providers, while including layering concepts, goes far beyond this formal definition, and commonly specifies some or all of the following: interfacing considerations across multiple protocol layers (including physical connectors, for example); selection of interface points; interfacing equipment; QoS guarantees and measurement methods; charging methods and responsibilities; connectivity verification and other management tools; and regulatory issues.

25.1 Service transparency

The operation of PBBNs is, by design, largely transparent to Provider Bridges and PBNs as illustrated by Figure 25-1. The service provided by BEBs is transparent to the use of the MAC Service by end stations attached to the CBNs through PBNs and transparent to the operation of media access method-independent functions by Customer Bridges.

The service is not transparent to the operation of media access method-dependent convergence functions or to the operation of the media access method-specific functions specified by standards for each media access method. Media access method-dependent and -specific functions operate between Bridges—whether Customer Bridges, Provider Bridges, or PBBs—attached to the same LAN.

25.2 Customer service interface

A backbone provider can offer to customers one or more types of service interfaces, each providing different capabilities for service selection, priority selection, and service access protection (25.7, 25.8, 25.9). In some cases it is assumed the customer provides an S-VLAN component of a Provider Bridge while in other cases, more generic customer systems are also allowed. There are four basic types of customer service interfaces—Port-based, S-tagged, I-tagged, and transparent service interface. The customer service interface types are summarized by Figure 25-3.

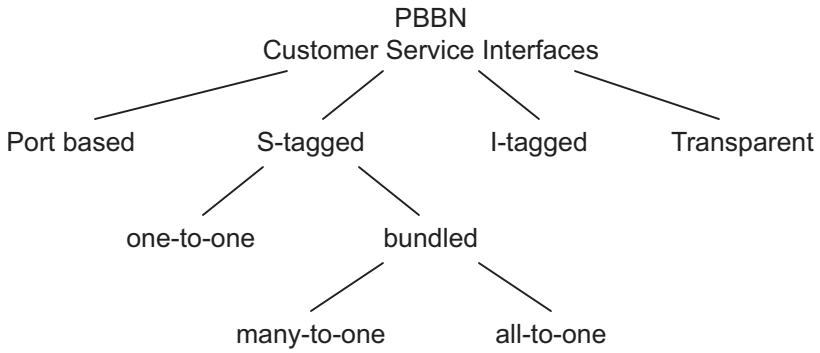


Figure 25-3—Customer service interface types

In all cases, segregation of different service instances is achieved at an interface wholly under the control of the backbone provider, and by verification of customer provided parameters that provide service instance selection. Stronger authentication and authorization of the attached customer systems can be achieved by use of IEEE Std 802.1X.

NOTE—The term service access protection describes provision of service access over multiple access LANs and (or) nodes with redundancy and rapid failover in case of failure of an access LAN or attached equipment.

Access to a given backbone service instance can be provided through different types of customer interfaces.

25.3 Port-based service interface

A PBBN may provide a Port-based service interface for customer attachment. The PBBN Port-based interface provides the same type of service to a customer as the PBN Port-based interface described in 15.3. A Port-based service interface is delivered on a CNP provided by a BEB as illustrated in Figure 25-4 and Figure 25-5. A Port-based service interface may attach to a C-VLAN Bridge (5.9), MAC Bridge, router, or end-station. The service provided by this interface forwards all frames without an S-TAG over the backbone on a single backbone service instance. All frames with an S-TAG that has a non-null VID are discarded by a Port-based service interface.

The Port-based service interface requires specific constraints on the configuration of the I-component. Each I-component CNP providing a Port-based interface is associated with one and only one VIP with exactly the same parameters for their tagging functions support. More specifically both CNP and VIP

a) Have the Acceptable Frame Types parameter configured to Admit Only Untagged and Priority-tagged frames.
b) Have equal PVID values.
c) Are exclusive members of the same PVID member set.
d) Are members of the PVID untagged egress set.

Figure 25-4 illustrates a customer system attached to a PBBN over a Port-based service interface.

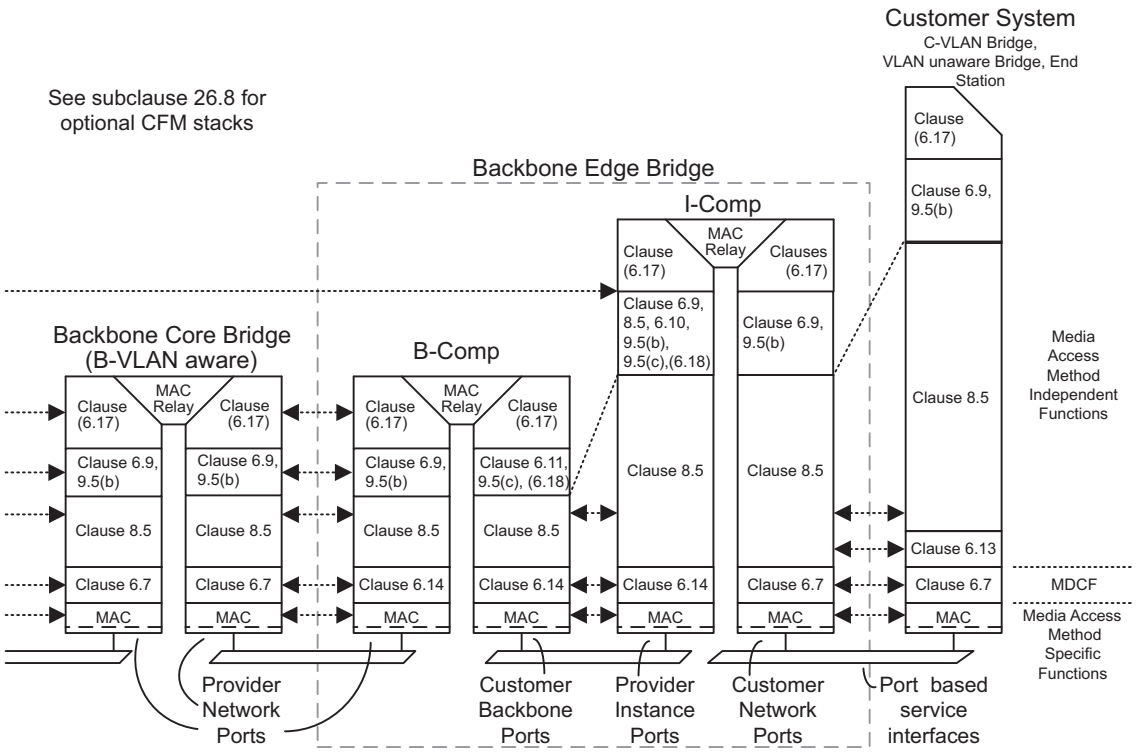


Figure 25-4—Port-based service interface

Figure 25-5 shows an example of equipment used to implement an unprotected Port-based service interface. For details on redundant connections and equipment, see 25.9. An I-component may support one or more Port-based service interfaces. Each CNP may be associated with one Port-based service interface. A CNP is connected to a customer system (or network) using a LAN.

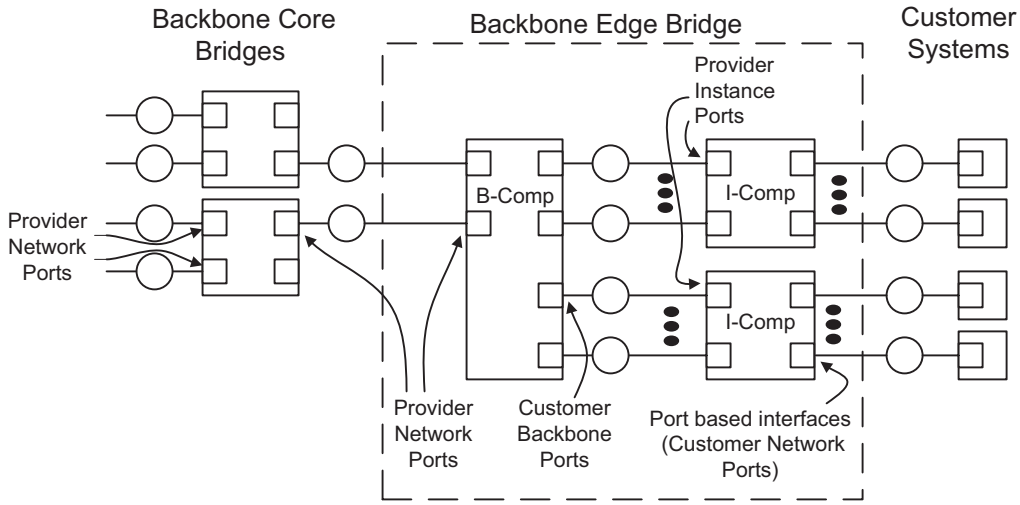


Figure 25-5—Port-based interface equipment

25.4 S-tagged service interface

The S-tagged service interface maps a service instance from a PBN, identified by an S-VID, to a backbone service instance on the PBBN, identified by an I-SID. There are two types of S-tagged service interfaces—one performing a one-to-one mapping of S-VIDs to I-SIDs and the other bundling S-VIDs to I-SIDs. Frames that are mapped to the I-SID are carried over the PBBN while frames that are not mapped to an I-SID are not carried over the PBBN.

NOTE 1—The restriction that each PBN S-VLAN map to a single backbone service instance on the PBBN allows the PBN equipment receiving frames to correctly identify the service instance used to deliver that frame and prevents the configuration of the I-component to create a multipoint service from point-to-point service instances, which could result in accidental creation of data loops. The backbone provider can offer a multipoint service through appropriate configuration of the B-VLAN component.

A PBBN may provide an S-tagged service interface for attachment to customer PBNs (15.5). An S-tagged service interface is provided by a BEB over a CNP as illustrated by Figure 25-7 and Figure 25-8. The attached Provider Bridges can in turn provide Port-based, C-tagged, or S-tagged service interfaces to their customers as described in 15.2, 15.3, 15.4, and 15.5.

The S-tagged service interface has the variations shown in Figure 25-3 under the S-tagged branch. The first variation, called a one-to-one S-tagged interface, uses a one-to-one mapping between S-VIDs and I-SIDs. This interface variation maps each S-VID to a single I-SID for use over the PBBN. The one-to-one mapped interface does not carry the S-TAG over the PBBN. The DEI and PCP bits may be regenerated on ingress and are then carried in the I-DEI and I-PCP bits in the I-TAG across the PBBN. On egress from the one-to-one S-tagged interface, the S-TAG can be deduced from the I-TAG received from the PBBN (the I-SID is mapped to an S-VID, the I-DEI and I-PCP bits may be regenerated and are then carried in the DEI and PCP bits).

The second S-tagged service interface variation is the bundling S-tagged service interface. This interface variation maps multiple S-VIDs to a single I-SID for delivery over the PBBN. To allow the remote end to reconstruct the S-VID, this interface variation will carry an S-TAG over the PBBN. On a bundled S-tagged interface, the DEI and PCP bits of the S-TAG may be regenerated and are then carried in both the DEI and PCP bits of the S-TAG and the I-DEI and I-PCP bits of the I-TAG over the PBBN.

A special case of the bundling S-tagged service interface is where all S-VIDs are mapped to a single I-SID. This special case is called an all-to-one bundling S-tagged service interface. The I-component used for an all-to-one bundled S-tagged service interface is constrained to supporting a single S-tagged service interface.

Figure 25-6 illustrates the information passed over each of the ISS interfaces of a BEB.

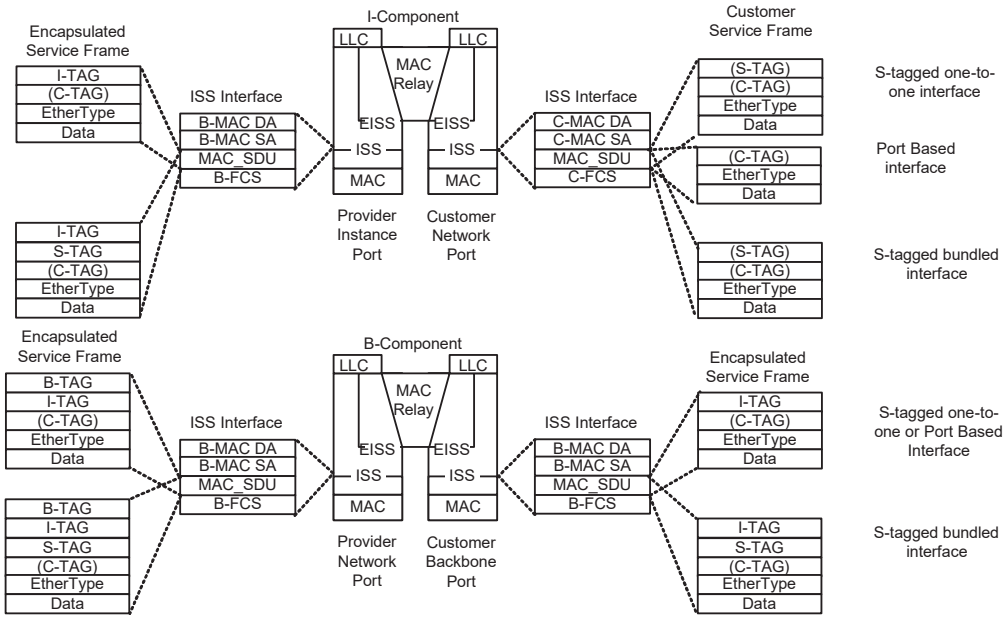


Figure 25-6—Encapsulated service frames at ISS

Figure 25-7 illustrates a customer network attached to a PBBN using an S-tagged service interface. The customer network uses Provider Bridges with S-VLAN components for connecting to the PBBN. The PBBN in turn is composed of BEBs interfacing to the customer Provider Bridges and BCBs used to forward frames between the BEBs.

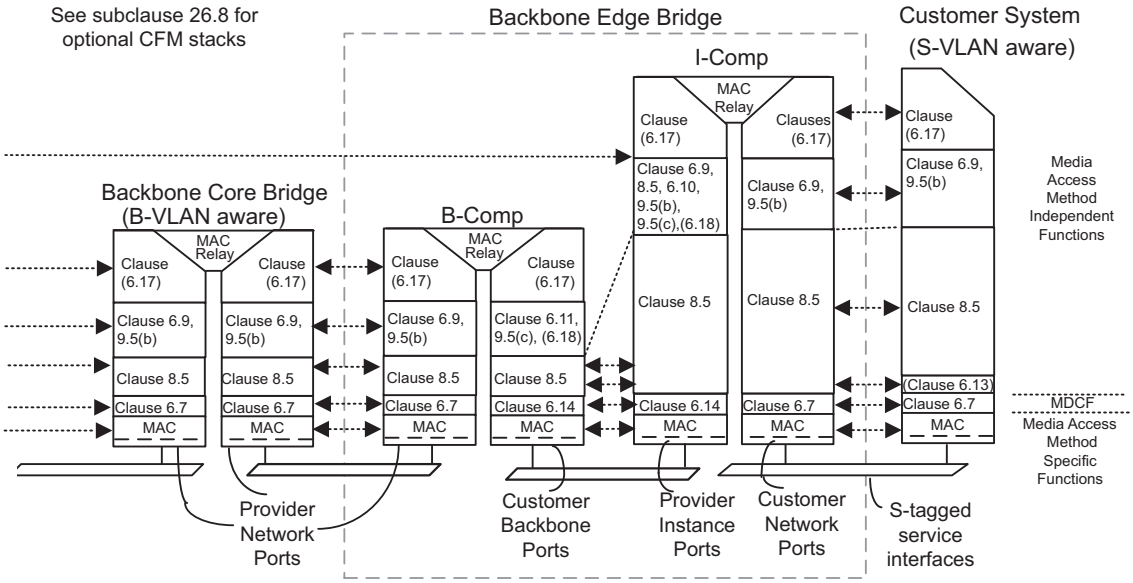


Figure 25-7—S-tagged service interface

Figure 25-8 shows an example of equipment used to implement an unprotected S-tagged service interface. For details on redundant connections and equipment, see 25.9. In this diagram, a BEB is formed by connecting two I-components and a B-component. These connections may be over a backplane or over a LAN. An I-component may support one or more S-tagged service interfaces. When an I-component supports an all-to-one bundled S-tagged service interface, the entire I-component must be dedicated to a single S-tagged service interface. Each CNP may be associated with one S-tagged service interface. A CNP is connected to a customer system (or network) using a LAN.

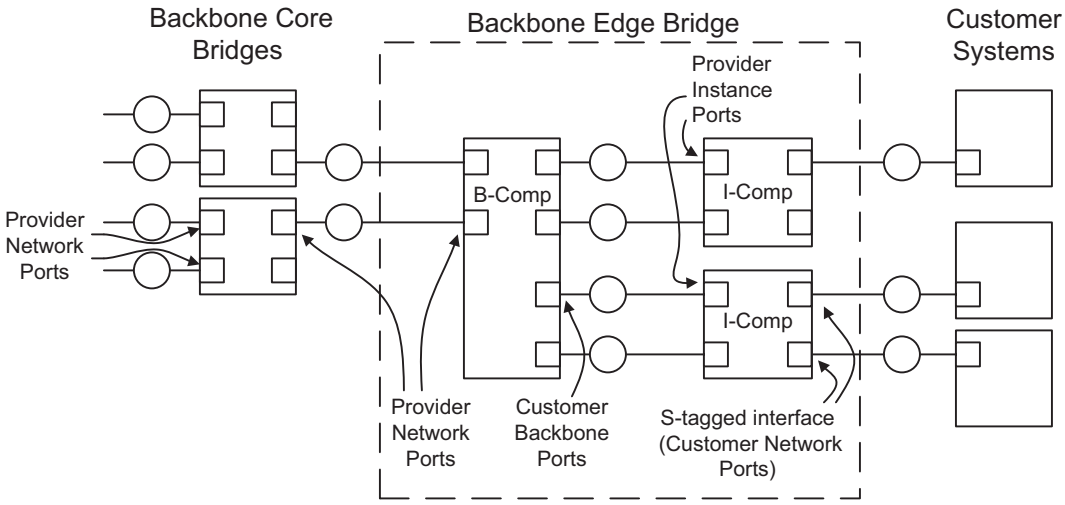


Figure 25-8—S-tagged service interface equipment

NOTE 2—It is always possible to build equipment that includes both BEB and Provider Edge Bridge components. In particular, it is possible for a BEB to support a C-tagged service interface (15.4) for attachment to a CBN by including a C-VLAN component with PEPs that connect to the CNPs of an I-component. A BEB can also support an RCSI (15.6) by including a C-VLAN component and a Port-mapping S-VLAN component.

25.5 I-tagged service interface

A PBBN may provide a native I-tagged service interface for attachment to another PBBN or for attachment to a customer's PIP. An I-tagged service interface can provide access to all the backbone service instances within a PBBN. Access to backbone service instances is controlled by the configuration of the CBP service instance tables (6.11). Each I-SID delivered over the I-tagged service interface by a customer identifies a service instance that will be carried over the PBBN. Service instances are carried over the PBBN inside a B-VLAN selected by the CBP. The customer must provide the B-DA for frames delivered to an I-tagged service interface.

Figure 25-9 illustrates a customer network attached to a PBBN using an I-tagged service interface. The customer network uses a BEB with an I-component (26.6.1) or a B-component (26.6.2) connecting to the PBBN. The PBBN in turn is composed of BEBs interfacing to the customer and BCBs in the core of the PBBN used to forward frames between the BEBs.

An I-tagged service interface may be provided at a CBP of a BEB as illustrated by Figure 25-9 and Figure 25-10. In this service interface, the I-SID provided over the service interface within the I-TAG is mapped 1-1 to an I-SID within the PBBN. As illustrated, a customer (or peer) may attach to the I-tagged service interface through a CBP. In this configuration, each PBBN is attached at a CBP.

Figure 25-10 shows an example of equipment used to implement an unprotected I-tagged service interface. For details on redundant connections and equipment, see 25.9. A B-component may support one or more I-tagged service interfaces. Each CBP may be associated with one I-tagged service interface. These CBP are connected to a customer system (or network) using an Ethernet LAN.

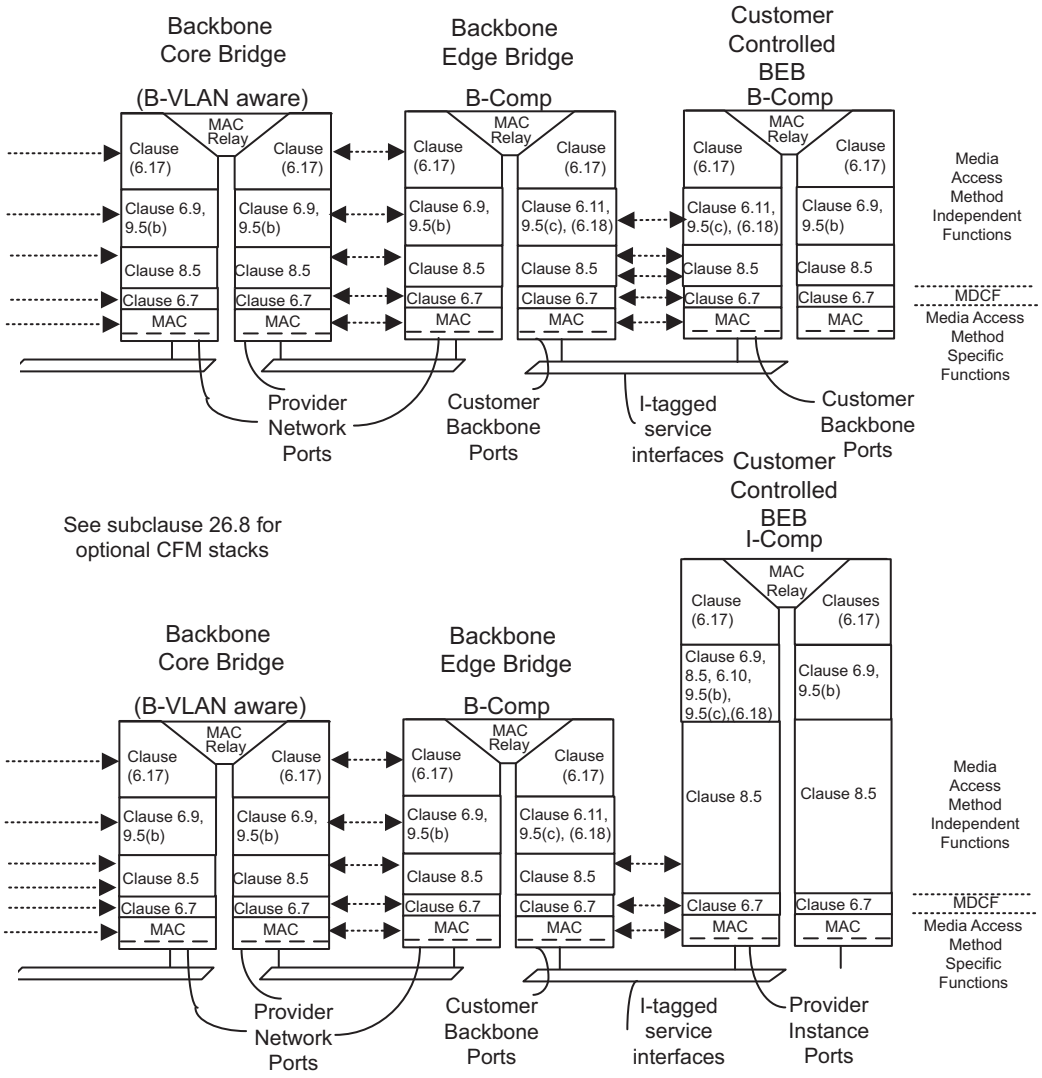


Figure 25-9—S-tagged service interface equipment

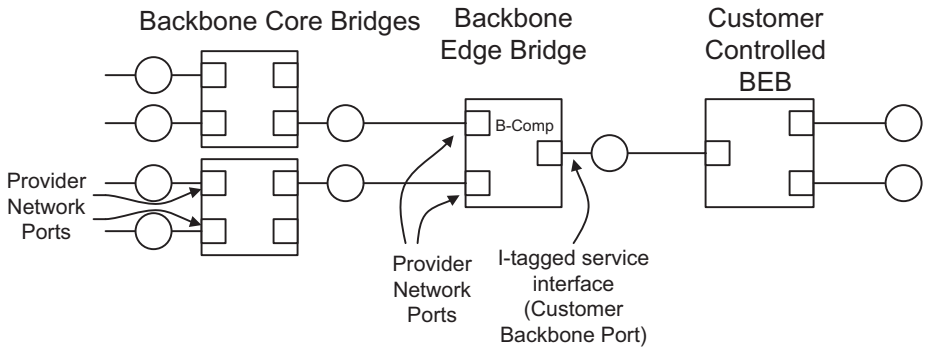


Figure 25-10—I-tagged service interface equipment

NOTE—A protected I-tagged service interface will have more than one PIP and can have a single backbone service instance, identified by an I-SID, enabled on more than one of those ports. This creates the potential for transit traffic on that backbone service instance to pass through the I-BEB without being delivered to a CNP. If this behavior is not desired, then the protected I-tagged service interface should be configured such that any single service instance is only enabled on a single PIP at any given time, or that only a single PIP is forwarding at any given time.

25.6 Service instance segregation

Segregation of data frames associated with different instances of MAC Service is achieved by supporting each service instance with a backbone service instance identified by an I-SID and ensuring that:

a) No service frames are transmitted through a CBP without an I-TAG.
b) No frames are accepted, i.e., received and relayed, from any customer system without first being subject to service instance selection.
c) No frames are delivered to any customer system without explicit service instance identification.
d) Prior to transmission through a PNP of a BEB, service frames are received either through an I-component's CNP or through a CBP. When the customer is attached to a CNP, the port is under the control of the backbone provider and is exclusively accessed by a single customer. In this case, the I-component used to support the CNP is under the control of the Backbone provider and is attached to a CBP through a PIP that is also under the control of the backbone provider and that may be shared with multiple customers. When the customer is attached to a CBP, the port is under the control of the provider and is exclusively accessed by a single customer. All frames received through the CNP or CBP (depending on how the customer is attached) must correspond to a service instance or instances that the customer is permitted to access. (The method used to ensure the port is attached to the specified customer and therefore secure is beyond the scope of this standard. See IEEE Std 802.1X.)
e) The BCBs and the B-component of each BEB within the PBBN can only be controlled by the provider.

A single backbone service instance may support many customer service instances. Each customer service instance is supported by a single backbone service instance.

25.7 Service instance selection and identification

Service instance selection is provided to the attached customer system by the Port-based, S-tagged, or I-tagged service interfaces (25.3, 25.4, 25.5). In the Port-based interface, only one backbone service instance is offered to the attached customer and the CNP of the I-component is configured to accept only untagged or priority tagged frames. In all S-tagged service interfaces, the CNP of the I-component is configured with Enable Ingress Filtering (8.6.2) and the Port is only included in the Member Set for S-VLANs corresponding to service instances that the customer is permitted to use. The service instance for each frame received by the attached customer system is identified in the same way as frames transmitted using the same interface, but not necessarily in the same way that the service instance is selected or identified at other interfaces. In the I-tagged service interface, the CBP of the B-component is configured (12.16.5, 6.11) with the acceptable backbone service instances and I-SID values for use by the customer. A single backbone service instance can support any combination of Port-based, S-tagged, or I-tagged service interfaces.

NOTE—The means used by a backbone provider and a customer to determine the S-VIDs and I-SIDs used by the customer to select and identify a given service instance are outside the scope of this standard.

25.8 Service priority and drop eligibility selection

For all service interface types, the service priority is selected using the received priority for each frame. For S-tagged and Port-based service interfaces, the priority and drop eligibility may be regenerated using the Priority Regeneration Table (6.9.4). For I-tagged service interfaces, the priority and drop eligibility may be regenerated using procedures of 6.11.

The mechanism for determining the received priority varies with the type of service interface. Service priority selection is provided for Port-based service interfaces using the received priority signaled from the media access method of the port. If the media access method used to attach to the interface does not directly

support priority, this will result in the selection of a single value for all frames. An attached system may also signal priority to a Port-based service interface on a per-frame basis by priority-tagging frames with an S-TAG that has a null VID (6.13).

Service priority selection is provided by S-tagged service interfaces using the PCP and DEI parameters conveyed in the S-TAG of each frame. An S-tagged service interface can provide a single backbone service instance for all S-VIDs received, and in this way functions like a Port-based service interface with the addition of the capability of delivering S-tagged service frames (whose S-TAG has a non-null VID).

Service priority selection is provided by I-tagged interfaces using the received priority decoded from the I-PCP and I-DEI fields in the I-TAG.

25.9 Service access protection

A customer system (or systems) that is part of a single PBN or that contains a customer operated I-component or B-component can attach to a PBBN using a protected service interface providing multiple LANs and (or) nodes, thus providing fault tolerance through redundancy of the service interface components. Three classes of service access protection may be supported (see Figure 25-11 and Figure 25-12), which provide for unprotected service interface, for link-level redundancy at the access link or link and node redundancy at the access point. An access service interface may be a Class I, II, III access service interface.

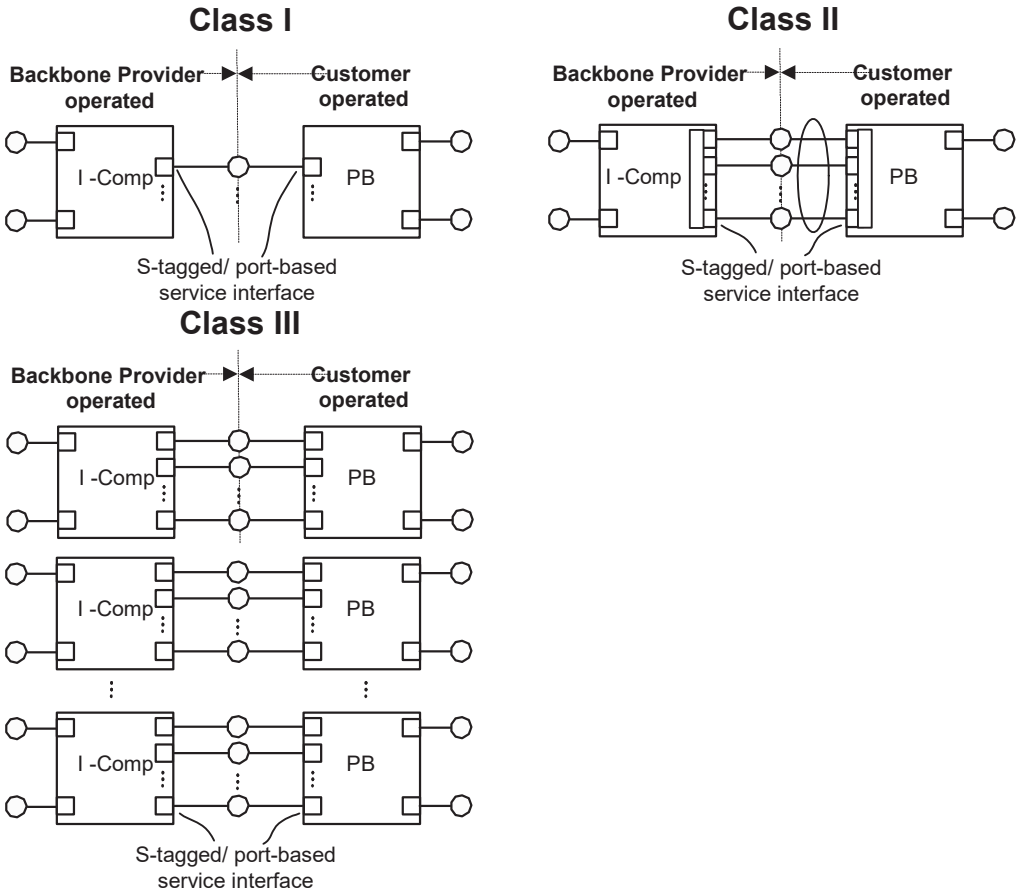


Figure 25-11—S-tagged and Port-based service interface access classifications

Protected Port-based, S-tagged, and I-tagged service interfaces are depicted in Figure 25-11 and Figure 25-12, respectively.

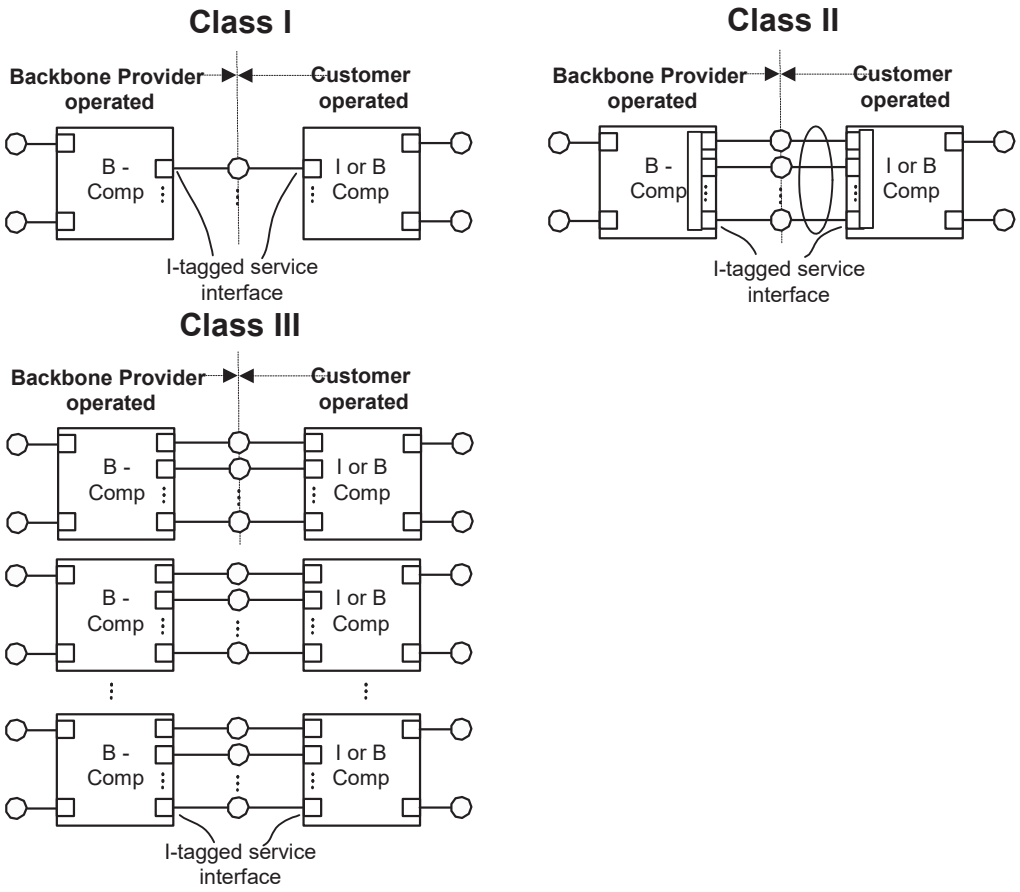


Figure 25-12—I-tagged service interface access protection classifications

Class I service interfaces depicted in these figures are unprotected service interfaces providing a single LAN and node. Class I service interface equipment is depicted in Figure 25-5, Figure 25-8, and Figure 25-10. These provide no redundancy and therefore will fail if any LAN or component fails.

Class II service interfaces are link protected service interfaces that provide multiple LANs; however, they do not provide any node redundancy. Class II service interfaces are tolerant of single or multiple LAN failures. These provide no node redundancy and therefore will fail if any node fails.

Class III service interfaces are link and node protected service interfaces providing multiple LANs and multiple nodes. Class III service interfaces are tolerant of single or multiple LAN failures and/or single or multiple node failures. The operation of a Class III service interface switches between access nodes within both the customer and provider networks; therefore, protection switching over a Class III service interface always results in state changes spreading over the customer and provider networks.

To attach a PBN to a PBBN, the following rules must be maintained to ensure loop-free operation over the extended network:

a) Each PBN and PBBN prevents forwarding loops by running an independent spanning tree.
b) Each PBN connects to other PBNs only through a PBBN.

c) Each PBN ensures that no data frame passes through more than one BEB attachment point into or out of the PBBN. An attachment point is a single LAN connection to a PBBN. This connection may be part of a protected or unprotected Port-based (see Figure 25-4), S-tagged (see Figure 25-7), or I-tagged service interface (see Figure 25-9). A PBN may use L2GP (13.40) to ensure only a single link is active when using a backup link to the PBBN.

d) Each PBN ensures that it attaches any given S-VLAN to no more than one PBBN.

NOTE—When an attached PBN uses the L2GP (13.40) to enforce criterion c), then the PBBN may implement a Class I, II, or III protection interface. If the PBBN is configured for Class I or II protection, then it will provide multipoint services with the services delivered to two or more Class I or II interfaces for attachment to the PBN. In this case, the PBN is responsible for selecting one of the two attachments using the L2GP to ensure criterion c). If the PBBN is configured for Class III protection, then the PBN must support MVRP over the access links to inform the PBBN which S-VIDs are active on which LAN connections.

25.9.1 Class II redundant LANs access protection

A Class II redundant interface is implemented using IEEE Std 802.1AX (Link Aggregation). Using Link Aggregation, a single CNP and associated PNP of a Provider Bridge, or CBP and associated PIP, may be implemented using multiple LANs. A failure on any of the LANs implementing the link will cause all traffic to migrate to the remaining LAN. CFM may run both on the aggregate and on each individual link as shown in Figure 22-8.

It is desirable for the distribution algorithm used on a Class II interface to divide traffic between the multiple links based on the service instance. One distribution algorithm that always retains a service on a single LAN is to place all the traffic on one of N links. In the event of a failure, all traffic is shifted to the highest priority remaining link. This distribution algorithm has the advantage that it provides for full reserved bandwidth on the backup link.

Another distribution algorithm that divides traffic by service and also allows traffic on all redundant links is to divide the traffic by either the S-VID or the I-SID. Distributing traffic based on the S-VID would be used for traffic over multiple LANs comprising an S-tagged interface, while distributing traffic based on the I-SID would be used for traffic over multiple LANs comprising an I-tagged interface. With either of these distribution schemes, services are allocated to one of the LANs used to implement the provider CNP or CBP and the customer PNP, PIP, or CBP. In the event of a failure, the services are moved to the remaining LANs.

25.9.2 Class III simple redundant LANs and nodes access protection

A Class III interface uses redundant LANs to connect a primary and one or more secondary customer nodes to a primary and one or more secondary BEBs. The operation protects the interface against failures on any of the interconnecting LANs or nodes used on each side of the interface. It is possible to use Class II protected interfaces for each link of the Class III interface. In this case, the Class II protection procedures must happen first and complete before a Class III protection switch begins.

For a Class III interface, each customer node is connected to a BEB using a single LAN. The interface is provisioned with a priority for each LAN that is part of the interface. Each of the LANs is constantly monitored using either PHY management, CFM, or both. In operation, a Class III interface uses only the highest priority operating LAN for traffic. The other LANs are protection paths. In a Class III interface, any switch in the LAN used for traffic will also switch both the customer node and the PBBN BEB since the connections of a Class III interface are sets composed of a customer node, a LAN, and a BEB.

When providing a Class III protected S-tagged interface, multiple CNPs, each on a different BEB, are used to create a single S-tagged interface. Each LAN of the S-tagged interface executes CFM at the port level to detect failures over the interface LANs. Information from CFM is used by the customer to determine which LANs of the S-tagged interface are operating and which are inactive. Each customer network runs MSTP to determine which S-VLANs are active on which LANs of the Class III interface. To avoid loops through the

Class III interface, either the I-components participate in the customer network spanning tree (13.42), or the ports on the customer equipment that connects to the I-components are configured as Layer 2 Gateway Ports (13.40). Upon an active link failure between customer node and its corresponding BEB or upon the customer node failure, the customer network switches to one (or more) of the backup links and informs the PBBN which S-VLANs are active on which links using MVRP (11.2) on the access LANs. The BEB(s), upon receiving the MVRP message(s) from the customer network, generate the corresponding MRP-based message(s) for the affected I-SIDs and send these messages over the associated B-VLANs. The far-end BEBs, upon receiving these messages, will flush their C-MAC entries in their FDB corresponding to the affected I-SIDs.

When providing a Class III protected I-tagged interface, multiple CBPs, each on a different B-BEB, are used to create the single I-tagged interface. In this scenario, each B-BEB is connected via a single link to the customer I-BEB where the link can be Class II protected. The customer I-BEB is in turn connected via multiple CNPs to the customer network. Each customer network runs MSTP to determine which S-VLANs are active on which LANs of the Class III interface. To avoid loops through the Class III interface, either the I-components participate in the customer network spanning tree (13.42), or the ports on the customer equipment that connects to the I-components are configured as Layer 2 Gateway Ports (13.40). PHY management or port-level CFM is used to detect failures over the interface LANs between the customer I-BEBs and the customer network. When a failure is detected, the customer network informs the customer I-BEBs which S-VLANs are active on which links using MVRP (11.2). The customer I-BEBs in turn notify the provider B-BEBs using MRP-based messages corresponding to the effected I-SIDs. The provider B-BEBs relay this message to the other BEBs in the PBBN over the associated B-VLANs. The far-end BEBs, upon receiving these messages, will flush their C-MAC entries in their FDB corresponding to the effected I-SIDs. Each LAN of the I-tagged interface also executes PHY management or CFM at the port level to detect failures over the I-tagged interface. In case of a complete I-tagged interface failure between the customer I-BEB and the provider B-BEB, the I-BEB uses this info to deactivate all its CNP ports toward the customer network.

25.10 Support of the MAC Service by a PBB-TE Region

A PBB-TE Region comprises a continuous set of IB-BEBs and BCBs, capable of providing TESIs, that have allocated a common subset of B-VIDs to the control of an external agent (8.9) responsible for setting up Ethernet Switched Paths (ESPs). Each IB-BEB that belongs to a PBB-TE Region can provide interfaces that encapsulate customer frames in ESPs, thus allowing the PBBN operator to offer TESIs.

A PBB-TE Region providing the MAC Service to attached stations is modeled as a sequence of relay functions, as illustrated in Figure 25-1. The MST Configuration Table associated with each BCB or B-component of an IB-BEB specifies a set of VIDs, each of which may be exclusively used throughout the PBB-TE Region to form part of an ESP identifier. Such a VID is called an ESP-VID and is associated with a special value of the MSTID in the MST Configuration Table, the TE-MSTID (8.9), indicating that the VID is not under the control of a spanning tree protocol.

The I-components of IB-BEBs supporting PBB-TE are responsible for encapsulating frames received from customers and allocating each frame to a backbone service instance and for decapsulating frames received from the network via backbone service instances. The allocation of customer frames to backbone service instances that will be transported by TESIs is done at the PIP as described in 6.10. At the PIP the customer frame is encapsulated by an I-TAG, which includes the I-SID, and a set of source and destination B-MAC addresses. The source B-MAC address is the PIP MAC address that is configured to take the same value as the CBP MAC address of the internally connected CBP on the B-component. As a result, the B-MAC addresses of frames associated with TESIs, the ESP MAC addresses, are always equal to the CBP MAC addresses.

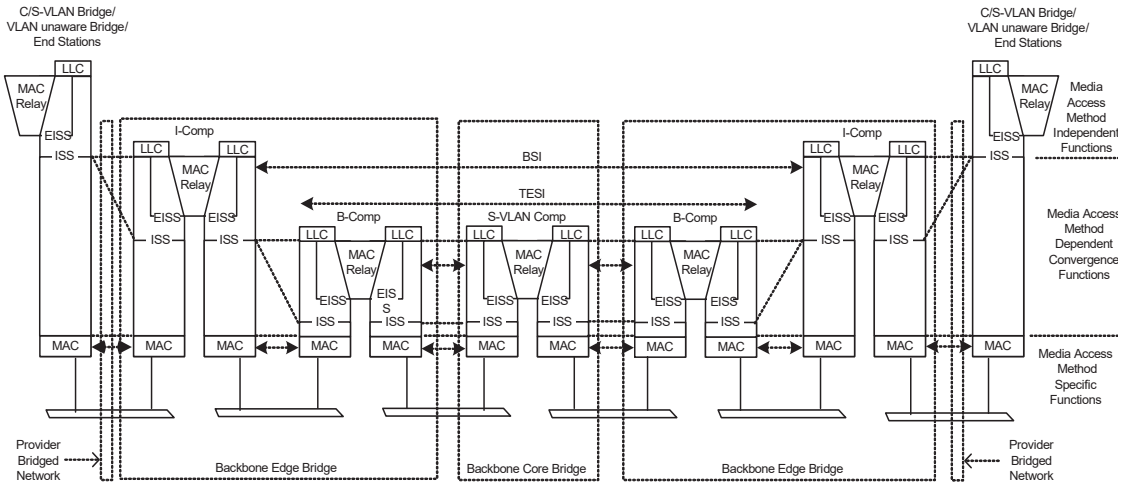


Figure 25-13—Internal organization of the MAC sublayer in a PBB-TE Region

CBPs on B-components in IB-BEBs supporting PBB-TE use the I-SID to map the encapsulated customer frames to TESIs or B-VLANs (6.11). Figure 25-1 depicts a TESI providing the MAC Service at two CBPs. For an I-SID mapped to a TESI, the Backbone Service Instance table contains the terminating CBP's MAC address, the ESP-DA, and the ESP-VID of the associated ESP. I-SIDs mapped to a B-VLAN must not use a B-VID from the ESP-VID space. The B-Component MAC relay forwards frames belonging to an ESP between the CBP and PNPs or between PNPs using the ESP-DA and ESP-VID as described in 8.6.

25.10.1 Provisioning TESIs

ESPs are provisioned in a PBB-TE Region by an external agent. This replaces the spanning tree protocols and populates the filtering tables of the corresponding B-components and BCBs by creating static filtering table entries for the ESP MAC addresses and ESP-VIDs (Figure 25-14).

The ability of a PBB-TE Region to utilize an external management or control plane is facilitated by PBB because the PIP MACs and correspondingly the ESP MAC addresses can be managed by the Provider and therefore can all be identified in the Provider's topology by the external management or control plane.

The external PBB-TE management/control plane is responsible for maintaining and controlling all the active topology information to support point-to-point or point-to-multipoint ESPs over the PBB-TE Region. The PBB-TE active topology can co-exist with active topologies associated with spanning tree protocols and the allocation to a specific active topology is governed by the B-VID value. The PBB-TE external agent takes control of the ESP-VID range on the Bridges in a PBB-TE Region.

Similar to the forwarding connectivity created by the operation of spanning tree and learning, the PBB-TE management/control plane can form an active topology of CBP rooted trees, from each CBP belonging to a PBB-TE Region to a specific subset of any other CBPs in this region. These traffic engineered trees define the path(s) taken by the frames that belong to ESPs within the PBB-TE Region. Furthermore each such tree is further qualified by the PBB-TE reserved ESP-VID, thus enabling the construction of independent trees per ESP-VID. As a result each such CBP rooted tree can be identified by a CBP MAC address associated with the root of the tree, the CBP MACs associated with the leaves of the tree and the ESP-VID. The PBB-TE management/control plane routes the ESPs along these trees by explicitly populating the FDBs in the Bridges along each tree with the Static Filtering Entries containing the CBP MAC DA and ESP-VIDs. The mechanism by which the PBB-TE management/control plane selects the path for a routing tree is not within

the scope of this standard. The PBB-TE management/control plane also manages the bandwidth of all ESPs along each routing tree. For each destination CBP, which is part of a routing tree maintained by the PBB-TE management/control plane, PBB-TE will maintain tree(s) which provide symmetric paths from the CBP MAC DA to the CBP MAC SA. The ESP-VID(s) used in this reverse ESP(s) need not have the same ESP-VID used for the forward ESP. Accordingly each of the ESPs can be identified by a 3-tuple:

<ESP-DA, ESP-SA, ESP-VID>,

where the three component fields are described as follows:

a) The ESP-SA is the address of the PIP encapsulating the customer service instance that by configuration is the same as the address of the internally connected source CBP.
b) The ESP-DA is identifying the CBP destination address(es).
c) The ESP-VID is a VID value distinguishing among ESPs having the same <destination, origin> pair. It can only take values that are allocated to the PBB-TE Region identified by the TE-MSTID (8.9).

An ESP is point-to-point or point-to-multipoint.

d) A point-to-point ESP is an ESP where the ESP-DA and the ESP-SA in its 3-tuple identifier are individual MAC addresses.
e) A point-to-multipoint ESP is an ESP between one root CBP to *n* leaf CBPs, identified by a 3-tuple where the ESP-DA is a group MAC address identifying the *n* leaves CBPs, and the ESP-SA is the individual MAC address of the root.

A TESI, is an instance of the MAC Service supported by a set of ESPs, collectively identified by a single TE-SID, forming a bidirectional service. The following two types of TESIs are described:

f) A point-to-point TESI that is supported by two point-to-point ESPs where the ESPs' endpoints have the same CBP MAC addresses.
g) A point-to-multipoint TESI that is supported by a set of ESPs that constitute one point-to-multipoint ESP from a root to each of *n* leaves plus a point-to-point ESP from each of the *n* leaves to the root.

NOTE—For reasons relating to TESI monitoring diagnostics, operational simplicity, etc., this standard assumes the point-to-point ESPs associated with a point-to-point TESI are symmetric and that the point-to-point ESPs associated with a point-to-multipoint TESI are routed from each of the *n* leaves to the root along the branches of the point-to-multipoint ESP. Support for a TESI that comprises ESPs not routed in this way is problematic, and is not defined in this standard.

Although an ESP is identified by the 3-tuple <ESP-DA, ESP-SA, ESP-VID> it is only the ESP-DA, ESP-VID pair that are used for forwarding decisions. The combination (ESP-DA, ESP-VID) is treated as though it was a single 60-bit address, where 12 bits are the ESP-VID and 48 bits are the ESP-DA. This ESP-VID field is used as a path selector to the destination CBP rather than a B-VID, allowing up to 2^{12} unique routing trees to any single CBP. In Figure 25-14, two paths are configured to reach S2. These two paths are separated by using a different ESP-VID in combination with the ESP-DA for a second path.

If the ESP-VID range delegated is the 4094 possible values, then each CBP termination can sink ($2^{12} – 2$) routing trees, and the theoretical network maximum is about 2^{60} ESPs. The number of ESPs supported by PBB-TE is constrained by issues related to coordinated management, independent management of groups of nodes or independent routing choices through parts of the path, limit through intermediate nodes, etc. In the cases where B-VLAN services are also offered by the same network, it is expected that most B-VIDs will be allocated to those B-VLANs since the use of the MAC addresses as part of the ESP identifiers allows at least 2^{48} ESPs and the ESP-VIDs can be used mainly to provide path diversity.

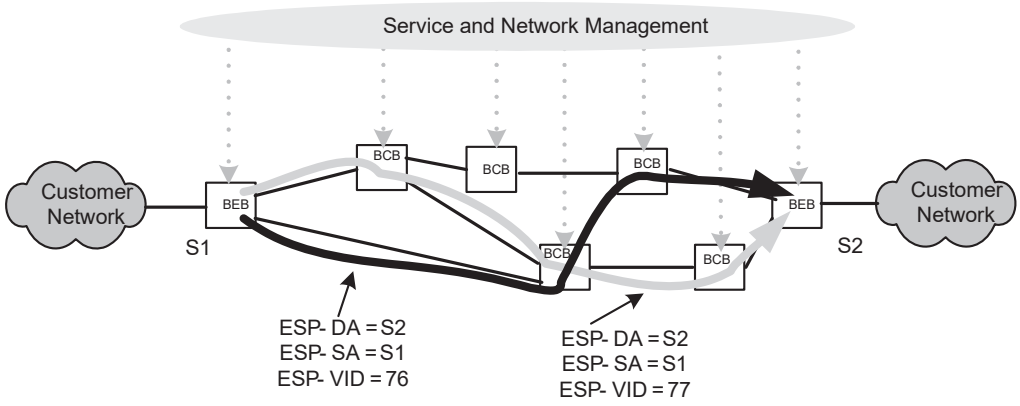


Figure 25-14—PBB-TE Region

25.10.2 ESP forwarding behavior

Forwarding of frames belonging to an ESP-VID differs from forwarding of frames belonging to B-VLANs in the following ways:

a) Frames associated with the ESP-VID are discarded when a Static Filtering Entry corresponding to the (ESP-DA, ESP-VID) is not found in the FDB [item b) in 5.4.5]. Proper operation of PBB-TE requires the provisioning of an FDB entry in each Bridge through which an ESP passes in order to specify the forwarding of traffic associated with that ESP. Such an entry may be absent due to a provisioning error. In the event of such an error, it is important that frames associated with the improperly configured ESP not be flooded, as PBB-TE would be violated if traffic intended for a particular ESP is sent on one or more other ESPs. Further, flooding based on the ESP-VID may result in unbounded looping and replication as the ESP-VID is not associated with a spanning tree. For this reason, frames associated with the ESP-VID are discarded when a Static Filtering Entry corresponding to the (ESP-DA, ESP-VID) is not found in the FDB. Such an ESP MAC address may represent an individual address, for which no more specific Static Filtering Entry exists or a group address, for which no more specific Static Filtering Entry exists (8.8.1).

b) MAC learning is not performed on receipt of a frame carrying an ESP-VID [item a) in 5.4.5]. Where ESPs have been correctly provisioned, learning would not interfere with the proper operation of Bridges, but in the presence of provisioning errors, learning may result in undesired behavior.

c) The active topology for the ESP-VIDs allocated to PBB-TE is no longer controlled by spanning tree protocols but by an external agent that is responsible for setting up the ESPs [item b) in 5.4.5].

NOTE 1—In a network supporting both VLAN (i.e., PBB) and ESP (PBB-TE) traffic, the establishment of an ESP and the policing of traffic at the ingress of the ESP are necessary but not sufficient conditions to ensure that traffic associated with an ESP receives the QoS intended by the network operator. The operator should ensure that the QoS requirements of an ESP are satisfied and that sufficient network capacity is available to accommodate broadcast-unknown traffic, spanning tree control traffic, and other traffic associated with VLAN usage.

Key properties of an ESP are as follows:

d) The ESP is identified at all points along its path by a single identifier <ESP-DA, ESP-SA, ESP-VID>.

e) The information referenced for forwarding <ESP-DA, ESP-VID> is contained within the ESP Identifier.

f) The information referenced for forwarding <ESP-DA, ESP-VID> does not change along the length of the ESP.

NOTE 2—The static and provisioned nature of an ESP provides support for traffic engineering. These properties of the ESP, together with policing and queuing functions supported by a Bridge (8.6) can provide per ESP QoS.

25.11 Transparent service interface

A PBBN may provide a transparent service interface for customer attachment. A transparent service interface is delivered on a CNP provided by a BEB as illustrated in Figure 25-15 and Figure 25-16. A transparent service interface may attach to a Provider Bridge, C-VLAN Bridge (5.9), MAC Bridge, router, or end-station. The service provided by this interface forwards all frames over the backbone on a single backbone service instance.

A transparent service interface does not recognize, add, remove, or modify either S-tags or C-tags on customer frames. It does not learn customer addresses, nor does it filter frames based on any MAC addresses except the TPMR component Reserved addresses listed in Table 8-3 and the management address of the TPMR component.

Figure 25-15 illustrates a customer network attached to a PBBN using a transparent service interface. The customer network uses End Stations, Customer Bridges, or Provider Bridges for connecting to the PBBN.

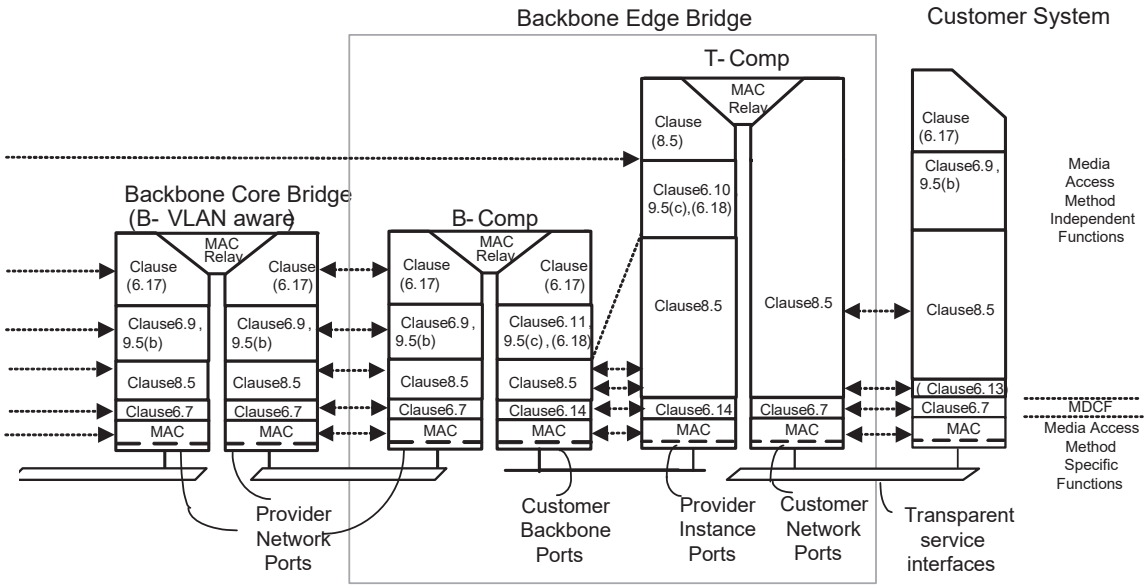


Figure 25-15—Transparent service interface

Figure 25-16 shows an example of equipment used to implement a transparent service interface. In this diagram a BEB is formed by connecting two T-components and a B-component. These connections may be over a backplane or over a LAN. A T-component supports a single transparent service interface associated with a CNP. A CNP is connected to a customer system (or network) using a LAN.

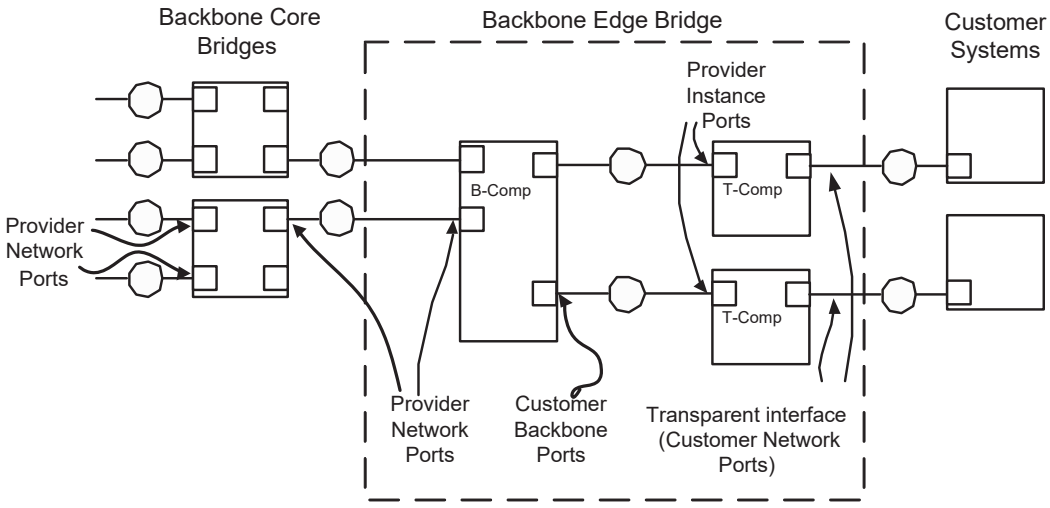


Figure 25-16—Transparent service interface equipment

26. Principles of Provider Backbone Bridged Network (PBBN) operation

This clause establishes the principles and a model of PBBN operation. It provides the context necessary to understand how the:

a) Operation of individual Backbone Edge Bridges (BEBs) and Backbone Core Bridges (BCBs) (Clause 8, Clause 25);
b) Configuration and management of individual BEBs and BCBs (Clause 12); and
c) Management of spanning tree and VLAN topologies within a PBBN (Clause 7, Clause 11, and Clause 13)

support, preserve, and maintain the quality of each of the instances of the MAC Service offered to the customers of the PBBN (Clause 6, Clause 25) including the following:

d) Independence of each service instance supported by a PBBN from other service instances (25.6).
e) Identification of service instances and backbone service instance within the PBBN (25.7, 8.8).
f) Maintenance of service availability in the event of the failure, restoration, removal, or insertion of LAN components connecting a customer network to a PBBN (Clause 6, Clause 11, Clause 13, 25.9).

A PBBN is a Virtual Bridged Network that comprises BEBs at the edge of the PBBN and BCBs at the core of the PBBN and attached LANs, under the administrative control of a single backbone provider. The principal elements of PBBN operation are those specified in Clause 16, as amended by this clause.

NOTE 1—The term PBBN is used exclusively to refer to networks configured and managed as specified by this clause and comprising only (a) BCBs and BEBs and (b) communications media and equipment providing the ISS (IEEE Std 802.1AC). While the requirements of Clause 25 are generally applicable to similar services, a generalized framework for all the network designs that could support these requirements, while useful in the context of other equipment and services, is outside the scope of this standard. This clause describes specific best practice for PBBNs to ensure that the requirements for Bridge functionality are clear. Conformance of a BEB implementation to this standard does not require that the implementation be used as specified in this clause; merely, that it is capable of being so used.

NOTE 2—Within a PBBN, an instance or instances of the MAC Service are reserved for the backbone provider's own use to configure and manage the network. All frames associated with such service instances, and that are not confined to an individual LAN, are subject to service instance selection, segregation, and identification as specified in 26.1.

26.1 PBBN overview

The principal elements of PBBN operation comprise the following:

a) Encapsulation/de-encapsulation of service frames in B-MAC Frames (6.10).
b) Service instance segregation within a PBBN for service frames (25.6).
c) Service instance selection on ingress, and service instance identification on egress, for each customer frame (25.7).
d) Service access protection (25.9).
e) Resource allocation and configuration to provide service instance connectivity (26.3).

The following may also be included:

f) Management of customer end station address learning (26.4)
g) Prevention of connectivity loops formed through attached networks (26.5)
h) Scaling of PBBNs (26.6)
i) Provisioning of PBBN services (26.7)
j) Management of PBBN service connectivity (26.8)

26.2 PBBN example

An example PBBN is illustrated by the Figure 26-1. The example network is divided into three major areas: the customer equipment area, which is owned by the customer and is interfaced to the PBBN; the PBBN area, which is owned by the backbone provider and interconnects to the customer equipment and to other PBBNs; and the other PBBN area, which is owned by the same or other backbone providers and interconnects to multiple PBNs allowing the network to scale indefinitely.

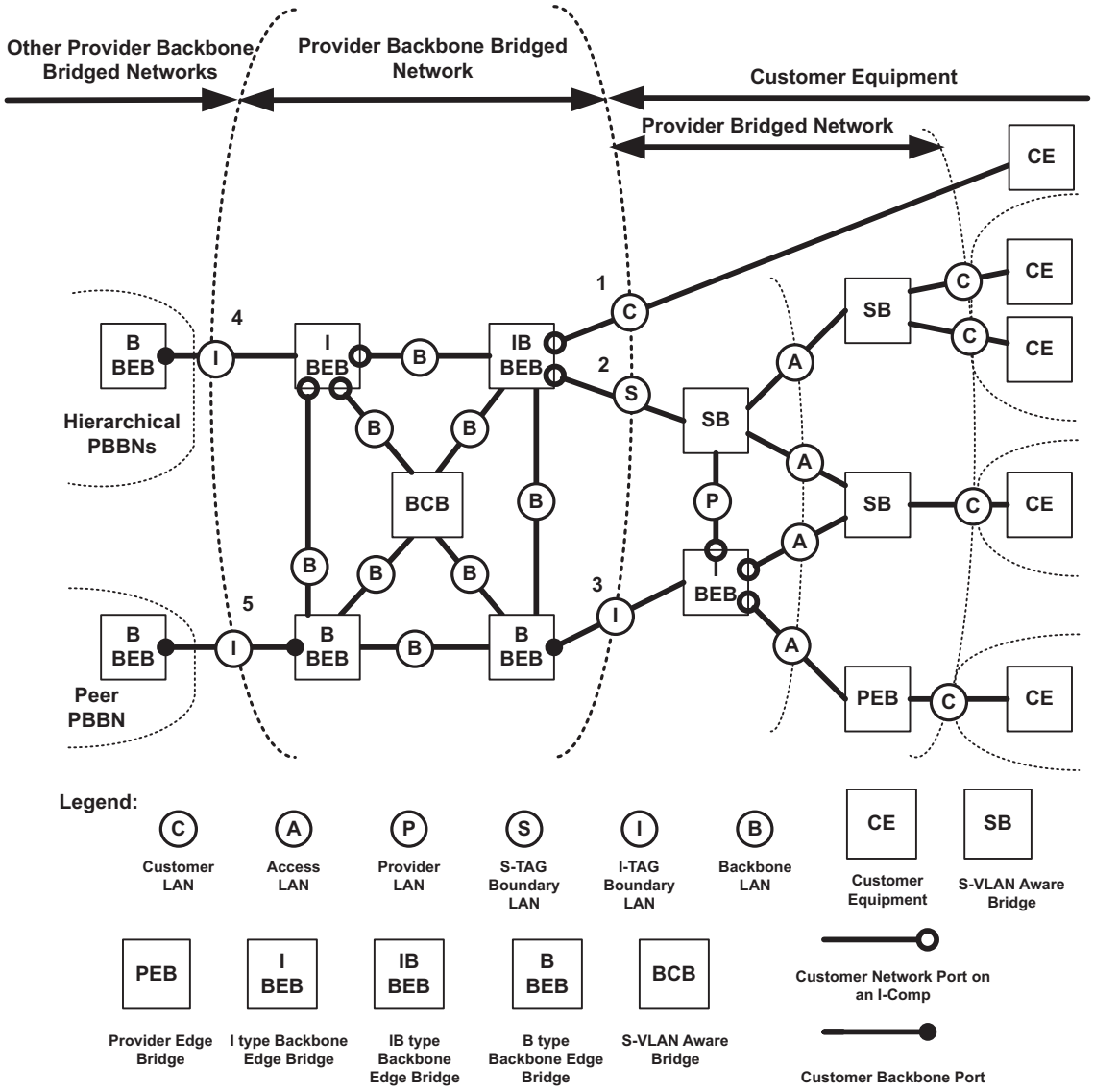


Figure 26-1—PBBN example

The interface between a BEB and a Provider Bridge is a CNP of an I-Component as specified in 6.10. The interfaces between BEBs and BCBs and between BCBs and BCBs are PNPs. In Figure 26-1, these interfaces are over LANs labeled S and B. The interfaces between B-BEB and I-BEBs, or between B-BEBs in different PBBNs, are over LANs labeled I. All exterior interfaces from a PBBN are over S, I, or C LANs; whereas, all interior interfaces within a PBBN are over B LANs. The S, I, and C LANs (exterior interfaces) are at the boundary between the PBBN and the attached customer networks.

The B LANs (interior interface) are backbone LANs, which interconnect all the PBBs within a PBBN.

Within the network example, BEBs, BCBs, and B LANs are secured so that only the backbone provider operating the PBBN can manage the reception, transmission, and relay of frames between BEBs and BCBs. The arbitrary physical network topology of the PBBN and the connectivity that it provides to support segregated instances of the MAC Service is designed and managed by the backbone provider to meet bandwidth and service availability requirements at the CBPs and PIPs. Application of the service instance ingress and egress rules at these Ports in support of service instance selection and identification ensures that frames cannot be transmitted or received on any backbone service instance by any customer's equipment without prior agreement with the provider.

The active MSTP topology of the PBBN area is separated from the active topology of the customer equipment area. This is accomplished by isolating the MST BPDUs for each customer network from the PBBN at the BEBs that surround the perimeter of the PBBN. The BEBs also stop the propagation of MST BPDUs, used to support the active topology of the PBBN, into the Provider Bridged area. In Figure 26-1, Provider Bridge MST BPDUs are propagated over the A, P, C, and S LANs but not over the I or B LANs, while PBB MST BPDUs are propagated over the B LANs but not over the I, C, A, P, or S LANs.

For Port-based service interfaces, the entire C LAN is treated as a single instance of the MAC Service. The BEBs extend the C LAN over the backbone by mapping all service frames on a single backbone service instance identified by an I-SID. The I-SID used is provisioned by the provider operating the PBBN. The provider sets the I-SID on each BEB port attached to a C LAN that is part of the port based service. The BEBs encapsulate the service frames with an I-TAG, B-TAG, B-SA, and B-DA. During the encapsulation, any C-TAG delivered to the CNP is retained in the encapsulated frame as part of the SDU. The BEBs then map the frames onto a B-VLAN with its B-VID contained in the B-TAG and which interconnects the BEBs provisioned for the service. These new frames are transmitted over the B LANs by the BEBs and by the BCBs that carry the B-VLAN. Since the initial octets of the data conveyed in each backbone frame comprise an S-TAG, the frames may be forwarded by BCBs of the PBBN until they reach the next BEB where they might be de-encapsulated. During de-encapsulation, the B-DA, B-SA, B-TAG, and I-TAG are stripped. The C-DA and C-SA from the I-TAG will become the DA and SA transmitted to the receiving C LAN. If the encapsulated SDU contains a C-TAG, it becomes the outside tag as the frame is transmitted to the receiving C LAN.

For S-tagged service interfaces, each instance of MAC Service is carried over the S LANs on one or more S-VLANs. The BEBs preserve the S-VLAN over the backbone by mapping them onto an I-SID and in the case of S-VLAN bundling carrying the S-TAG. This operation is performed by the backbone provider operating the PBBN by configuring the VIP-ISID on each BEB attached to an S LAN. The BEB maps the S-VID to I-SID and encapsulates the original service frame with a new I-TAG, B-SA, and B-DA. The BEB then maps the frame onto a B-VLAN, which interconnects BEBs. This new frame is transmitted over the B LANs by the BEBs and by the BCBs. Since the initial octets of the data conveyed in each backbone frame comprise an S-TAG, the frames may be forwarded by BCBs of the PBBN until they reach the next BEB where they might be de-encapsulated.

For I-tagged service interfaces, each instance of MAC Service is identified by an I-SID value carried over the I LAN in an I-TAG. The BEB maps the frame onto a B-VLAN, which interconnects BEBs. This new frame is transmitted over the B LANs by the BEBs and by the BCBs. Since the initial octets of the data conveyed in each backbone frame comprise an S-TAG, the frames may be forwarded by BCBs of the PBBN until they reach the next BEB where they might be de-encapsulated.

B-MAC addresses are used to identify the destination BEB's PIP. These B-MAC addresses are learned by each PBB as frames are exchanged over B-VLANs. To perform the encapsulation and de-encapsulation of service frames, BEBs use the connection identifier stored in the FDB (see 8.8) to correlate C-MAC addresses to B-MAC addresses. At startup, the BEBs have not learned the B-MAC or C-MAC addresses yet. When the B-MAC address is unknown, the BEB encapsulates the service frames using the Default

Backbone Destination address. The same holds true for the service frames having a group or broadcast destination address. An individual B-DA is used for forwarding unknown or group frames when the service is point-to-point and where the far end individual address is known. Both the B-MAC and C-MAC addresses are learned by the provider BEB (see Clause 8).

Frames containing encapsulated service data are carried within the B-VLANs created over the PBBN. It is also possible to carry unencapsulated S-VLAN traffic in the PBBN core by allocating some of the PBBN VID space to S-VLANs. The B-VLAN determines the route that the frames will take and limits broadcasting within the backbone. The B-TAG is added to the frame at the CBP. The selection of B-VLAN used to form the B-TAG is determined by the configuration of the CBP Backbone Service Instance table. This table maps I-SIDs to B-VIDs and is created as part of service provisioning.

If a BEB's PIP receives a B-MAC Frame whose B-SA is the same as the B-MAC address of the PIP, then a loop exists through the BEBs. Optionally, the BEB may use this condition for loop detection.

26.3 B-VLAN connectivity

The B-VLAN topology of each B-VLAN is established by the mechanisms introduced in 7.1 and Figure 7-1. The backbone provider can use and configure MSTP to provide a number of independent spanning tree active topologies and can assign each B-VLAN to one of these active topologies to best use the resources in the network. MVRP running in the context of each spanning tree active topology configures the extent of each B-VLAN to the subset of that active topology necessary to support connectivity between the customer points of attachment to the instance of MAC Service provided, and can reconfigure that connectivity as required if the spanning tree active topology changes.

The operation of MSTP within a Backbone Provider's network is independent of the operation of any spanning tree protocol within attached provider or customer networks. This is achieved by removing all MST BPDUs received or to be transmitted at the service access interfaces.

The operation of MVRP within a PBBN is independent of the operation of any configuration protocol within attached customer networks. The Provider Bridge MVRP address (Table 8-1) is used as the destination address of all MRPDUs transmitted in support of the MVRP Application. Frames received by CBPs and addressed to the Customer Bridge MVRP address (Table 10-1) are subject to service instance selection and relay in the same way as service frames. The MVRP Administrative Control for each B-VLAN is either Registration Fixed (New Ignored) or Registration Forbidden on all CBPs, so no information is received from any BEB MVRPDU that has been erroneously transmitted by a customer system.

26.4 Backbone addressing

When customer frames enter a PBBN they are encapsulated by the addition of B-MAC addresses and the creation of an I-TAG. The encapsulation is the result of the actions of a PIP as specified in 6.10. The PIPs represent the endpoints of a backbone service instance, and the B-MAC addresses identify these endpoints. (More specifically the VIPs of the PIP represent the endpoints of a backbone service instance, and the combination of the B-MAC addresses and the I-SID identify these endpoints. Since the I-SID identifies which VIP of a PIP is the Backbone Service Instance endpoint, the B-MAC address need only identify the PIP. Therefore, all VIPs of a PIP can share the same MAC address.) This encapsulation ensures that only I-components learn C-MAC addresses, while B-components and Bridges in the PBBN core learn only B-MAC addresses.

The B-SA of an encapsulated frame identifies the PIP that performed the encapsulation and is referred to as the PIP MAC address. For a PIP that connects to an external LAN, this is the address of the PIP itself. For a PIP that has an internal connection to a CBP in the same BEB, this can be any address that results in delivering received I-tagged frames to the I-component, such as the Bridge address of that I-component.

When the PIP MAC address is also used by CFM MPs instantiated on the PIP, there are additional constraints on the uniqueness of that address (26.4.3).

The B-DA of an encapsulated frame identifies the PIP(s) to which the frame should be delivered. The default value for the B-DA is the Backbone Service Instance Group address constructed by concatenating the three octet OUI shown in Table 26-1 with the three octet I-SID, and asserting the I/G bit in the first octet of the resultant value to signify a group MAC address. In a Backbone Service Instance Group address formed in this way, the OUI value is encoded in the first three octets of the address, with the most significant octet of the OUI encoded in the first octet, with the I/G bit (the LSB) set, and the least significant octet of the OUI encoded in the third octet; the most significant octet of the I-SID is encoded in the fourth octet of the address and the least significant octet of the I-SID in the sixth octet.

Table 26-1—Backbone Service Instance Group address OUI

Name	Value
IEEE 802.1Q Backbone Service Instance Group address OUI	00-1E-83

NOTE—Table 26-1 uses the Hexadecimal Representation specified in IEEE Std 802.

When the B-DA of a frame is the Backbone Service Instance Group address, the nominal behavior of the PBBN is to deliver the frame to all CBPs reachable within the B-VLAN to which the backbone service instance is mapped. Filtering based on I-SID by the egress CBP ensures that frames are not transmitted by CBPs that are not part of the backbone service instance. Flooding frames throughout the B-VLAN and filtering at egress provides the correct connectivity for the backbone service instance, but may result in inefficient use of PBBN resources. More efficient frame delivery can be achieved by configuring Static Filtering Entries in the backbone Bridges, or using MMRP to create MAC Address Registration Entries, that restrict the delivery to just the endpoints of the backbone service instance. More efficient delivery can also be achieved by learning individual B-MAC addresses at a PIP, and in some cases by configuring the CBPs to translate the Backbone Service Instance Group address.

26.4.1 Learning individual backbone addresses at a PIP

Individual backbone addresses are learned by means of the connection_identifier parameter generated by the PIP and stored in the FDB. For each received frame, the PIP includes in the EM_UNITDATA.indication a connection_identifier parameter that identifies the backbone source address of the frame. When the I-component Learning Process creates or updates a Dynamic Filtering Entry for a Customer Source MAC address (C-SA) of a frame received through a PIP, it stores the connection_identifier parameter of the EM_UNITDATA.indication for that frame. The connection_identifier parameter is included in the EM_UNITDATA.request for subsequent frames destined to that customer address. Within the PIP, the connection_identifier determines the individual backbone address associated with the customer address. This individual address is then used as the B-DA in place of the Backbone Service Instance Group address.

When a backbone service instance includes only two VIPs, it is possible to use a learned individual backbone address as the default B-DA instead of the Backbone Service Instance Group address. This is accomplished by configuring the AdminPointToPointMAC parameter for the VIP to ForceTrue, which results in the operPointToPointMAC parameter having a value of TRUE. In this case, the PIP copies the B-SA of frames received for that VIP (i.e., the individual MAC address of the peer PIP) to the Default Backbone Destination parameter of the VIP. Subsequent frames transmitted by the PIP on that backbone service instance will then use the individual MAC address of the peer PIP as the B-DA even if the C-DA is unknown or broadcast. Enabling the enhanced filtering criteria (8.7.2) on a VIP will prevent the I-component from creating Dynamic Filtering Entries for C-MAC addresses unnecessarily when the backbone service instance is point-to-point and the S-VLAN that maps to the backbone service instance has only the VIP and one CNP in its member set.

When the enableConnectionIdentifier of a VIP is set to FALSE, the connection_identifier is kept to a NULL value and correspondingly the B-DA used by frames associated with this VIP is always the Backbone Service Instance Group address.

26.4.2 Translating backbone destination addresses at a CBP

In some cases, when the B-DA is the Backbone Service Instance Group address it may be advantageous that the CBP translate this to a different address. Examples where such translation may be useful include the following:

a) When a backbone service instance has only two endpoints within a PBBN, the Backbone Service Instance Group address may be translated at the ingress CBP to the individual address of the egress CBP.
b) When multiple backbone service instances connect the same set of CBPs, the ingress CBP may translate the Backbone Service Instance Group address to a single group address chosen for the set of backbone service instances.

These translations can be accomplished by configuring the Default Backbone Destination parameter in the service instance table of the CBP (6.11). Whenever an ingress CBP is configured to translate the B-DA, the egress CBP must be configured to translate the B-DA back to the Backbone Service Instance Group address. This allows multiple PBBNs connected through Peer E-NNIs to use addresses local to each PBBN.

The CBP is also capable of translating the I-SID on frames entering and exiting the PBBN. This allows the values of the I-SID to be local to a PBBN. If the B-DA of the frame is the Backbone Service Instance Group address and the CBP translates the I-SID, the CBP will also reconstruct the Backbone Service Instance Group address using the new value of the I-SID.

26.4.3 Backbone addressing considerations for CFM MPs

Possible placement of CFM shims in a PIP and a CBP are shown in Figure 26-2. In the PIP, these include MPs to monitor backbone service instances (identified by I-SIDs) in the PBBN, as well as MPs to monitor service instances (identified by VIDs of S-VLANs) in the attached PBNs. In the CBP, these include MPs to monitor backbone service instance (identified by I-SIDs) in the PBBN, as well as MPs to monitor B-VLANs in the PBBN. All of these MPs are assigned individual addresses subject to the constraints specified in 19.4; however, there are additional considerations for the addresses used by MPs in PIPs and CBPs.

In a PIP, the individual address assigned to the backbone service instance-level MPs must be unique within the PBBN. The individual address assigned to the S-VLAN-level MPs must be unique within the set of PBNs interconnected by any backbone service instance supported by the PIP. Therefore, these two groups of MPs may use a common address that is globally unique; however, they may need distinct addresses if local addressing is used in the PBBN.

In the CBP, both the backbone service instance-level MPs and the B-VLAN-level MPs require an individual address that is unique within the PBBN. Therefore, these two groups may use a common address whether it is a global or local address.

26.5 Detection of connectivity loops through attached networks

The transmission and reception of MST BPDUs through CNPs will detect accidental direct connection of those ports. A backbone provider cannot rely on any customer network relaying such frames, and should develop a policy and mechanisms to deal with potential data loops that can arise if the attached customer systems do not operate their own instance or instances of a spanning tree protocol.

A bridged network can be redundantly attached to a PBBN by the means of several Layer Two Gateway Ports (13.40). By way of communication within their region and without any influence from the PBBN, those ports will provide connectivity to the PBBN through a single Layer Two Gateway Port, thus avoiding any bridging loop between the PBBN and the network.

NOTE 1—Use of the restrictedRole parameter at ingress ports ensures that receipt of BPDUs addressed to the Provider Bridge Group address cannot disrupt internal connectivity within the PBBN.

NOTE 2—Specification of PBBN policies, mechanisms, and heuristics used to detect or minimize the impact of data loops created by customer systems is not addressed by this standard. They can include, but are not limited to, bandwidth limitation, charging policies, detection of the repetitive movement of the apparent location of customer stations, and customer agreement to allow the use of PBBN loop detection protocols by not filtering the associated frames.

NOTE 3—A data loop is not the only possible cause of excess bandwidth consumption by a given customer of a PBBN, and the PBBN is usually required to meet service guarantees to other customers irrespective of the cause of the excess bandwidth demand. Data loops are not a unique threat to satisfactory overall network performance. Their distinct characteristic is consumption of discretionary bandwidth without benefiting any customer. The customer that creates the loop can suffer particularly serious network degradation or excess cost as the PBBN limits the total bandwidth consumed by that customer. It is therefore in the interests of each individual customer and the PBBN to raise service satisfaction by preventing and detecting loops.

26.6 Scaling of PBBs

For PBBN deployments, it is important to be able to interconnect PBBNs operated by different organizations. The interfaces between PBBNs are examples of the MEF Forum External Network to Network Interface (E-NNI) referred to in the MEF reference model (section 7.2 and Figure 3 of MEF 4 [B51]). E-NNIs for interconnection of PBBNs can be further classified into two types: hierarchal interconnect and peer interconnect. Examples of hierarchal and peer interconnects are depicted in Figure 26-1 at the interfaces marked 4 and 5.

26.6.1 Hierarchal PBBNs

The hierarchal interconnect connects the PBBNs in a leveled hierarchy. In this interconnect model one PBBN acts as a second-level (n + 1) PBBN to a first-level (n) PBBN. This model allows scaling the number of services by additional hierarchal level. Each level of a hierarchal interconnect adds an additional encapsulation layer.

In the hierarchical model, the (n + 1)-level PBBN carries the n-level PBBN B-VLANs as services in the same manner that the first-level PBBN carries the customer S-VLANs as services. In this model an S-VLAN is presented to a level n PBBN for transport. The PBBN transports the S-VLAN as an instance of MAC Service within a B-VLAN generated by the n-level PBBN. The n-level PBBN is connected to an (n + 1)-level PBBN over a hierarchal E-NNI interface. The (n + 1)-level PBBN carries B-VLANs from the attached n-level PBBN as service instances in (n + 1)-level B-VLANs through the (n + 1)-level PBBN.

Since each hierarchal level requires an additional encapsulation, the nesting depth is limited by the maximum defined frame length for the MAC type used.

26.6.2 Peer PBBNs

The peer interconnect between PBBNs results in a flat service space that does not increase the encapsulation nesting depth. The network scales the number of services over the combined PBBNs by service localization. Further localization and scaling of services is supported by the I-SID filtering functions in addition to the optional I-SID translation functions of the CBP interfaces on each side of the peer E-NNI (6.11). Services that are limited in extent to a single PBBN do not consume any resources within the other connected PBBNs.

The peer interconnect will extend backbone service instances across the peer connected PBBNs. In the peer interconnect a service instance in PBBN A is connected to a service instance in PBBN B by the peer E-NNI between the PBBNs. The peer E-NNI is formed by an I-tagged Service Interface between two CBPs (6.11), one in each of the peer PBBNs. The I-SID used over the E-NNI must be agreed to mutually by both providers. At each end of the E-NNI the CBP may optionally translate the I-SID (and the B-DA if it is the default multicast address generated from the I-SID) used over the E-NNI to a new I-SID for use within the PBBN. The CBPs also map the I-SID to a B-VLAN within the PBBN, as no B-TAGs are transmitted across the peer interconnect.

26.7 Network management

Management of a PBB is directly under the control of the backbone provider. PBN customers shall not have access to managed objects related to elements of PBBs within the PBBN.

In SNMP management systems, this can be realized by implementing one management entity acting as an agent in the Provider Bridge and separating the management views that include customer networks information from the management views that include provider networks information using the mechanisms defined by the SNMP management framework in IETF RFC 3411.

26.8 CFM in PBBs

CFM (Clause 18 through Clause 22) may operate over LANs, C-VLANs, S-VLANs, B-VLANs, and backbone service instances identified by I-SIDs. CFM Maintenance domain Endpoints (MEPs) and Maintenance domain Intermediate Points (MIPs) may be inserted at any of the EISS service interfaces described by 6.9, 6.10, and 6.11, at the ISS service interface described in IEEE Std 802.1AC, and within the EISS and Backbone Service Instance Multiplex Entity described in 6.17 and 6.18.

Within a PBBN, the encapsulation performed by PIPs also encapsulates CFM frames sourced by customers attached to CNPs. Encapsulation of S-VLAN and C-VLAN CFM frames hides them from the PBBN enabling a new set of independent MD levels to be defined in the PBBN for CFM, which may be used for managing B-VLANs spanning between the B-components and BCBs of the PBBN, and over LANs that span between PBB ports. In addition, the backbone may support MAs per backbone service instance that are identified by I-SIDs and span between the PIPs and CBPs of I-components and B-components of the PBBN. A full set of eight maintenance levels exists within each PBBN for use by B-VLAN CFM frames. The Backbone Service Instance CFM frames may extend over a E-NNI, therefore providing eight levels of Backbone Service Instance CFM for the extended backbone, which includes all peer connected PBBNs. All eight levels of CFM frames generated in customer networks are carried over the backbone as encapsulated data and may be used by customer networks. Another eight maintenance levels exist for the LANs for which no frames are untagged. This may be the case for the PNP-PNP LAN links. The CFM stacks for the PIP and CBP are depicted in Figure 26-2. The stacks for the CNP and PNP are as depicted in 22.1.1.

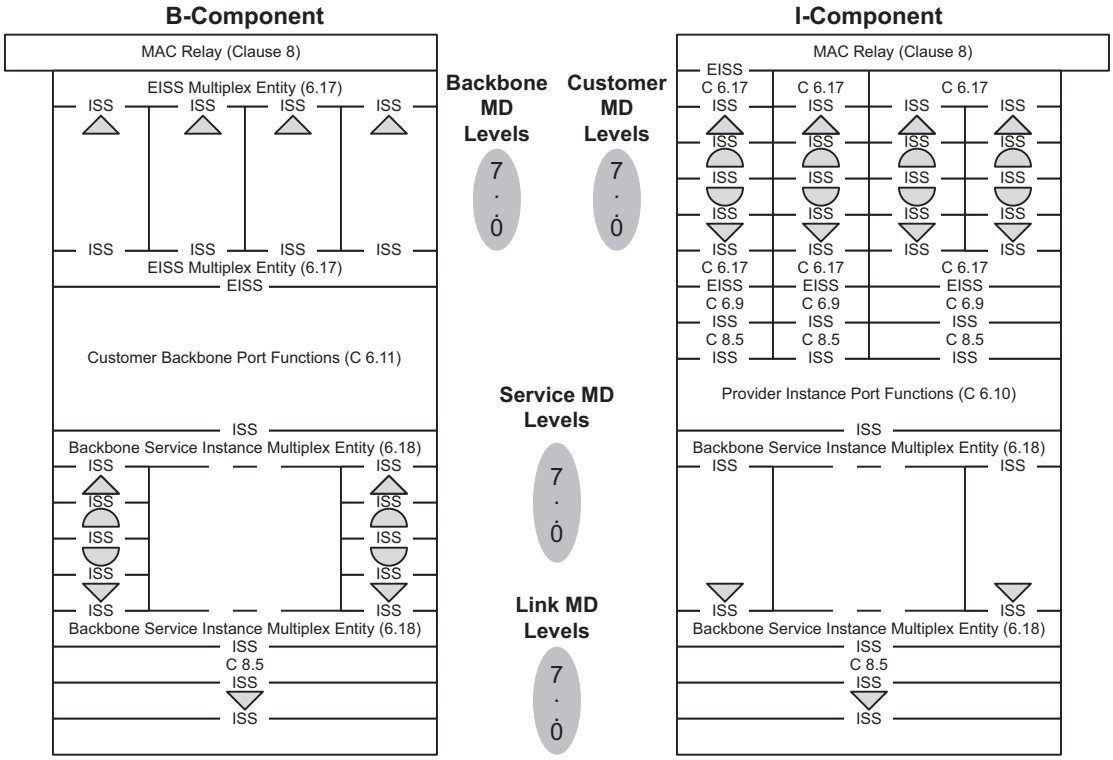


Figure 26-2—CFM shim model

Figure 26-3 and Figure 26-4 show possible MAs at the three types of PBBN service interfaces described in 25.3, 25.4, and 25.5, respectively. These three interfaces are depicted in Figure 26-1, where they are labeled 1, 2, and 3. Figure 26-5 and Figure 26-6 show possible MAs at the two types of PBBN E-NNI interfaces, which are described in 26.6.1 and 26.6.2, respectively. These two types of E-NNIs are depicted in Figure 26-1, where they are labeled 4 and 5. The MAs indicated in Figure 26-3 through Figure 26-6 are example MAs for each PBBN service interface type and PBBN E-NNI type. Typically not all these MAs would be supported within any given PBBN since some MAs illustrated provide redundant capabilities and since the selection of MAs will depend on the service-level agreements used for a particular service, on the operational environment of a particular PBBN and on the equipment used in the particular PBBN.In these figures, four distinct categories of MAs are depicted. These are the S-VLAN and C-VLAN MAs, the Backbone Service Instance MAs, the B-VLAN MAs, and the LAN MAs. Each of these four classes of MAs is associated with independent sets of MDs introducing four independent sets of eight maintenance levels. The selection of which levels for each of these MDs to use in a particular network depends on the specific network implementation. The S-VLAN MAs are only visible within the I-component where customer frames are un-encapsulated. Customer CFM frames are encapsulated along with the other customer frames at the VIPs within the I-component. Once the S-VLAN CFM frames are encapsulated, they appear just like any data frame within the PBBN; therefore, they do not activate any CFM functions within the PBBN past the VIPs. The Backbone Service Instance CFM frames may optionally be generated at the Backbone Service Instance Multiplex Entity within the PIP or CBP. These CFM frames are only visible within the PBBN where the I-TAG is being processed, that is at the CBP and at the PIP. Each Backbone Service Instance MD may be assigned to one of eight maintenance levels. Since the Backbone Service Instance CFM maintenance domain may extend over E-NNI boundaries, these eight levels extend over all interconnected PBBNs until they are terminated at a VIP. B-VLAN MAs manage the B-VLANs within a single PBBN. The B-VLAN MDs have a new set of eight maintenance levels, which are separate for each PBBN and never extend out of

the PBBN. Finally, the LAN links within a PBBN (PIP to CBP, PNP to PNP), between two PBBNs (CBP to CBP, PIP to CBP) and entering/egressing the PBBN (to/from CNP) may optionally be monitored by LAN link MAs, generated/terminated within the PIP, CBP, PNP, and CNP. LAN link MAs are typically confined to the LAN link.

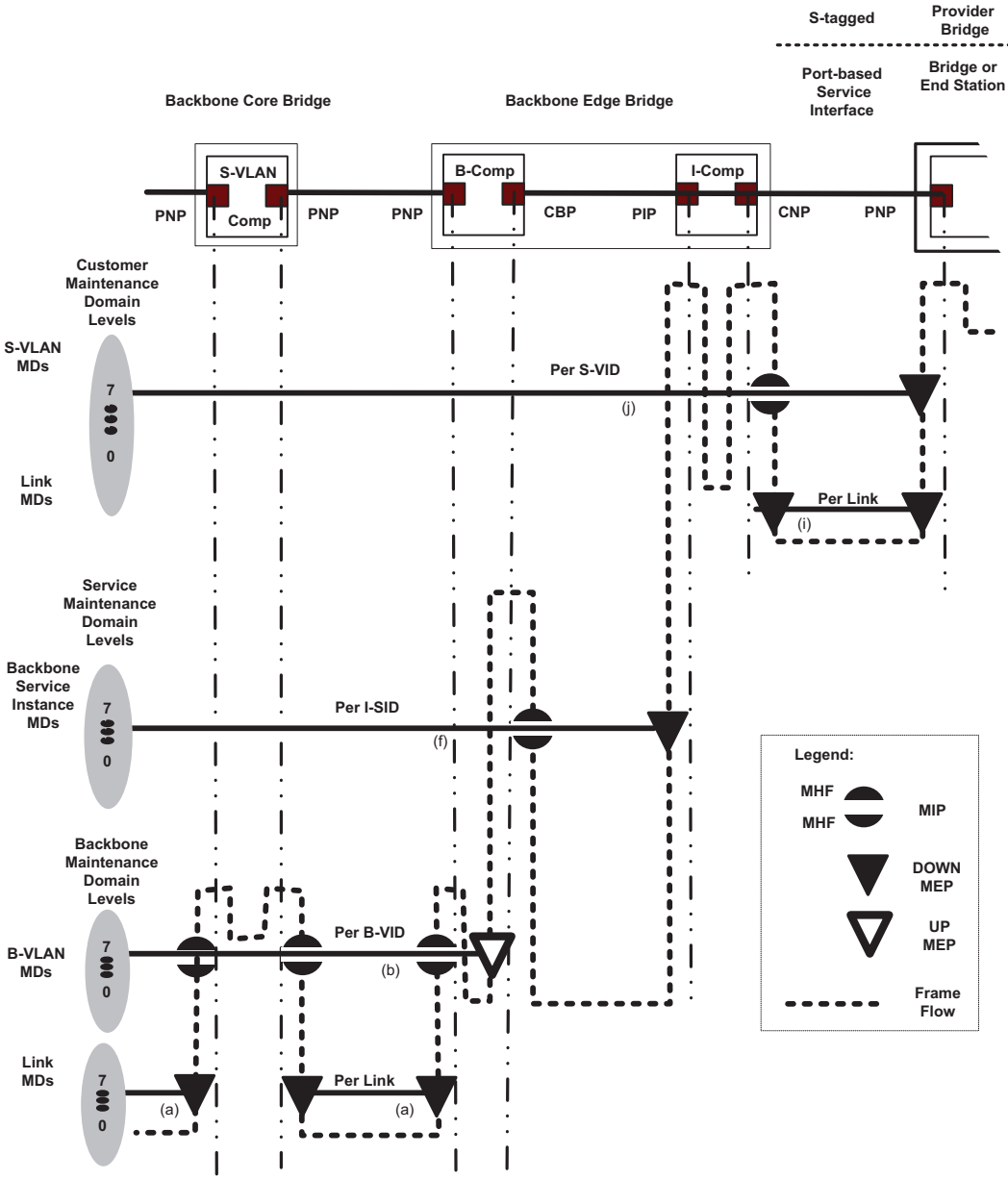


Figure 26-3—CFM example applied to a Port-based and S-tagged service interface

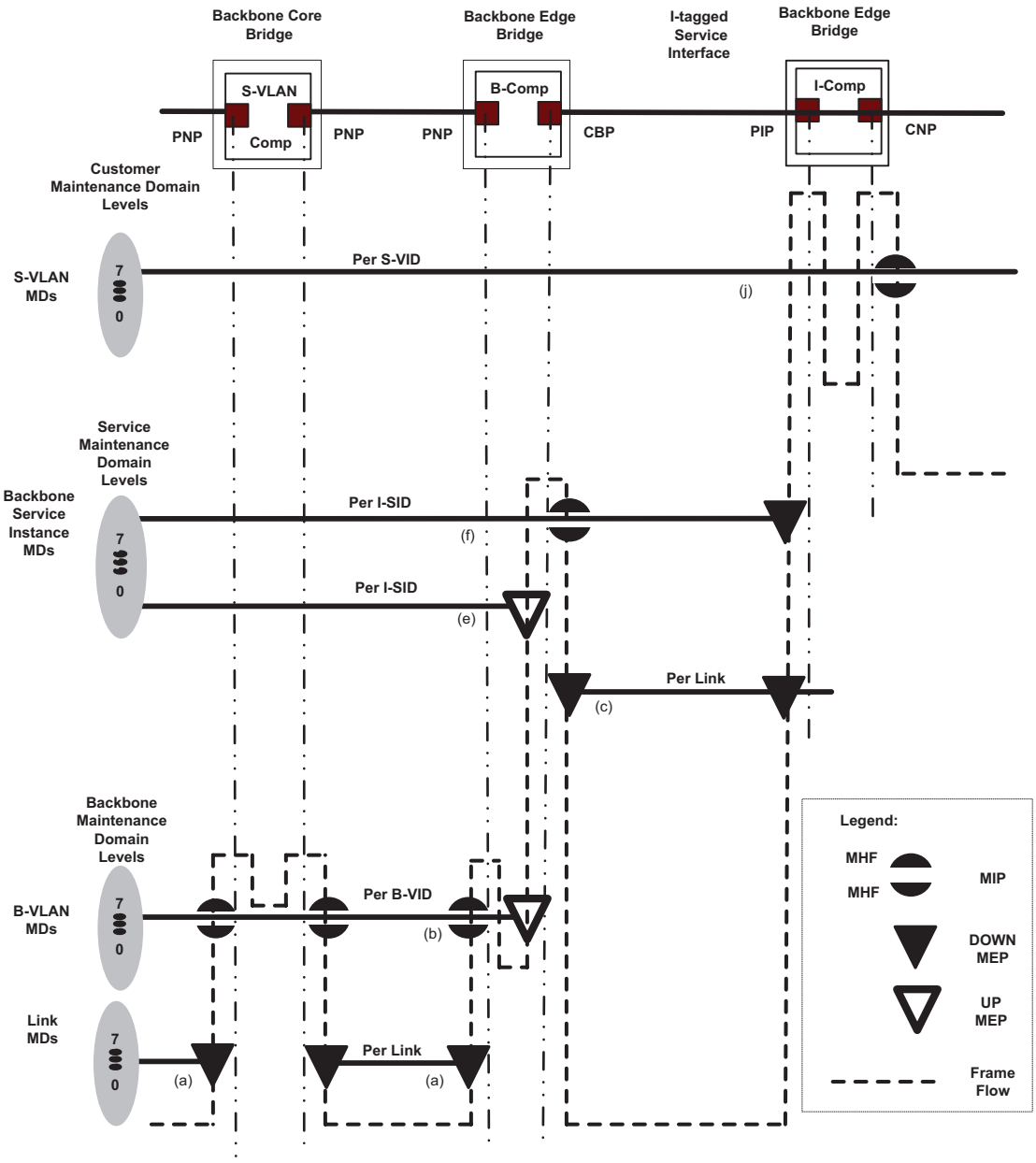


Figure 26-4—CFM example applied to an I-tagged Service Interface

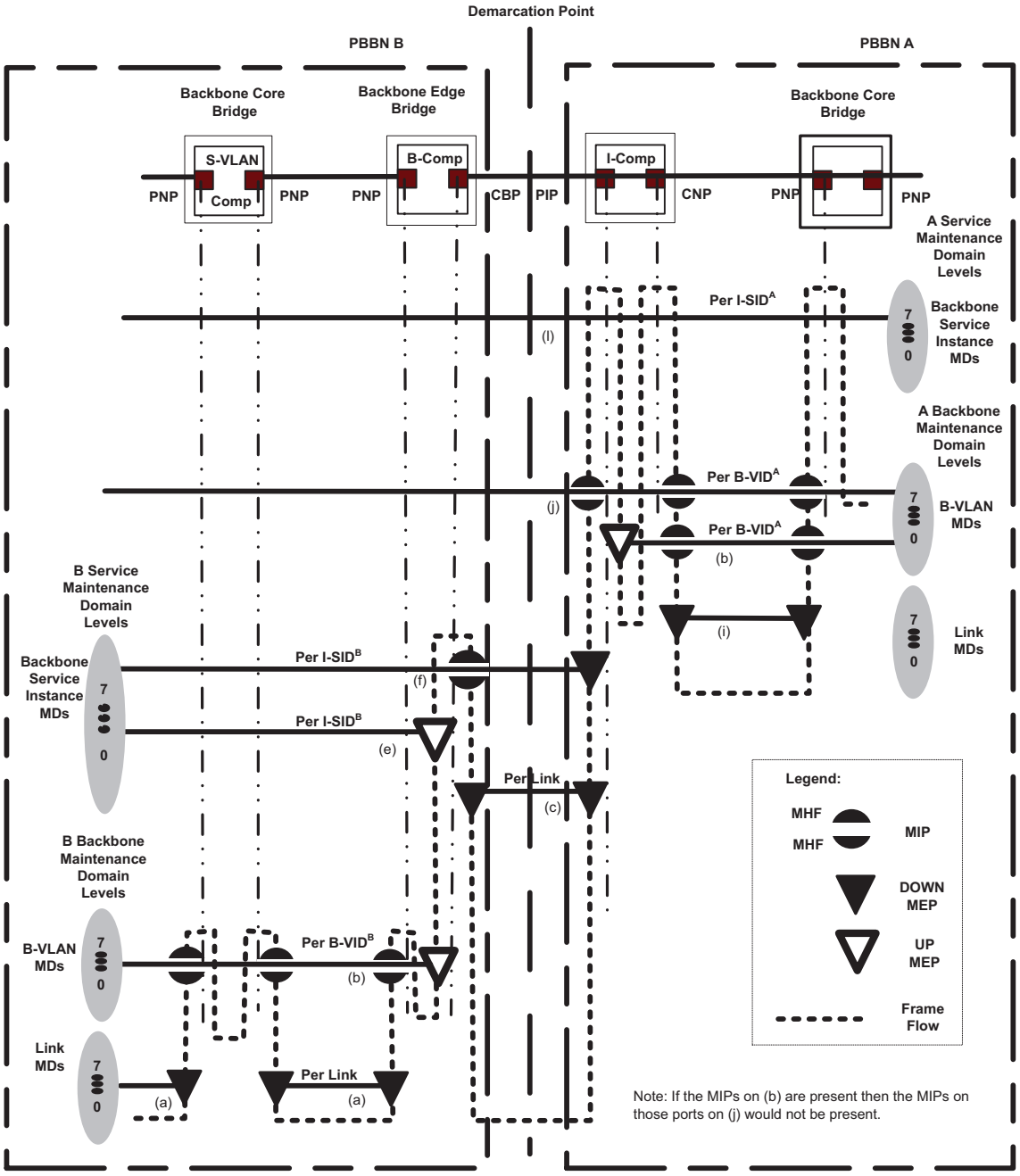


Figure 26-5—CFM example applied to a hierarchal E-NNI, CBP-PIP Demarc

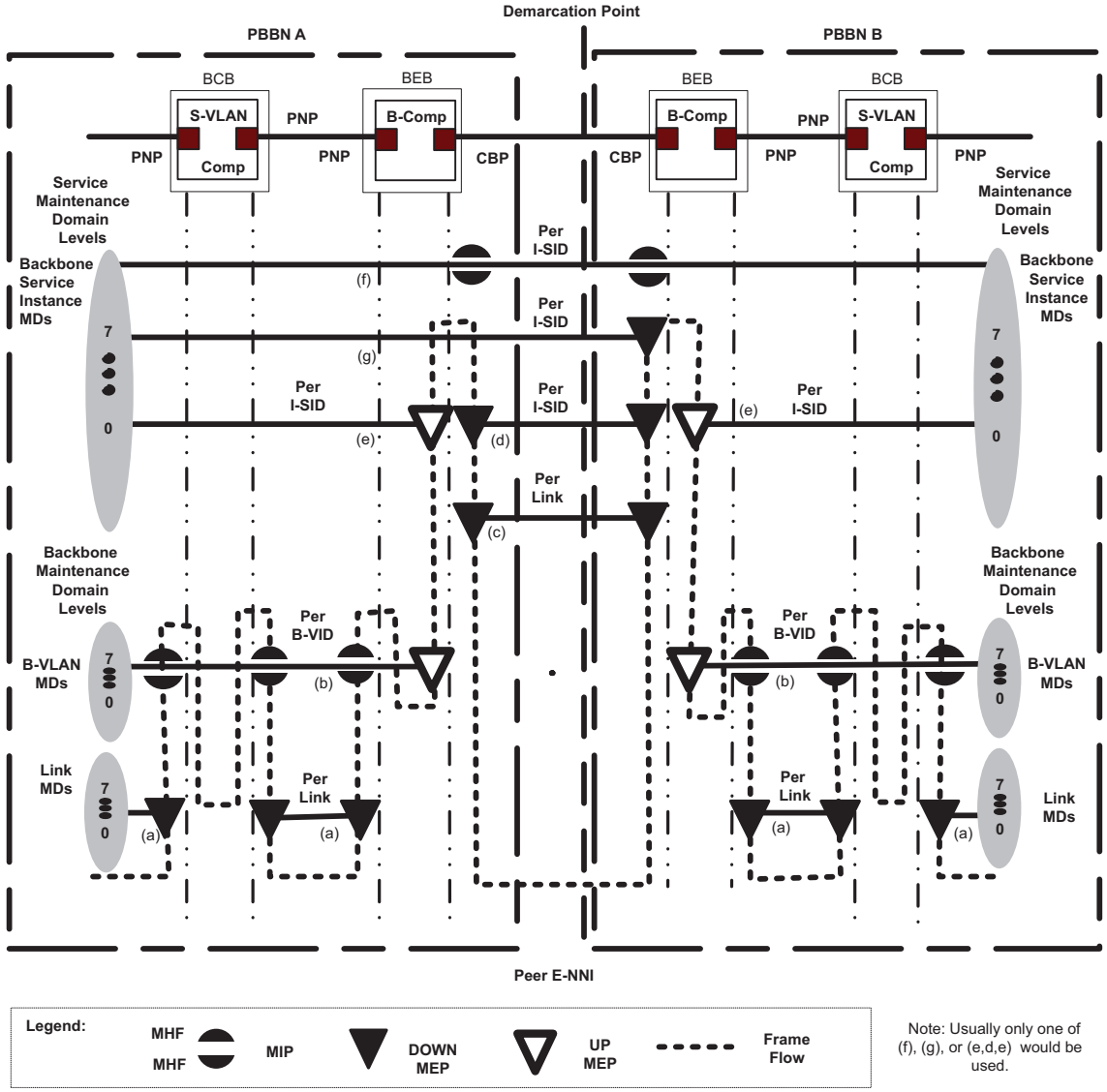


Figure 26-6—CFM example applied to a peer E-NNI, CBP-PIP

26.8.1 CFM over Port-based and S-tagged service interfaces

Figure 26-3 shows example MAs for the Port-based or S-tagged service interface described in 25.3 and 25.4 and depicted in Figure 26-1 labeled 1 and 2.

MAs (a) and (b) illustrated in Figure 26-3 through Figure 26-6 are used to monitor the PBBN core. Each PBBN has an independent backbone MD-level space. MAs (a) and (b) are assigned Backbone Maintenance Levels from the backbone MD-level space of their PBBN in the same manner used to assign S-VLAN MAs described in Clause 22. The MAs (a) are used to monitor each individual LAN that interconnects PNPs. The MAs (b) monitor specific B-VLANs. The B-VLAN monitoring, illustrated in the example, begins at the up MEP located at the top of the CBP. A given B-VLAN may exit a B-component on multiple PNPs, each of which may have a MIP on MA (b) if desired.

MAs (i) and (j) illustrated in Figure 26-3 through Figure 26-6 are two possible customer MAs. Attached customers have an independent customer MD-level space. MAs (i) and (j) are assigned Customer Maintenance Domain Levels from their customer MD-level space in the manner used for S-VLAN MAs described in Clause 22. The MAs (i) monitor the links between the customer equipment and the CNP or the PBBN. At the Port-based or the S-tagged service interface, MAs (i) may be terminated by the provider by an MEP at the CNP and used to monitor the customer's access link. The MAs (j) monitor the service instance from the customer over the PBBN. MAs (j) extend between all the customer attachments of the extended PBBN, passing through any PBBN E-NNI interfaces. At the VIPs located at the edge of the extended PBBN, the CFM frames for MA(j) will be mapped to/from an I-SID and carried over the extended PBBN as encapsulated frames. These CFM frames are encapsulated by the PBBN in the same manner as data frames. The encapsulation makes them invisible to any MPs within the extended PBBN.

In the case of a Port-based service interface, the MA(j) CFM frames are untagged or C-tagged over the interface formed between the CNP and the customer equipment. In this case, the MA(j) CFM frames have an S-VID assigned from the PVID at the CNP, which will be carried to the VIP within the I-component. In the case of an S-tagged service interface, the MA(j) CFM frames are untagged, C-tagged, or S-tagged over the interface formed between the CNP and the customer equipment. In this case, the MA(j) CFM frames have the S-VID carried over the service interface or, if the CFM frame is not S-tagged, it will have an S-VID assigned from the PVID of the CNP.

MA (f) depicted in Figure 26-3 through Figure 26-6 is used for backbone service instance management. MAs (f) are within the Backbone Service Instance MD-level space, which is shared over the entire extended PBBN. MAs (f) are assigned Service Maintenance Domain Levels from this Backbone Service Instance MD-level space. The MEPs for MA(f) are formed at the PIP within the Backbone Service Instance Multiplex Entity (6.18) as seen in Figure 26-2. MA(f) may have MIPs located in the CBP also formed by a Backbone Service Instance Multiplex Entity as depicted in Figure 26-2.

26.8.2 CFM over I-tagged Service Interfaces

Figure 26-4 shows possible MAs for the I-tagged service interface described in 25.5 and depicted in Figure 26-1 labeled 3. The MAs (a) and (b) in Figure 26-4 are used for PBBN core monitoring as described in 26.8.1.

MAs (c) in Figure 26-4, Figure 26-5, and Figure 26-6 are used to monitor the link between the PIP and CBP. The MAs (c) CFM frames are unique among the other CFM frames because they are transmitted without an I-TAG over the CBP to PIP LAN.

MAs (f) depicted in Figure 26-4 are used for service management as described in 26.8.1. In an I-tagged service interface, MAs (f) have an MEP in the customer network located at the Backbone Service Instance Multiplex Entities (6.18) of the customer PIP and may have MIP within the extended provider network located at the Backbone Service Instance Multiplex Entities of the CBPs. The provider may use MAs (e) to monitor each service instance by placing a MEP at the Backbone Service Instance Multiplex Entities of the CBP. The backbone service instance-level space is shared between the customer and provider who must agree on the levels used for provider and customer Backbone Service Instance CFM messages.

Customer S-VLAN MAs (j) are encapsulated by the customer equipment and are indistinguishable from data within the PBBN.

26.8.3 CFM over hierarchal E-NNI

Figure 26-5 shows possible MAs for the hierarchal E-NNI described in 26.6.1. In Figure 26-1 the hierarchal E-NNI labeled 4 depicts an E-NNI with the demarcation point between the CBP and PIP. Example MAs for a hierarchal E-NNI with demarcation between CBP and PIP are illustrated in Figure 26-5. The MAs (a) and (b) in Figure 26-5 are used for PBBN core monitoring as described in 26.8.1.

The operation of the backbone service instance and LAN MAs (f), (e), and (c) are as described in 26.8.2. Since each PBBN-A B-VLAN MA (j) is mapped into a PBBN-B backbone service instance monitored by MAs (f) and/or (e) the MAs (f) and (e) may be used to monitor the extended B-VLAN from PBBN-A.

MAs (j) are not visible to PBBN-B as described in 26.8.2. The per PBBN-A Backbone Service Instance MAs (l) illustrated in Figure 26-5 are never visible to PBBN-B since they are encapsulated along with the B-VLAN.

26.8.4 CFM over peer E-NNI

Figure 26-6 shows possible MAs for the peer E-NNI described in 26.6.2 and depicted in Figure 26-1 labeled 5. The MAs (a) and (b) in Figure 26-6 are used for PBBN core monitoring as described in 26.8.1. The LAN MAs (c) and Backbone Service Instance MAs (e) and (f) in Figure 26-6 are as described in 26.8.2.

The MAs (f), (g), (d), and (c) extend over the demarcation point between PBBN-A and PBBN-B, while the MAs (e) are within PBBN-A and PBBN-B and do not extend over the demarcation point. The MA (f) is a Backbone Service Instance MA that extends through both PBBN-A and PBBN-B providing monitoring for the service from VIP to VIP. MAs (f) may have a MIP on each side of the demarcation point to allow isolation of a fault to an individual PBBN. The MAs (g) also are Backbone Service Instance MAs that extend over the demarcation point. MAs (g) are launched by PBBN-B at the CBP facing the E-NNI rather than at the service originating VIP and extend to the far edge of PBBN-A. MAs (g) may be used by PBBN-B to monitor the backbone service instance over PBBN-A, but only provides information to PBBN-A on the operation of the backbone service instance over the demarcation point to PBBN-B. The MA (d) is a Backbone Service Instance MA that monitors the service over the demarcation point, but does not provide any monitoring deeper in PBBN-A or PBBN-B. MAs (e) provide internal monitoring of the backbone service instance within PBBN-A and PBBN-B, respectively.

26.9 CFM in a PBB-TE Region

CFM as specified in Clause 18 through Clause 22, provides capabilities useful in detecting, isolating, and reporting connectivity faults in VID-based service instances, backbone service instances, TESIs, and Infrastructure Segments. The list of features that are specifically related to TESIs and Infrastructure Segments is summarized here.

NOTE—MIP function is not supported for an Infrastructure Segment MA. Loopback is supported on Infrastructure Segment MEPs. It is not useful to apply the Linktrace operation to an Infrastructure Segment MA. No extension is made to the Loopback or Linktrace operations supporting their use for an Infrastructure Segment MA. This does not preclude the use of MIPs associated with a PBB-TE MA.

In particular, this subclause summarizes PBB-TE considerations related to the following:

a) Addressing PBB-TE MEPs (26.9.1)
b) TESI identification (26.9.2)
c) PBB-TE MEP placement in a Bridge Port (26.9.3)
d) PBB-TE MIP placement in a Bridge Port (26.9.4)
e) TESI Maintenance Domains (26.9.5)
f) PBB-TE enhancements of the CFM protocols (26.9.6)
g) Addressing Infrastructure Segment MEPs (26.9.7)
h) Infrastructure Segment identification (26.9.8)
i) Infrastructure Segment MEP placement in a Bridge Port (26.9.9)
j) Infrastructure Segment Maintenance Domains (26.9.10)
k) IPS extensions to Continuty Check operation (26.9.11)

26.9.1 Addressing PBB-TE MEPs

The configuration of an MA requires a parameter (or a list of parameters) that associates it with the monitored service. A TESI is identified by the list of ESPs supporting it. Correspondingly, the configuration of a PBB-TE MA, requires the list of the monitored TESI's ESPs, each identified by the 3-tuple <ESP-DA, ESP-SA, ESP-VID> or collectively by the TE-SID (12.14.5.3.2).

The MEPs related to a TESI require the same set of parameters as a VID-based MEP requires, with the following changes:

a) The Primary VID is not writable but is always set to the value of the ESP-VID parameter that corresponds to the MA's ESP that has the MEP's MAC address in its ESP-SA field [item d) in 12.14.7.1.3, 20.9.7].
b) The MAC address of the MEP is the MAC address of the CBP upon which the MEP is operating [item i) in 12.14.7.1.3].

26.9.2 TESI identification

In contrast to VID-based services where the vlan_identifier is used to identify the service, independent ESPs could have the same VID value in their ESP-VID field if some other parameters in their identifying 3-tuples are different. Figure 26-7 depicts such a case where the two ESPs are distinguished by their source addresses. The TESI Multiplex Entity (6.19) allows shims defined for PBB-TE to be instantiated per TESI at a SAP that supports multiple TESIs.

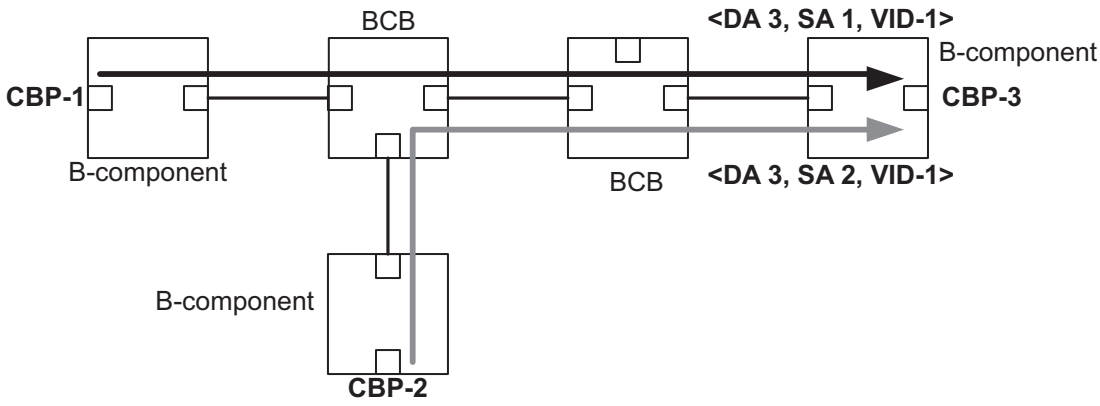


Figure 26-7—Independent ESPs using the same ESP-DAs and ESP-VIDs

26.9.3 PBB-TE MEP placement in a Bridge Port

PBB-TE MEPs are always Up MEPs and can only be placed on CBPs as these correspond to the demarcation points of the ESPs supporting the PBB-TE service. The PBB-TE MEPs are placed between the Frame filtering entity (8.6.3) and the Port filtering entities (8.6.1, 8.6.2, and 8.6.4) in the ESP-VID space identified by the EISS Multiplex Entity (6.17). Since the ESP MAC addresses can be reused by different ESPs, the PBB-TE MEPs need to be further differentiated by the TESI Multiplex Entity (6.19). In principle, separately for each TESI, there can be from zero to eight Up MEPs, ordered by increasing MD Level, from Frame filtering toward Port filtering, even though not more than one MD Level is expected for PBB-TE MAs. Figure 26-8 depicts an example of PBB-TE MEPs on a CBP.

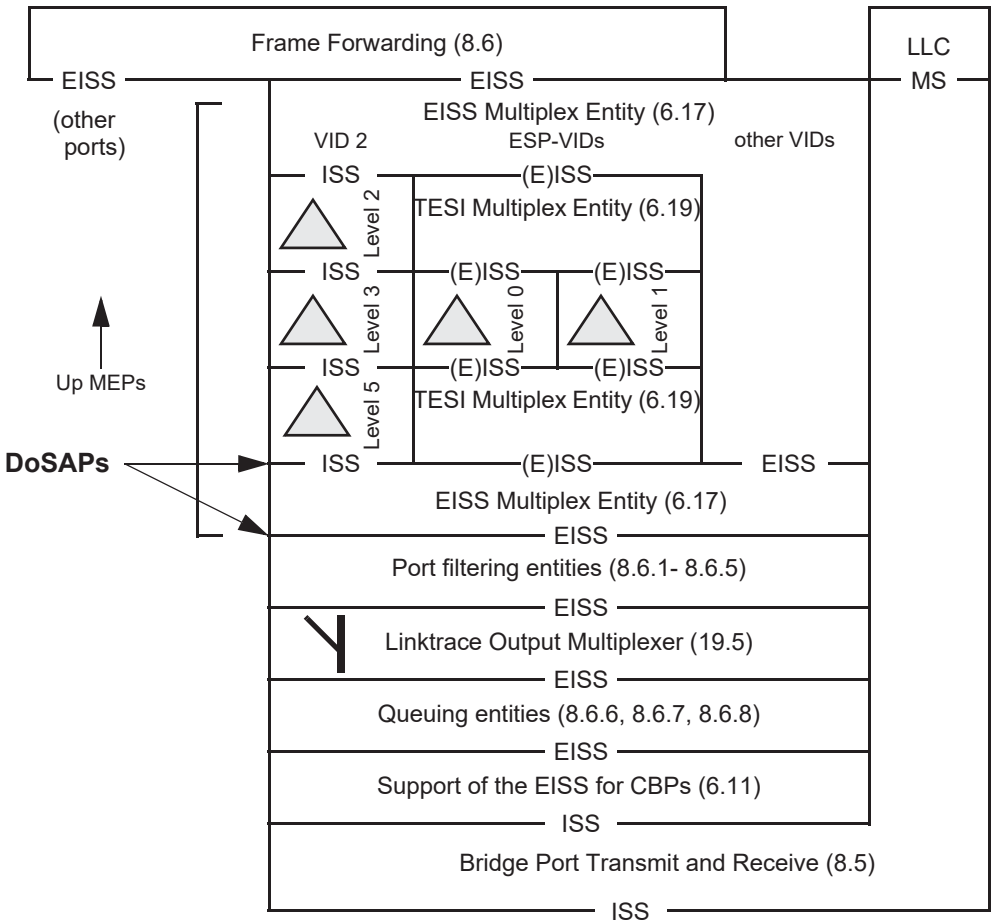


Figure 26-8—PBB-TE MEP placement in a CBP

26.9.4 PBB-TE MIP placement in a Bridge Port

PBB-TE MIPs creation is based on the algorithm described in 22.2.3. PBB-TE MIPs are created per identified ESP-VIDs on PNPs. Figure 22-9 depicts an example of a pair of PBB-TE MHFs on a PNP.

26.9.5 TESI Maintenance Domains

A PBB that is capable of providing TESIs supports a new set of TESI MDs in addition to those described in 26.8. In particular the CFM stacks in Figure 26-2 will need to have TESI MD levels in parallel to the depicted Backbone MD levels for CBPs initiating TESIs while TESI MDs will have to be present in parallel to the Backbone MD levels depicted in Figure 26-3.

26.9.6 PBB-TE enhancements of the CFM protocols

26.9.6.1 Continuity Check protocol in a PBB-TE MA

The Continuity Check protocol is described in 20.1 and the corresponding state machines in Clause 20. The only enhancement required by the PBB-TE MA is in the procedure that is responsible for constructing and transmitting a CCM (20.11.1):

a) The destination_address parameter is set to the MAC address indicated by the value of the ESP-DA field of the ESP having as ESP-SA the MAC address of the MEP emitting the CCM.

PBB-TE MAs may also implement the following enhancements to the Continuity Check protocol:

b) The procedure MEPprocessEqualCCM() on PBB-TE MEPs does not include the check of the MAID on received CCMs [item b) in 20.17.1].

c) PBB-TE MEP's may:

1) Set the Traffic field (21.6.1.4) bit on transmitted CCMs based on information from the Backbone Service Instance table associated with the CBP upon which the MEP is configured. In particular, the procedure xmitCCM() (20.11.1) is performing the additional action to fill the Traffic field with the presentTraffic variable (20.9.8); and

2) Check the Traffic field bit on received CCMs (20.16.13); and

3) Implement the MEP Mismatch state machines (20.26).

All other Continuity Check processes are the same as those for a VID-based MA.

26.9.6.2 Loopback protocol in a PBB-TE MA

The Loopback protocol is described in 20.2 and the corresponding state machines in Clause 20. The enhancements required by the PBB-TE MA are summarized below:

a) The LBMs transmitted by a MEP associated with a PBB-TE MA use as the destination_address parameter, the MAC address indicated by the value of the ESP-DA field of the MA's ESP that has the MEP's MAC address indicated in its ESP-SA field [item a) in 20.31.1]. To enable MIPs to selectively intercept LBMs that are targeting them, the PBB-TE MIP TLV (21.7.5) is inserted as the first TLV [item f) in 20.31.1] in an LBM. The PBB-TE MIP TLV is not included if the LBM destination address in 12.14.7.3.2 is associated with any of the values in the ESP-DA field of the monitored MA's ESPs. The format of the PBB-TE MIP TLV is described in 21.7.5 and is constructed as follows:

1) The MIP MAC address field contains the MAC address of the MIP to which the LBM is targeted [item b) in 12.14.7.3.2].

2) The Reverse VID field contains the parameter provided in item f) in 12.14.7.3.2, which it uses as the vlan_identifier in the replied LBR.

3) The Reverse MAC field is only included if the MEP is associated with a point-to-multipoint TESI. If the MEP is the root MEP, the Reverse MAC field contains the ESP-SA value of any of the point-to-point ESPs in the TESI. If the MEP is a leaf MEP, the Reverse MAC field contains the ESP-DA of the point-to-multipoint ESP in the TESI.

b) LBMs received by PBB-TE MEPs are not processed and are discarded if the received LBM carries a PBB-TE MIP TLV. A PBB-TE MHF forwards all received LBMs except those carrying a PBB-TE MIP TLV containing in their MIP MAC address field the MAC address of the MIP associated with that PBB-TE MHF [item f) in 20.28.1].

c) The destination_address parameter used by LBRs transmitted by PBB-TE MEPs is the value of the ESP-DA of the MA's ESP that has the MEP's own address in its ESP-SA field. In the case of a PBB-TE MHF, the destination_address parameter for the transmitted LBR is:

1) The value carried in the Reverse MAC field contained in the PBB-TE MIP TLV of the received LBM, if this is a group MAC address; otherwise,

2) The value of the source_address of the received LBM.

d) The source_address of LBRs transmitted by PBB-TE MHFs is set to:

1) The destination_address of the received LBM if this destination address is an individual MAC address; otherwise,

2) The value carried in the Reverse MAC field contained in the PBB-TE MIP TLV if the received LBM's destination address is a group MAC address.

e) The vlan_identifier used by LBRs transmitted by PBB-TE MEPs is set to the value of its Primary VID [item d) in 12.14.7.1.3]. The vlan_identifier used by LBRs transmitted by PBB-TE MHFs is set to the value carried in the Reverse VID field contained in the PBB-TE MIP TLV of the received LBM.

All other Loopback processes are the same as those for a VID-based MA.

26.9.6.3 Linktrace protocol in a PBB-TE MA

The Linktrace protocol is described in 20.3 and the corresponding state machines in Clause 20. The enhancements required by the PBB-TE MA are summarized as follows:

a) The LTMs transmitted by a MEP associated with a PBB-TE MA use as the destination_address parameter, the MAC address indicated by the value of the ESP-DA field of the MA's ESP that has the MEP's MAC address indicated in its ESP-SA field [item a) in 20.42.1]. LTMs carry the PBB-TE MIP TLV constructed as follows:
   1) The MIP MAC address field is null.
   2) The Reverse VID field contains the parameter provided in item e) in 12.14.7.4.2, which is used as the vlan_identifier of the replied LTR.
   3) The Reverse MAC field is only included if the MEP is associated with a point-to-multipoint TESI. If the MEP is the root MEP, the Reverse MAC field contains the ESP-SA value of any of the point-to-point ESPs in the TESI. If the MEP is a leaf MEP, the Reverse MAC field contains the ESP-DA of the point-to-multipoint ESP in TESI.

b) No special destination_address validation tests are performed by the ProcessLTM() procedure in the case of PBB-TE MAs [item c) in 20.47.1].

c) The process to identify a possible egress port by an intermediate device that implements a MIP associated with a PBB-TE MA, queries the FDB of the corresponding Bridge, using the destination_address, and the vlan_identifier of the LTM as the parameters for the lookup (20.47.1.2). The LTMs can be further forwarded by PBB-TE MIPs even if the lookup identifies more than one Egress port.

d) Finally an LTR issued by a PBB-TE MP:
   1) Uses as destination_address: the value carried in the Reverse MAC field contained in the PBB-TE MIP TLV of the received LTM, if this is a group MAC address; otherwise, the source_address of the received LTM [item a) in 20.47.4].
   2) Uses as source_address: its MAC address if the LTR is issued by a PBB-TE MEP; otherwise, the destination_address of the received LTM if this is destination address is an individual MAC address; otherwise, the value carried in the Reverse MAC field contained in the PBB-TE MIP TLV of the received LTM [item b) in 20.47.4].
   3) Sets the vlan_identifier parameter to the value carried in the Reverse VID field contained in the PBB-TE MIP TLV of the received LTM [item c) in 20.47.4].

All other Linktrace processes are the same as those for a VID-based MA.

26.9.7 Addressing Infrastructure Segment MEPs

The configuration of an Infrastructure Segment MA requires a parameter identifying the associated Infrastructure Segment. An Infrastructure Segment is composed of a pair of counterdirectional and co-routed Segment Monitoring Paths (SMPs) (26.11.1). Each SMP is identified by an SMP Identifier (SMP-ID). Thus, an Infrastructure Segment is identified by a pair of SMP-IDs that is known as an Infrastructure Segment Identifier (SEG-ID). The SEG-ID is specified on configuration of the associated Infrastructure Segment MA (12.14.5.3.2).

A MEP associated with an Infrastructure Segment requires the same set of parameters required by a VID-based MEP, with the following changes:

a) The Primary VID is not writable but is always set to the value of the SMP-VID parameter that corresponds to the MA's SMP that has the MEP's MAC address in its SMP-SA field [item d) in 12.14.7.1.3].
b) The MAC address of the MEP is the MAC address of the PNP upon which the MEP is operating [item i) in 12.14.2.1.2].

26.9.8 Infrastructure Segment identification

Two SMPs are distinct if their corresponding SMP-ID values (3-tuples) differ in at least one parameter. Thus, independent Infrastructure Segments can be associated with SMPs having identical values of SMP-DA and SMP-VID. Figure 26-9 depicts a case in which two SMPs, having identical values of SMP-DA and SMP-VID, are distinguished by their SMP-SA values. The Infrastructure Segment Multiplex Entity (6.21) allows shims defined for PBB-TE IPS to be instantiated per Infrastructure Segment at a SAP that supports multiple Infrastructure Segments.

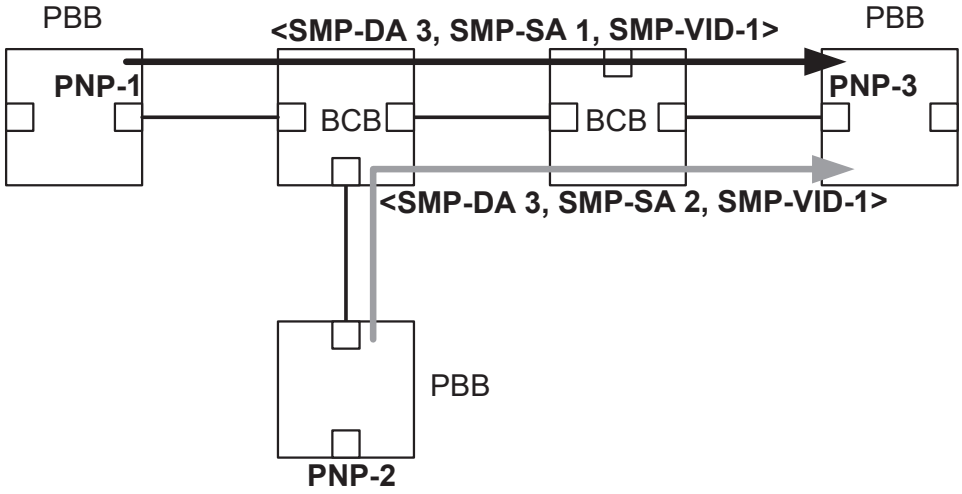


Figure 26-9—Independent Infrastructure Segments distinguished by SMP-SA

26.9.9 Infrastructure Segment MEP placement in a Bridge Port

Infrastructure Segment MEPs are always Down MEPs and are placed only on PNPs as these correspond to the demarcation points of the Infrastructure Segment. The Infrastructure Segment MEPs are placed between the Port filtering entities (8.6.1, 8.6.2, and 8.6.4) and the Queuing entities (8.6.5, 8.6.6, 8.6.7, and 8.6.8) in the SMP-VID space identified by the EISS Multiplex Entity (6.17). Since the Infrastructure Segment MAC addresses can be reused by different Infrastructure Segments, the Infrastructure Segment MEPs need to be further differentiated by the Infrastructure Segment Multiplex Entity (6.21). In principle, separately for each Infrastructure Segment, there can be from zero to eight Down MEPs, ordered by increasing MD Level, from Frame filtering towards Port filtering, even though not more than one MD Level is expected for Infrastructure Segment MAs. Figure 26-10 depicts an example of Infrastructure Segment MEPs on a PNP.

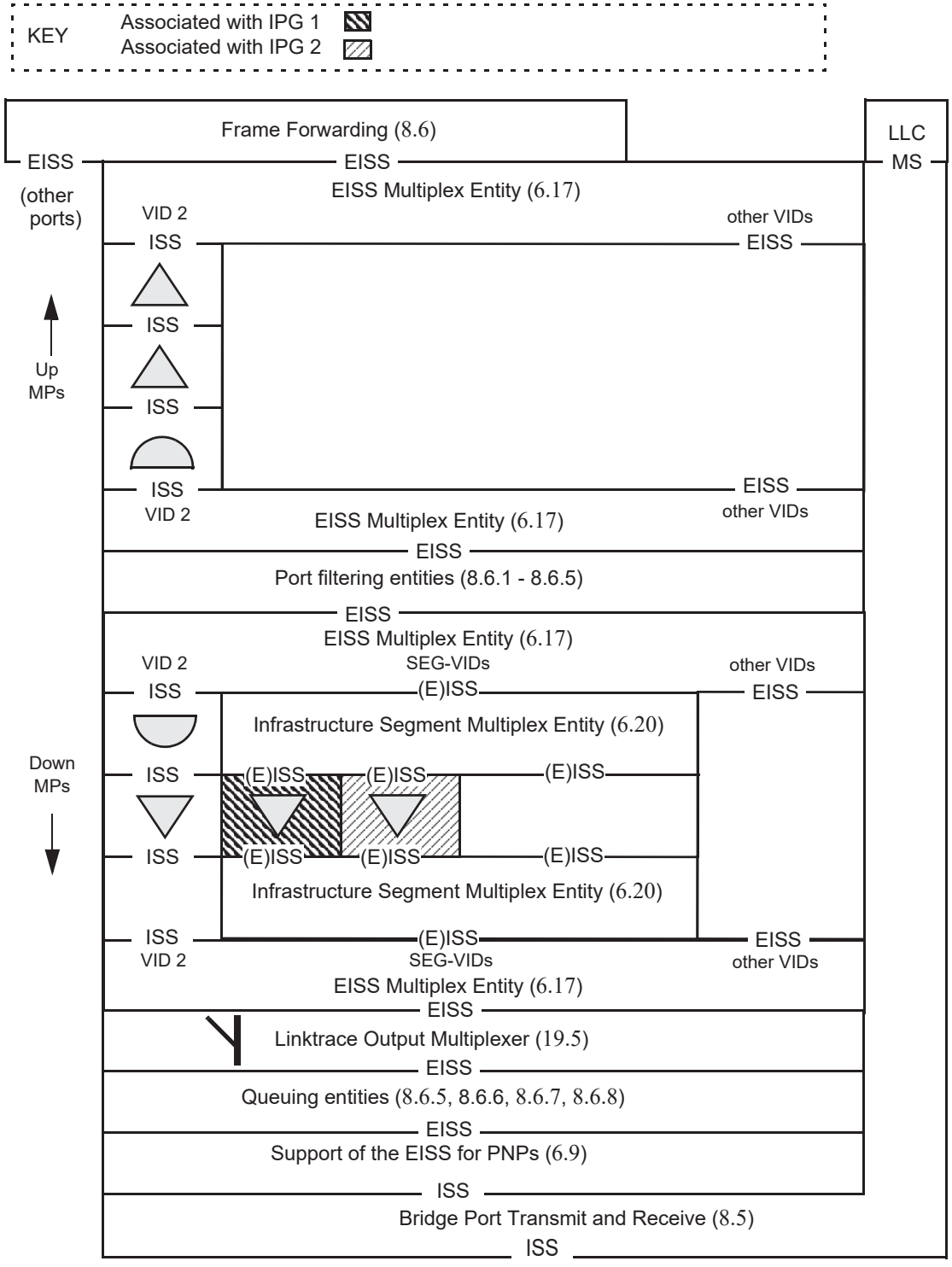


Figure 26-10—Infrastructure Segment MEP placement in a PNP

26.9.10 Infrastructure Segment Maintenance Domains

A PBB deploying IPS specifies a set of Infrastructure Segment MDs independent of those described in 26.8 and 26.9.5. In particular the CFM stacks in Figure 26-2 have Infrastructure Segment MD levels in parallel to the depicted Backbone MD levels for Ports instantiating Infrastructure Segments while Infrastructure Segment MDs will be present in parallel to the Backbone MD levels depicted in Figure 26-3.

26.9.11 IPS extensions to Continuity Check operation

The Continuity Check protocol is described in 20.1 and the corresponding state machines in Clause 20. The only enhancement required by the Infrastructure Segment MA is in the procedure that is responsible for constructing and transmitting a CCM (20.11.1):

a) The destination_address parameter is set to the MAC address indicated by the value of the SMP-DA field of the SMP-ID having as SMP-SA the MAC address of the MEP emitting the CCM.

All other Continuity Check processes are the same as those for a VID-based MA.

26.10 Protection switching for point-to-point TESIs

26.10.1 Introduction

In contrast to PBB, spanning tree protocols and broadcasting/flooding are not used in PBB-TE. FDBs are populated using a network management system or a control plane, allowing ESPs to be engineered and provisioned across the network. PBB-TE provides end-to-end linear protection for point-to-point TESIs, where a dedicated protection point-to-point TESI is established for one particular working point-to-point TESI, and the traffic is automatically switched from the working TESI to the protection TESI when a failure occurs on the working entity. The protection entity is preestablished, ensuring the availability of those resources when a defect is detected on the working entity, and allowing for a corresponding sub-50 ms switchover.

Figure 26-11 depicts the essential elements of the PBB-TE protection scheme and its arrangement. In this, 1:1 (i.e., 1 for 1) arrangement, traffic is sent on only one of the paths at any point in time based on information from OAM processes or network operators.

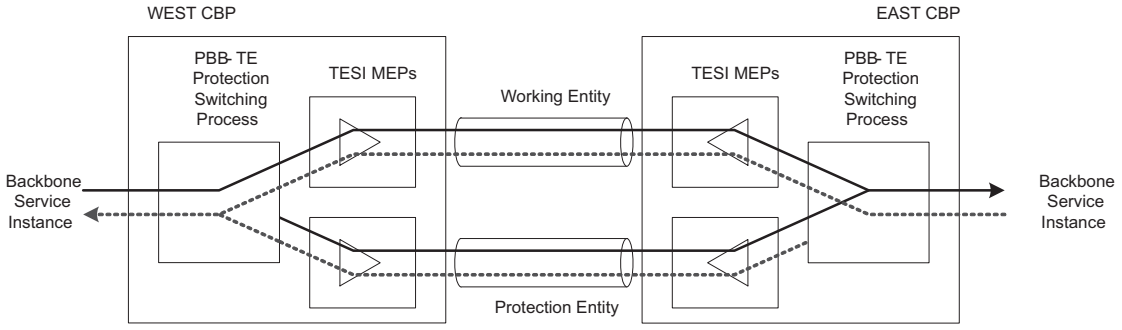


Figure 26-11—Protection switching architecture

Protection switching may be triggered by manual operation or by CFM information arising from, periodic monitoring of the working and protection paths, or from physical layer monitoring, such as loss of signal or other defects detected through CFM.

The PBB-TE protection switching mechanism aims to offer the capability to switch completely (both ends) in less than 50 ms following the detection of the fault.

NOTE 1—The capability of supporting the above switchover requirement on TESIs, is provided by configuring the interval of CCMs on the MAs associated these TESIs to be equal to or lower than 10 ms enabling the detection of the fault and the signaling of the coordination information end to end in less than 50 ms.

The PBB-TE protection scheme may be configurable to be "revertive" or "nonrevertive," where traffic transmission reverts, or not, to the working path automatically once CFM indicates the fault or defect has been cleared. The protection switching mechanism may also incorporate hold-off and wait to restore timers, the first to allow the fault to be protected by a lower layer protection switching mechanism for instance, while the latter ensures the performance of the working path is fully restored before switching back to it. The hold-off timer obviously slows the overall recovery time for a fault within the protected domain.

NOTE 2—A complete discussion on the various protection switching mechanisms and terminology is provided by ITU-T G.8031 [B48]. As a caution it should be noted that ITU-T uses the term "Bridge" for the logical entity that selects either or both of the transmit paths at the sending end of a protected domain. This is not to be confused with the term Bridge used in this standard.

The description herein, defines and provides a scalable end-to-end resiliency mechanism that offers end-to-end 1:1 bidirectional linear protection switching capable of load sharing for point-to-point TESIs in a PBB-TE Region.

NOTE 3—Some scenarios exist where multiple input events may cause the protection switching state machines in a protection group to select diverse TESIs on which to send traffic. The Mismatch defect informs the operator of such an occurrence thereby allowing the appropriate corrective action to be taken.

Protection for point-to-multipoint TESIs may be provided by external mechanisms or agents, which are out of scope for this specification.

26.10.2 1:1 point-to-point TESI protection switching

In a PBB-TE Region, IB-BEBs constitute the demarcation between the PBBN of interest and the networks attached to it. The protected domain is defined to be the area between the CBPs on the different B-Components of the involved IB-BEBs.

The starting point in providing protection switching is the creation and configuration of a TE protection group. A TE protection group is a group of two point-to-point TESIs between a pair of CBPs, which carries an assigned set of backbone service instances, and continues to carry these backbone service instances if any one of the TESIs in the group is failed or disabled. The creation of the TE protection group requires the assignment of one TESI as a working entity and a second TESI with the same terminating points as a protection entity providing a different bidirectional connectivity path (12.14.1.2). The configuration of the TE protection group is completed with the assignment of the list of the backbone service instances that are to be protected by the TE protection group [item b) in 12.18.2.1.3].

The protection switching mechanism is capable of load sharing as the TESIs that are assigned to a TE protection group can be reused in a number of TE protection groups enabling a list of I-SIDs to be distributed among a set of interdependent TE protection groups [item c) in 12.18.2.1.3]. A set of interdependent TE protection groups forms a coordinated protection group. Protection switching requests to interdependent TE protection groups must be coordinated for an operator to manage the TESIs in a coherent manner and to avoid potentially competing requests for each TESI. For example, to unconditionally remove traffic from a TESI, one request to Lock Out the TESI results in a request to each TE protection group to which the TESI belongs, either LoP or FS according the role of the TESI in each group. Similarly, to conditionally remove traffic from a TESI, one Manual Switch request for the TESI results in the appropriate Manual Switch request to each TE protection group to which the TESI belongs. Allowing a single operator request per coordinated protection group and coordinating the resulting requests to each TE protection group reduces the operational complexity of the set of interrelated TE protection groups. Using a coordinated

protection group, the service traffic (backbone service instance) load can be shared across a set of TESIs and at the same time be protected against single faults by 1:1 protection.

NOTE 1—If the operator initiates switching of an individual load shared TE protection group the mmCCMdefect may not detect a switch mismatch.

NOTE 2—The load sharing mode of operation corresponds to 1:1 ETH Sub Network Connection Group protection with Inherent monitoring (ETH SNCG/I) in the ITU-T protection switching terminology.

The following description of the PBB-TE protection switching mechanism is an example provided for illustrative purposes. Figure 26-12 depicts a network where two point-to-point TESIs have been provisioned. The TE-1 service instance on the top of the figure consists of two ESPs each identified by a 3-tuple: <CBP-B, CBP-A, VID-1> is depicted in black and <CBP-A, CBP-B, VID-2> in gray. The TE-2 service instance below consists of two other ESPs identified by the 3-tuples <CBP-B, CBP-A, VID-3> and <CBP-A, CBP-B, VID-3> which are depicted in white. The use of the same ESP-VID on the TE-2 ESPs is only for illustrative purposes. There are no explicit requirements on using the same or different ESP-VIDs on the ESPs comprising the TESIs that are assigned to a TE protection group. One set of backbone service instances, shown by the black arrows just outside the two CBPs, has TE-1 assigned as its working TESI and TE-2 assigned as its protecting TESI.

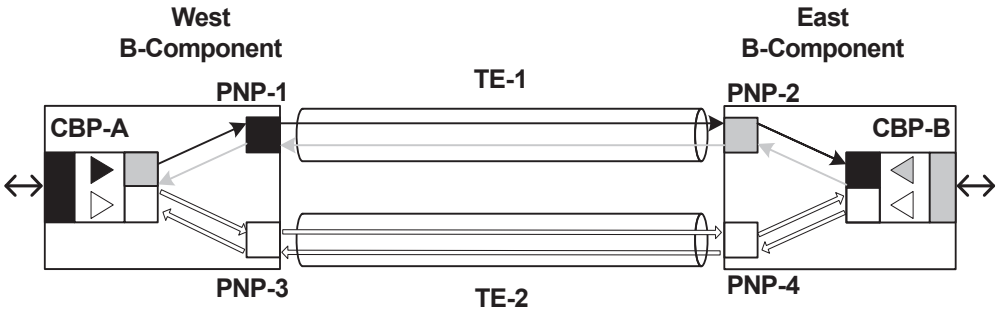


Figure 26-12—PBB-TE point-to-point protection switching

The ESPs are provided by configuring entries in the FDBs on all the Bridges that these ESPs need to pass through. On the terminating IB-BEBs, the VLAN membership of each participating port has to be configured for the B-components. In Figure 26-12, this is depicted by the color of the boxes that are placed inside each of the B-Component boxes. For example, the upper right PNP-1 port on the West B-component is a member of the VID-1 (black), while the CBP on the same component is a member of VID-2 (gray) and VID-3 (white). Only frames tagged with the appropriate VID parameter can egress these ports.

NOTE 3—The PNPs are shown for illustrative purposes only and that there is no explicit requirement to diversify PNPs on the terminating IB-BEBs.

Each of the TESIs is monitored by an independent MA. One MA is set to monitor the top (TE-1) TESI and a second to monitor the bottom (TE-2) TESI. Each of these two MAs is associated with a pair of ESPs and identified by their corresponding 3-tuples. Two Up MEPs, associated with the MA monitoring the TE-1 service instance, are configured on the CBPs that terminate the TE-1 service instance. Each of these MEPs has its own primary VID, VID-1 (black) for the MEP on the West B-component associated with the TE-1 service instance, and VID-2 (gray) for the MEP on the East B-component. In this configuration each MEP receives frames that are tagged with the ESP-VID corresponding to the primary VID of the associated remote MEP and can only send frames that are tagged with its own primary VID. In particular, in the depicted example the MEP for the top entity on the West B-component can send only CCMs tagged with VID-1 (black) and receive CCMs tagged with VID-2 (gray), while the corresponding MEP on the East component can only send CCMs tagged with VID-2 (gray) and receive CCMs tagged with VID-1 (black). The primary VID of each MEP is depicted by the color of the MEP. It should be also noted that all the depicted ports in Figure 26-12 have their Enable Ingress Filtering parameter (8.6.2) reset to its default value, i.e., Disable Ingress Filtering.

Data traffic is mapped to a TESI by configuring the CBP parameters (6.11). In particular, the CBP I-SID is used to allow specific service instances to be carried by the TESI while the entries of the B-VID column in the Backbone Service Instance table are indicating how to map the identified service instances to a specific ESP. The CBP's B-VID value is depicted in Figure 26-12 by the color of the vertical bars (black for CBP-A, gray for CBP-B) placed at the tips of the arrows representing the set of backbone service instances.

As a result customer frames that need to be transported by a TESI and are identified by a specific I-SID and reach the CBP on the West B-component from the left can be mapped to the black ESP or the white ESP while frames on the same service that reach the CBP on the East B-component from the right will be mapped to the gray ESP or the white ESP based on the CBP's configured B-VID value. If all the services are normally mapped to the black ESP and gray ESP, then TE-1 would correspond to the working entity and TE-2 to a stand-by protection entity. Irrespective of how the data traffic is mapped to the TESIs, CCM frames are exchanged on both TESIs in order to regularly check the provided connectivity.

If a fault occurs on any of the ESPs, the MEP on the receiving end will be notified. In particular if a fault on the black ESP occurs, as shown in Figure 26-13, the MEP on the East B-component will declare a remote MEP defect by setting the rMEPCCMdefect parameter (20.19.1). The timer counter for timing out CCMs has a granularity finer than or equal to 1/4 of the time represented by the CCMinterval variable (20.8.1). A Bridge does not set rMEPCCMdefect within (3.25 × CCMinterval) seconds of the receipt of a CCM, and sets rMEPCCMdefect within (3.5 × CCMinterval) seconds after the receipt of the last CCM. The setting of the rMEPCCMdefect parameter will result in a change of the appropriate B-VID entries in the Backbone Service Instance table, of the east CBP from the gray VID-2 to the white VID-3, which is the ESP-VID of the associated ESP on the protection TESI.

NOTE 4—The B-VID parameter will also change when the xConCCMdefect (20.23.3) or the errorCCMdefect (20.21.3) parameters are set as these indicate a very serious misconfiguration problem.

All subsequent CCMs sent by the east gray MEP on TE-1 will have the RDI field set for as long as proper CCMs are not received by the MEP. A reception of a CCM frame with the RDI field set (or an event that causes setting of the someRMEPCCMdefect, xConCCMdefect, or errorCCMdefect) by the MEP associated with TE-1 on CBP-A will cause a change of the appropriate B-VID entries in the Backbone Service Instance table of the CBP-A on the West B-component, to the pre-configured value of the protection ESP. The result will be to move the affected service instances to the protection TE-2 service instance as depicted Figure 26-13. Consequently, the approximate maximum time before a bidirectional switch occurs following a unidirectional failure would be approximately equal to (3.5 × CCMinterval) + the time required for a CCM PDU to travel between the MEPs monitoring the TESI + the time to update the associated Backbone Service Instance table entries.

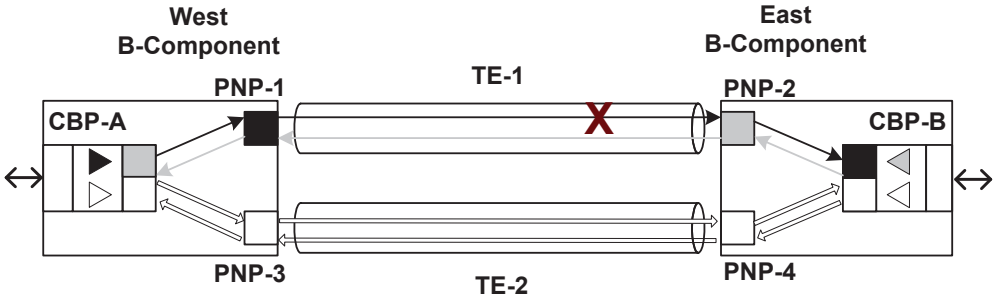


Figure 26-13—Mapping data traffic to the protection entity

26.10.3 Protection Switching state machines

The local protection commands and protection behavior specified here follow the architectural model used in ITU-T G.8031 [B48]. The relationships among the protection switching state machines are illustrated in Figure 26-14. That figure uses conventions similar to those of 13.24, and of Figure 13-13: open arrows denote variables that are set by one state machine and both read and set by another; closed arrows denote variables that are set by the owning state machine, and only read by other state machines.

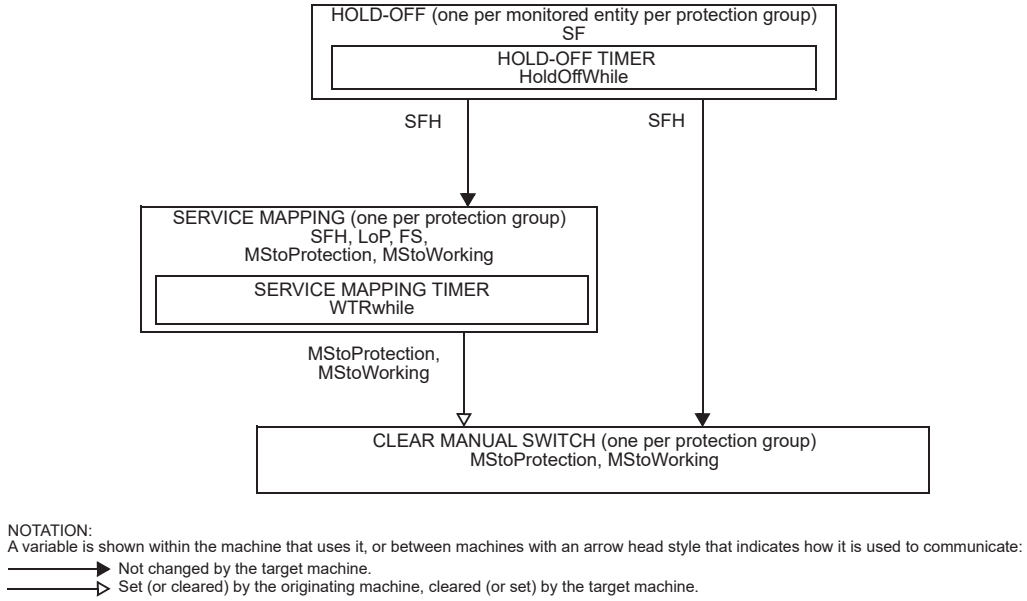


Figure 26-14—Relationships of the Protection switching state machines—overview

There is one set of Protection Switching state machines per protection group on each Bridge that terminates the protection group. The protection group consists of the working and the protection entities. The Protection Switching state machine reuses the defect variables that are presented in Table 20-1. Variables and procedures that are preceded with "w." refer to the working entity while those that are preceded with "p." refer to the protection entity. These internal prefix/entity associations remain the same following a protection switch to the protection entity.

26.10.3.1 Notational conventions used in state diagrams

The Protection Switching state machines are specified using the notational conventions defined in Annex E.

26.10.3.2 State machine timers

The timer variables declared in this subclause are part of the specification of the operation of Protection Switching. The accompanying descriptions of their meaning and use are provided to aid in the comprehension of the protocol only, and are not part of the specification.

One instance of the following may be implemented per Service Mapping state machine:

a) WTRwhile (26.10.3.2.1)

One instance of the following may be implemented per Hold-off state machine:

b) HoldOffWhile (26.10.3.2.2)

26.10.3.2.1 WTRwhile

A timer to be used to prevent frequent operation of the protection switch due to an intermittent defect. This timer allows for a fixed period of time to elapse before data traffic is mapped from the protection entity to the working entity when in revertive mode.

26.10.3.2.2 HoldOffWhile

In order to coordinate timing of protection switches at multiple layers or across cascaded protected domains, a hold-off timer may be required. The purpose is either to allow a server layer protection switch to have a chance to fix the problem before switching at a client layer, to allow an upstream protected domain to switch before a downstream domain, or to allow the inner protected domain to switch before the outer protected domain in the case of IPS nested protection domains.

26.10.3.3 Protection Switching variables

The following variables are defined for the Protection Switching state machines:

a) BEGIN (26.10.3.3.1)
b) SF (26.10.3.3.2)
c) SFH (26.10.3.3.3)
d) LoP (26.10.3.3.4)
e) FS (26.10.3.3.5)
f) MStoProtection (26.10.3.3.6)
g) MStoWorking (26.10.3.3.7)
h) WTRTime (26.10.3.3.8)
i) HoldOffTime (26.10.3.3.9)

Table 26-2 illustrates the inherent priority of each protection request.

Table 26-2—Protection Requests Hierarchy

Priority	Request
highest	LoP
	FS
	p.SF
	w.SF
	MStoProtection, MStoWorking
	WTR
lowest	NoRequest

NOTE—The priorities associated with the various requests in this table are in general alignment with the corresponding priorities in ITU-T G.8031 [B48]. The only difference is that the precedence of p.SF and FS are inverted since ITU-T G.8031 relies on an APS protocol to be running on the protection path.

26.10.3.3.1 BEGIN

This is a Boolean variable controlled by the system initialization process. A value of TRUE causes all Protection Switching state machines per protection group to continuously execute their initial state. A value of FALSE allows these state machines to perform transitions out of their initial state, in accordance with the relevant state machine definitions.

26.10.3.3.2 SF

SF is the logical OR of someRMEPCCMdefect (20.35.5), someRDIdefect (20.35.7), xConCCMdefect (20.23.3), and errorCCMdefect (20.21.3).

NOTE—Locally detected MAC/PHY faults may also be components of SF (e.g., to enable potentially faster fault detection), but are outside the scope of this standard.

26.10.3.3.3 SFH

A Boolean flag set and cleared by the Hold-off state machine to indicate that SF is set for a period that is equal to, or larger than, the HoldOffTime. The variable will be set equal to SF if the Hold-Off timer is not supported.

26.10.3.3.4 LoP

A Boolean flag indicating the administrative state of the protection entity. If set, it prohibits the use of the protection entity. Its value can only be controlled by an administrator action [item b2) in 12.18.2.3.2].

26.10.3.3.5 FS

A Boolean flag indicating the presence of an administrative command to force switch the data traffic to the protection entity. Its value is set to 1 by an administrator action [item b3) in 12.18.2.3.2 or 12.24.2.3.2]. It can be reset by an administrator action that corresponds to a request of the same or higher priority according to Table 26-2.

26.10.3.3.6 MStoProtection

A Boolean flag indicating the presence of an administrative command to manually switch the data traffic to the protection entity, in the absence of a failure of the working or the protection entity. Its value is set to 1 by an administrator action [item b4) in 12.18.2.3.2 or 12.24.2.3.2]. It can be reset by an administrator action that corresponds to a request of the same or higher priority according to Table 26-2 and by the operation of the Clear Manual Switch state machine.

26.10.3.3.7 MStoWorking

A Boolean flag indicating the presence of an administrative command to manually switch the data traffic to the working entity in the absence of a failure of the working or the protection entity. Its value is set to 1 by an administrator action [item b5) in 12.18.2.3.2 or 12.24.2.3.2]. It can be reset by an administrator action that corresponds to a request of the same or higher priority according to Table 26-2 and by the operation of the Clear Manual Switch state machine.

26.10.3.3.8 WTRTime

The wait-to-restore (WTR) period, as provided by the corresponding managed object item e) in 12.18.2.1.3 or item h) in 12.24.2.1.3]. May be configured by the operator in 1 min steps between 5 and 12 min; the default value is 5 min. A value of 0 indicates nonrevertive mode. The overall accuracy of the WTR timer (e.g., < ±25 ms) should be sufficient to allow both ports at the protection domain termination to revert to the working entity in less than 50 ms.

26.10.3.3.9 HoldOffTime

The Hold-Off period as provided by the corresponding managed object [item f) in 12.14.6.1.3 or item i) in 12.24.2.1.3]. The suggested range of the hold-off timer is 0 to 10 s in steps of 100 ms (accuracy of ±5 ms); the default value is 0.

26.10.3.4 Protection Switching procedures for PBB-TE TESI Protection

The following procedures are defined for the Service Mapping state machine:

a) mapDataToWorking() (26.10.3.4.1)
b) mapDataToProtection() (26.10.3.4.2)

NOTE 1—Since a merging selector is used, there is the potential for misordered frames at egress due to differential delay between the working and protection TESIs following a protection switch. If this is a concern, then briefly discarding frames prior to executing either mapDataToX() processes described in 26.10.3.4.1 or 26.10.3.4.2 will avoid the issue (e.g., 1 ms is equivalent to a 20% differential delay across 1000 km of fiber).

NOTE 2—The procedure descriptions in this subclause are specific to PBB-TE TESI Protection. A description of the corresponding procedures for IPS can be found in 26.11.4.1.1 and 26.11.4.1.2.

26.10.3.4.1 mapDataToWorking()

Maps the customer service(s) that are to be transported by a TE protection group [item b) in 12.18.2.1.3], to the working TESI identified by the 3-tuples <remote CBP MAC, local CBP MAC, ESP-VID(w)>, <local CBP MAC, remote CBP MAC, ESP-VID(w')>, by setting the VID values of the corresponding I-SID entry(-ies) in the Backbone Service Instance table to the ESP-VID(w).

26.10.3.4.2 mapDataToProtection()

Maps the customer service(s) that are to be transported by a TE protection group [item b) in 12.18.2.1.3], to the protection TESI identified by the 3-tuples <remote CBP MAC, local CBP MAC, ESP-VID(p)>, <local CBP MAC, remote CBP MAC, ESP-VID(p')>, by setting the VID values of the corresponding I-SID entry(ies) in the Backbone Service Instance table to the ESP-VID(p).

26.10.3.5 Protection Switching state machine diagram

The Protection Switching state machines implement the function specified by the state diagrams in Figure 26-15, Figure 26-16, and Figure 26-17, the variables in 26.10.3.3, and the procedures in 26.10.3.4. The Hold-off state machine shall be present only when the Hold-off timer is supported.

The current state of the Service Mapping state machine is available as a managed object [item c) in 12.18.2.1.3].

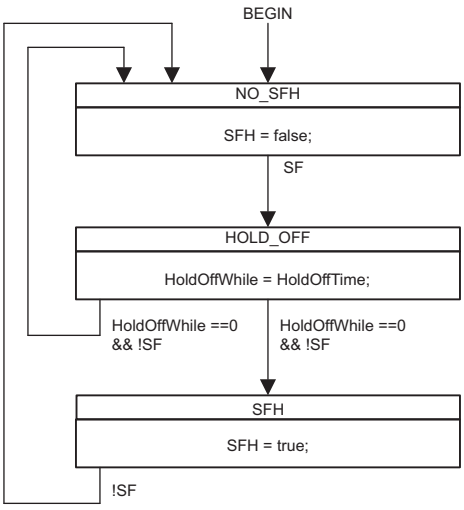


Figure 26-15—Hold-off state machine

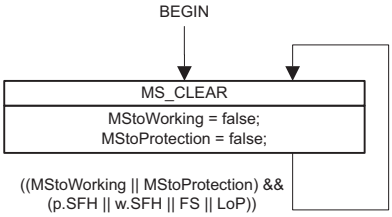


Figure 26-16—Clear Manual Switch state machine

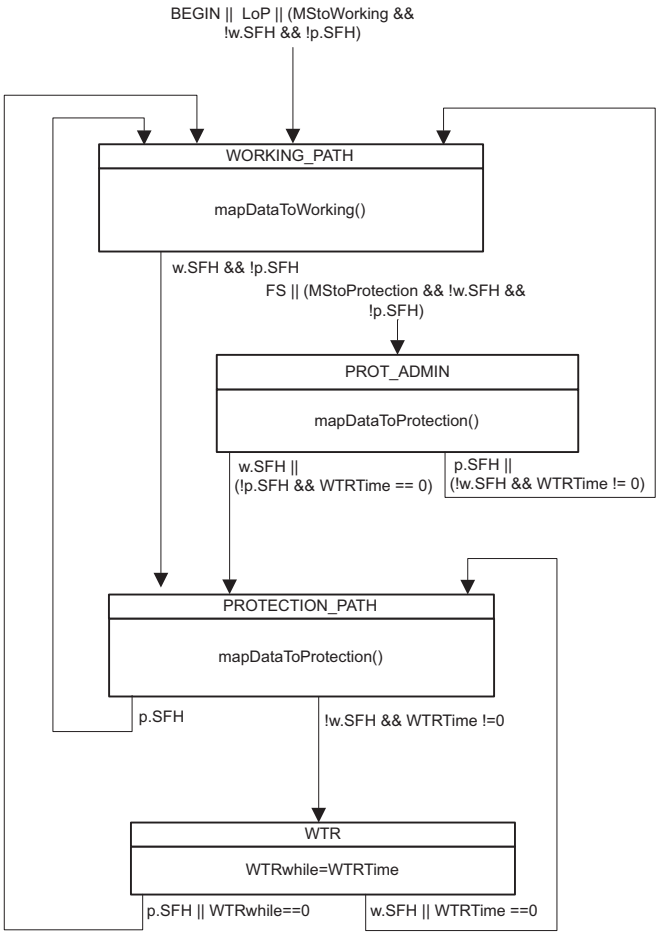


Figure 26-17—Service Mapping state machine

26.11 IPS in PBB-TE Region

In addition to supporting end-to-end linear protection for TESIs (26.10), PBB-TE supports localized protection of selected TESIs traversing a common sequence of PNPs. Such a sequence of PNPs, together with the intervening MAC relay entities and LANs, is called an Infrastructure Segment. The group of TESIs associated with the Infrastructure Segment is protected from the failure of one or more components (i.e., port, LAN, or MAC Relay Entity) of the Infrastructure Segment. The method of providing such protection is called Infrastructure Protection Switching (IPS). 1:1 IPS and M:1 IPS are described by this standard. Support for IPS is optional. If IPS is supported, 1:1 IPS is required, and M:1 IPS is optional. IPS may be triggered automatically by a change in the operational state of an Infrastructure Segment or manually by administrative command.

NOTE—A complete discussion on the various protection switching mechanisms and terminology is provided by ITU-T G.8031 [B48]. The ITU-T uses the term “bridge” for the logical entity that selects either or both of the transmit paths at the sending end of a protected domain. This is not to be confused with the term “Bridge” used in this standard.

As illustrated in Figure 26-18, a Bridge supporting IPS is a PBB. Definitions of entities associated with an Infrastructure Segment and properties of such entities are as follows:

a) A PBB terminating the Infrastructure Segment is a Segment Endpoint Bridge (SEB).
b) A PBB in the interior of the Infrastructure Segment is a Segment Intermediate Bridge (SIB).
c) A PNP terminating the Infrastructure Segment is called a Segment Endpoint Port (SEP).
d) A PNP in the interior of the Infrastructure Segment is called a Segment Intermediate Port (SIP).
e) A SEB contains one SEP and does not contain a SIP.
f) A SIB contains exactly two SIPs and, by definition, cannot contain a SEP.
g) A SEP is connected to a single SIP or SEP in a neighboring PBB via a LAN.
h) A SIP is connected to one other SIP within the SIB via the MAC Relay Entity and is connected to a single SEP or SIP in a neighboring PBB via a LAN.

The role of SEB or SIB is assigned to a PBB only with respect to a particular Infrastructure Segment. Similarly, the role of SEP or SIP is assigned to a Port only with respect to a particular Infrastructure Segment.

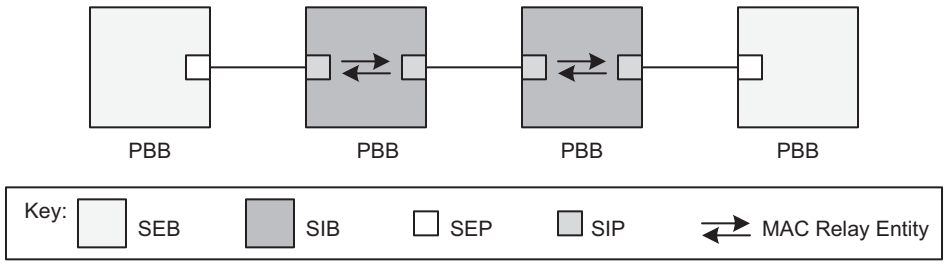


Figure 26-18—Segment terminology and properties

26.11.1 Infrastructure Segment monitoring

As illustrated in Figure 26-19, each Infrastructure Segment is associated with an MA for purposes of determining the connectivity state of that Infrastructure Segment. The Infrastructure Segment MA is associated with a pair of co-routed counterdirectional Infrastructure Segment Monitoring Paths (SMPs). Each SMP is identified by an <SMP-DA, SMP-SA, SMP-VID> 3-tuple that is known as an SMP-ID. The SMP-SA takes the value of the MAC address of the SEP from which the SMP originates. The SMP-DA takes the value of the MAC address of the SEP in which the SMP terminates. It follows from the co-routed and counterdirectional properties of the pair of SMPs that the SMP-DA value of one SMP in the pair of SMPs is equal to the SMP-SA value of the other SMP of the pair. The SMP-VID is a VID associated with a special value of the Multiple Spanning Tree Instance Identifier (MSTID) in the MST Configuration Table, the TE-MSTID, indicating that the VID is under the control of an external agent (8.9). The pair of SMP-IDs associated with an Infrastructure Segment is known as an Infrastructure Segment Identifier (SEG-ID). The MA managed object (12.14.6) associated with an Infrastructure Segment specifies the SEG-ID identifying that Infrastructure Segment. The value of the SEG-ID is inherited by the MEP associated with the Infrastructure Segment MA.

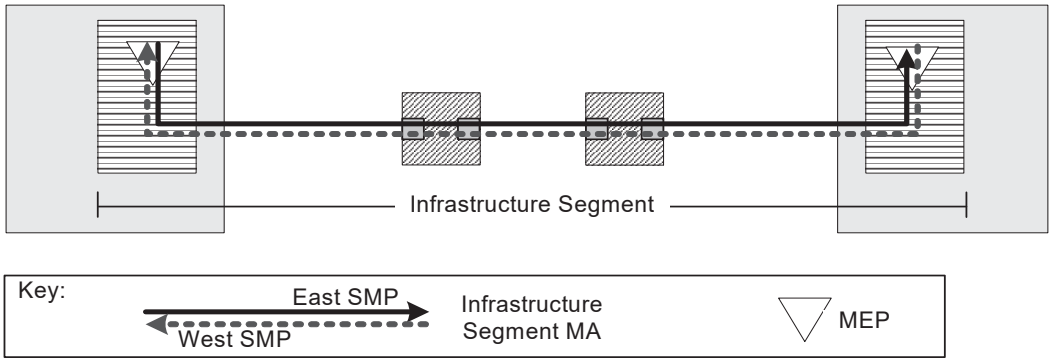


Figure 26-19—Infrastructure Segment monitoring

The operational state of the Infrastructure Segment is indicated by the Signal Fail (SF) variable (26.10.3.3.2) of the Protection Switching state machines (26.10.3). A value of TRUE indicates that the associated Infrastructure Segment is not operational. A value of FALSE indicates that the associated Infrastructure Segment is operational.

NOTE—For proper network operation, each SMP, of the pair of SMPs identifying an Infrastructure Segment MA, is represented by a Static Filtering Entry configured via the Create Filtering Entry operation (12.7.7.1) in each SIB along the path of the Infrastructure Segment. The SMP-ID <SMP-DA, SMP-SA, SMP-VID> would be represented by the Static Filtering Entry <SMP-DA, SMP-VID, outbound port value>. The outbound port value is the port number of the port by which the SMP exits the SIB. Proper operation further includes the creation, at each SEP, of a Maintenance Domain managed object (12.14.5), a Maintenance Association managed object (12.14.6), and a Maintenance association Endpoint managed object (12.14.7) associated with the Infrastructure Segment MA.

26.11.2 1:1 IPS

Figure 26-20 depicts two Infrastructure Segments with a TESI that has been provisioned to fully traverse the upper Infrastructure Segment. The Infrastructure Segment traversed by the provisioned TESI is known as the Working Segment with respect to that TESI. The lower Infrastructure Segment terminates in the same pair of SEBs that terminates the Working Segment but is otherwise diverse from the Working Segment. The lower Infrastructure Segment is known as the Protection Segment with respect to the TESI that traverses the Working Segment.

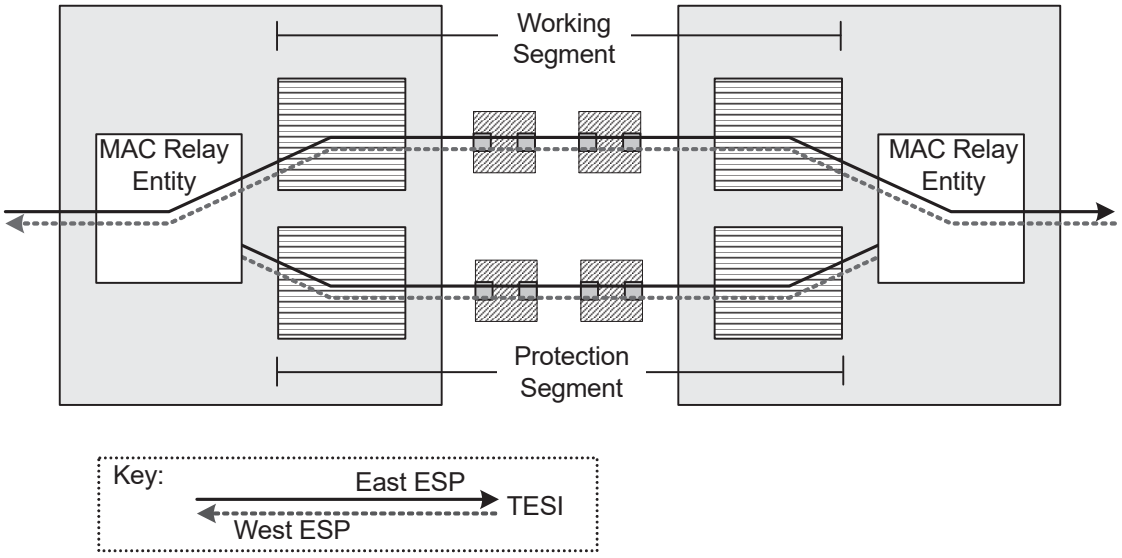


Figure 26-20—Working Segment and Protection Segment

26.11.2.1 Infrastructure Protection Group (IPG)

The associated Working and Protection Segments depicted in Figure 26-20 are said to form an IPG. The Working and Protection Segments are fully disjoint except for the common SEBs in which they terminate; that is, they share no common SEP, SIB, SIP, LAN, or MAC Relay Entity. One or more TESIs, each identified by a TE-SID are associated with an IPG at the SEB by which the TESI enters that IPG. A TESI is associated with the IPG via the Write IPG managed object (12.24.2.2.) Multiple TESIs may be associated with an IPG. TESIs associated with an IPG may have diverse end-to-end paths, but they follow a common path traversing the IPG. Two or more TESIs may be associated with ESPs having the same <ESP-DA, ESP-VID> 2-tuple. In particular this can occur if the TESIs are distinguished only by different values of ESP-SA. In such cases where TESIs share a common value of <ESP-DA, ESP-VID>, the association of one such TESI with an IPG at a SEB implies that all such TESIs are associated with that IPG. In other words, all such TESIs are protected by the IPG, or no such TESIs are protected by the IPG.

NOTE—An Infrastructure Segment can be associated with more than one IPG. For example, the operator can designate Infrastructure Segment 1 as the Working Segment of IPG1 and Infrastructure Segment 2 as the Protection Segment of IPG1. The operator can concurrently designate Infrastructure Segment 2 as the Working Segment of IPG2 and Infrastructure Segment 1 as an Protection Segment of IPG2. This property can be utilized as a method of load sharing across multiple Infrastructure Segments during normal operation.

26.11.2.1.1 Nested IPGs

IPGs are said to be nested with respect to a TESI if:

a) The TESI is associated with both IPGs, and
b) The set of SEPs and SIPs comprising the Working Segment of one IPG, the inner IPG, is identical to a contiguous sequence of SIPs contained within the Working Segment of the other IPG, the outer IPG.

In Figure 26-21, IPG2 (dashed) is nested within IPG1 (solid). IPG1 is the outer IPG, and IPG2 is the inner IPG. The Working Segment of the inner IPG is fully contained within the Working Segment of the outer IPG. The SEBs associated with the outer IPG are different from those associated with the inner IPG. Each nested IPG deploys an independent set of MAs for the purpose of monitoring the operational state of Infrastructure Segments associated with that IPG.

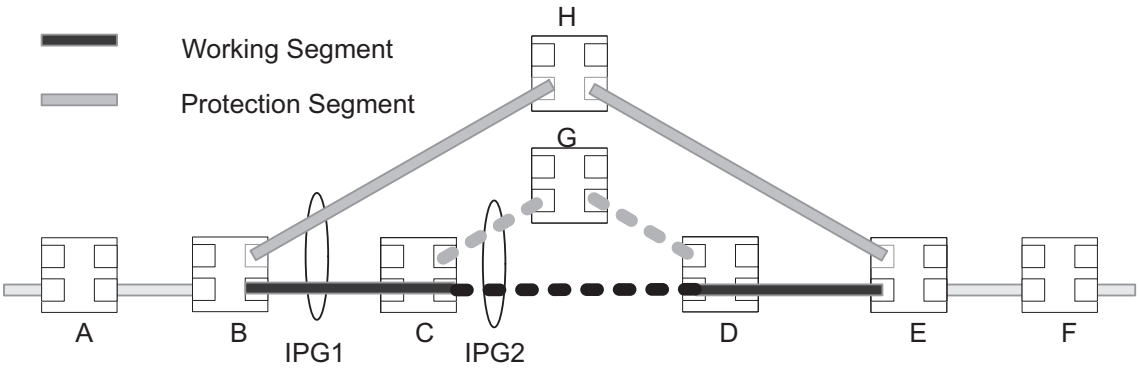


Figure 26-21—Nested IPGs

NOTE—Two IPGs are said to overlap with respect to a TESI if (a) the TESI is associated with both IPGs and (b) the IPGs share a sequence of PNPs. Designing networks having IPGs that overlap, but are not nested, requires careful study of issues not specifically identified in this standard.

26.11.2.2 Protection Switching method

When a TESI is assigned to an IPG by provisioning, traffic associated with that TESI transits the IPG via the Working Segment or the Protection Segment as directed by the Protection Switching state machines (26.10.3). In the absence of faults or outstanding administrative commands, TESI traffic transits the IPG via the Working Segment. The Protection Switching state machines can cause the TESI traffic to transit the IPG via the Protection Segment by invoking the Protection Switching procedure mapDataToProtection() (26.11.4.1.2). This procedure causes the value of the outbound Port field of the FDB entry corresponding to the <ESP_{in}-DA, ESP_{in}-VID> 2-tuple of each TESI associated with the IPG to be assigned the Port Number associated with the Protection Segment. The notation "ESP_{in}" denotes the ESP, of the pair of ESPs associated with the TESI, that *enters* the IPG via the SEB. The Protection Switching state machines can cause the traffic to transit the IPG via the Working Segment by invoking the Protection Switching procedure mapDataToWorking() (26.11.4.1.1) (26.11.4.1.2). This procedure causes the value of the outbound Port field of the FDB entry corresponding to each <ESP_{in}-DA, ESP_{in}-VID> 2-tuple of each TESI associated with the IPG to be assigned the Port Number associated with Working Segment. The two SEBs associated with the IPG perform protection activities independently. At any point in time, traffic associated with an IPG is carried on either the Working Segment or the Protection Segment. The Infrastructure Segment carrying the TESI traffic is known as the active Infrastructure Segment.

NOTE—Proper operation of the network requires that the FDB entry provisioned in a SIB to forward traffic along an Infrastructure Segment associated with the IPG identify only a single outbound Port. In other words, the portion of a TESI transiting an IPG is provisioned as point-to-point, without regard to whether the TESI is point-to-point or point-to-multipoint from an end-to-end perspective.

26.11.2.3 Hold-off timer

An IPG is provisioned with a "hold-off timer" value. The hold-off timer delays protection action associated with the failure of an Infrastructure Segment. The delay provides a lower layer with the opportunity to take corrective action before IPS is performed. Use of the hold-off timer can increase the total time required to recover from a failure.

In the case of nested IPGs, proper operation of the network requires that the outer IPG be provisioned with a "hold-off timer" value greater than that of the inner IPG. The outer IPG Working Segment is provisioned to coincide with the path of the inner IPG Working Segment. CCM traffic monitoring the outer IPG Working Segment traverses the Active Segment of the Inner IPG. The TESI list associated with the Inner IPG Endpoint Bridge is provisioned to include the SEG-ID associated with the CCM on the outer IPG Working Segment MA that ingresses the Inner IPG SEB. Thus, on a failure of the inner IPG Working Segment, traffic

associated with the outer IPG Working Segment, including the CCM traffic associated with the outer IPG Working Segment MA, is protected. The outer IPG will not be aware of the protection switch of the inner IPG and will not perform protection switching activities.

26.11.2.4 Reversion

An IPG is provisioned to operate in revertive mode or nonrevertive mode. In revertive mode, traffic is switched from the Protection Segment to the Working Segment when the Working Segment becomes operational. In nonrevertive mode, traffic remains associated with the Protection Segment when the Working Segment becomes operational unless:

a) The Protection Segment fails, or
b) Traffic is switched to the Working Segment by administrative command.

An IPG operates in revertive mode if that IPG is provisioned to support M:1 IPS.

26.11.2.4.1 Wait-to-restore timer

An IPG operating in revertive mode is provisioned with a "wait-to-restore (WTR) timer" value. The WTR timer delays reversion from the Protection Segment to the Working Segment on recovery of the Working Segment. Use of the WTR timer reduces the severity of "flapping," or rapid oscillation, that may occur if the Working Segment is experiencing intermittent connectivity failure. Setting the WTR time to zero indicates that the IPG is operating in nonrevertive mode.

26.11.2.5 Administrative commands

IPS supports the following administrative commands:

— **Lockout of Protection (LoP)** allows the operator to suppress automatic switching from Working Segment to Protection Segment.
— **Forced Switch (FS)** allows the operator to force traffic to the Protection Segment as if a connectivity failure exists on the Working Segment. The behavior persists until the command is withdrawn.
— **Manual Switch to Protection (MStoProtection)** switches traffic to the Protection Segment, but does not force traffic to remain associated with the Protection Segment.
— **Manual Switch to Working (MStoWorking)** switches traffic to the Working Segment, but does not force traffic to remain associated with the Working Segment.

26.11.3 IPS Control entity

The IPS Control entity contains the 1:1 IPS state machines (26.11.4) and, if M:1 IPS (26.11.5) is supported, the M:1 IPS state machines (26.11.5.1). There is an instance of the IPS Control entity for each SEB.

As shown in Figure 26-22, the operation of the IPS state machines depends upon input from Bridge Management and from each Infrastructure Segment MA associated with the IPG. The input from Bridge Management includes the list of TESIs [item e) in 12.14.2.1.2] associated with the IPG and Administrative commands (26.11.2.5) associated with the IPG. The outbound Port field of a Static Filtering Entry associated with an IPG can be modified by IPS Control. When a Static Filtering Entry is no longer associated with an IPG, the Outbound Port value of that Static Filtering Entry is restored by IPS control to the Port associated with the Working Segment of the IPG and IPS Control cannot subsequently modify the Outbound Port value. While the Outbound Port value can be modified by IPS Control, addition and deletion of FDB entries remains under the control of Bridge Management.

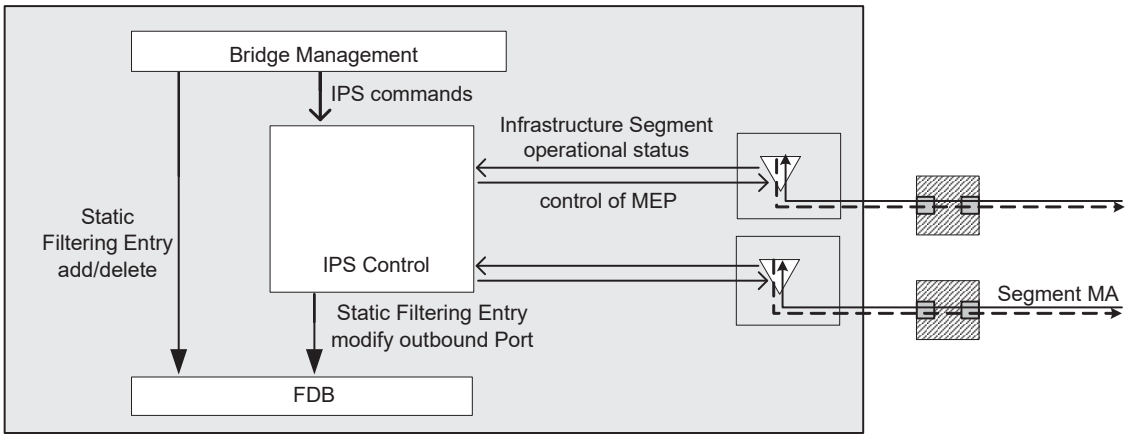


Figure 26-22—IPS Control entity

IPS Control maintains the following entities associated with the IPG:

a) The SEG-ID identifying the Working Segment MA
b) The SEG-ID identifying the Protection Segment MA
c) The 1:1 IPS state machines
d) The list of the TESIs describing traffic protected by the IPG

When an IPG is associated with optional M:1 IPS, the following additional entities are maintained:

e) The list of SEG-IDs identifying the MAs of candidate Protection Segments
f) The M:1 IPS state machines

26.11.4 1:1 IPS state machines

Protection switching for point-to-point TESIs (26.10) and 1:1 IPS (26.11.2)both utilize Protection Switching state machines (26.10.3). In the case of 1:1 IPS, the “Protection Group” is an “IPG,” the “working entity” is the “Working Segment,” and the “protection entity” is the “Protection Segment.” One set of Protection Switching state machines is instantiated per IPG per SEB.

26.11.4.1 Procedures referenced by the 1:1 IPS state machines

The procedures mapDataToWorking() and mapDataToProtection() referenced by the 1:1 IPS state machines and described in the subclauses that follow, differ from the procedures of the same name (26.10.3.4) referenced by the TESI Protection state machines.

26.11.4.1.1 mapDataToWorking()

This procedure changes the value of the outbound Port field of each Static Filtering Entry identified by the <ESP_{in}-DA, ESP_{in}-VID> 2-tuple associated with each TESI on the list of TESIs associated with an IPG to the port Number associated with the Working Segment of the IPG.

26.11.4.1.2 mapDataToProtection()

This procedure changes the value of the outbound Port field of each Static Filtering Entry identified by the <ESP_{in}-DA, ESP_{in}-VID> 2-tuple associated with each TESI on the list of TESIs associated with an IPG to the port Number associated with the Protection Segment of the IPG.

26.11.5 M:1 IPS

This subclause describes extensions to 1:1 IPS (26.11.2) supporting M:1 IPS when this optional feature is implemented. An IPG is constrained to operate in 1:1 revertive mode when that IPG supports M:1 IPS.

As illustrated in Figure 26-23, a list of candidate Protection Segments, ordered by priority value, is provisioned for each IPG. deploying M:1 IPS. The list contains at least one candidate Protection Segment. Candidate Protection Segments are mutually disjoint and disjoint from the Working Segment. The candidate Protection Segment having the highest (lowest numeric) priority among the operational candidate Protection Segments is the Protection Segment referenced by the 1:1 IPS state machine. This selected candidate Protection Segment is called the “current” Protection Segment. In the absence of any operational candidate Protection Segments, the current Protection Segment retains the value it had prior to the failure of the last candidate Protection Segment. In this case, the 1:1 IPS Protection Segment is declared to have failed. If the 1:1 IPS Protection Segment is not operational and a candidate Protection Segment becomes operational, that candidate Protection Segment assumes the role of 1:1 IPS Protection Segment, and the 1:1 IPS Protection Segment becomes operational. If a candidate Protection Segment of higher priority than the current Protection Segment becomes operational, then that candidate Protection Segment assumes the role of the 1:1 IPS Protection Segment following expiration of the M:1 wait-to-restore timer. If the current Protection Segment has changed and the 1:1 IPS Protection Segment is the active Infrastructure Segment, then Static Filtering Entries associated with TESIs protected by the IPG are updated with the Port number of the current Protection Segment as described in 26.11.2.2. Thus, M:1 IPS is deployed using an extension of 1:1 IPS that allows the current Protection Segment to be replaced by a candidate Protection Segment of higher priority, provided that such a candidate exists and is operational.

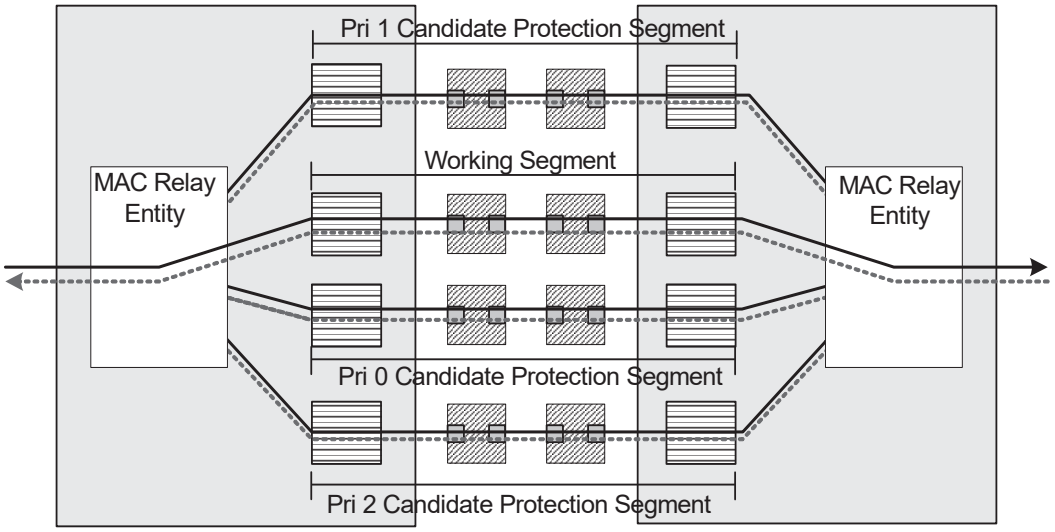


Figure 26-23—M:1 IPS

26.11.5.1 M:1 IPS state machines

There is one set of M:1 IPS state machines per IPG.

The M:1 IPS state machines comprise one M:1 Hold-off state machine (26.11.5.6) per candidate Protection Segment and one Protection Segment Selection state machine (26.11.5.7) per IPG, in addition to the 1:1 IPS state machines (26.11.4). The relationship between the M:1 IPS state machines and the 1:1 IPS state machines is illustrated in Figure 26-24.

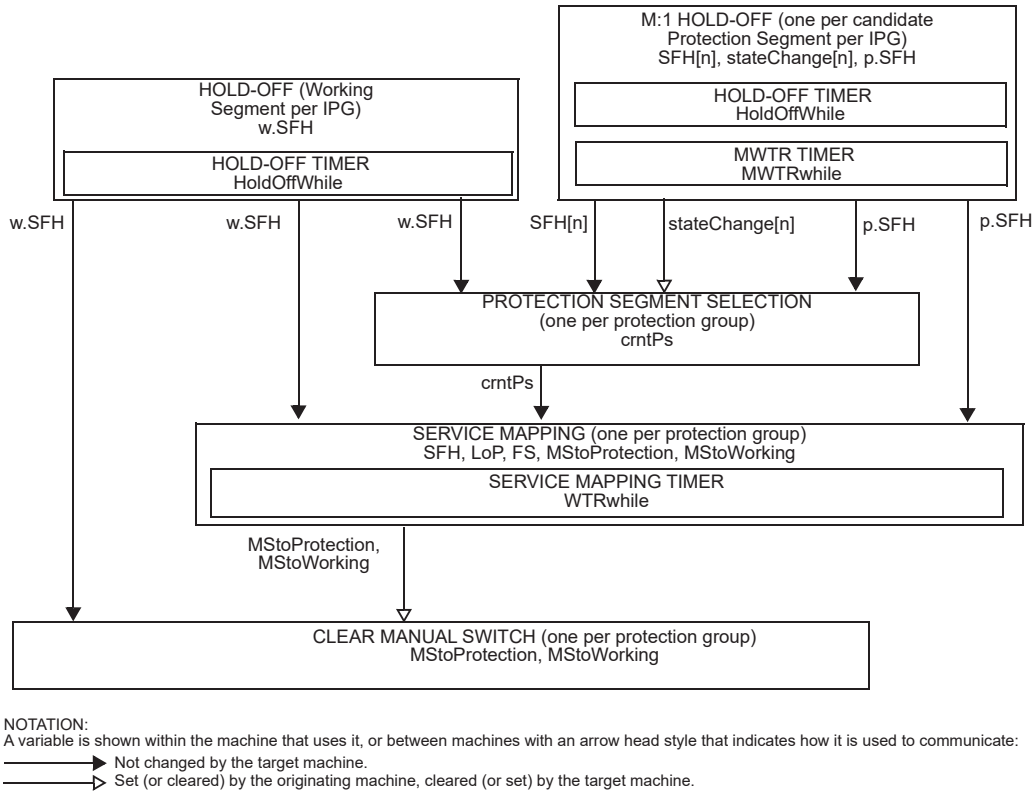


Figure 26-24—M:1 IPS state machines

26.11.5.2 Notational conventions used in state diagrams

The Protection Switching state machines are specified using the notational conventions defined in Annex E. Additionally, in cases of multiple instances of a state variable, each instance is represented by adding the suffix "[n]" to indicate the n^{th} instance. If instances of a state variable may be associated with either the Working Segment or the Protection Segment, the references can be distinguished by prefixing "w." or "p." to distinguish the two cases.

26.11.5.3 State machine timers

The timer variables declared in this subclause are part of the specification of the operation of Protection Switching. The accompanying descriptions of their meaning and use are provided to aid in the comprehension of the protocol only and are not part of the specification. Timer variables deployed by the M:1 IPS state machines are as follows:

a) HoldOffWhile (26.10.3.2.2): one instance per M:1 Hold-off state machine
b) MWTRwhile (26.11.5.3.1): one instance per M:1 Hold-off state machine

26.11.5.3.1 MWTRwhile

A timer to be used to prevent frequent operation of the protection switch among candidate Protection Segments due to an intermittent defect. This timer allows for a fixed period of time to elapse before data traffic is mapped from a lower priority Protection Segment to a higher priority Protection Segment when in M:1 revertive mode.

26.11.5.4 Variables referenced by M:1 IPS state machines

The following variables are referenced by the M:1 IPS state machines:

a) BEGIN (26.11.5.4.1)
b) SF (26.11.5.4.2)
c) SFH (26.11.5.4.3)
d) stateChange (26.11.5.4.4)
e) pri (26.11.5.4.5)
f) allPsSFH (26.11.5.4.8)
g) crntPs (26.11.5.4.6)
h) WTRTime (26.10.3.3.8)
i) MWTRTime (26.11.5.4.7)
j) HoldOffTime (26.10.3.3.9)

26.11.5.4.1 BEGIN

This is a Boolean variable controlled by the system initialization process. A value of TRUE causes all M:1 IPS state machines per IPG to continuously execute their initial state. A value of FALSE allows these state machines to perform transitions out of their initial state, in accordance with the relevant state machine definitions.

26.11.5.4.2 SF

SF is the logical OR of someRMEPCCMdefect (20.35.5), someRDIdefect (20.35.7), xConCCMdefect (20.23.3), and errorCCMdefect (20.21.3). An instance of this variable, identified by the notation SF[n], is specified per candidate Protection Segment.

26.11.5.4.3 SFH

A Boolean flag set and cleared by the M:1 Hold-off state machine to indicate that SF is set for a period that is equal to, or larger than, the HoldOffTime. The variable is set equal to SF if the hold-off timer is not supported. An instance of this variable, identified by the notation SFH[n], is specified per candidate Protection Segment.

26.11.5.4.4 stateChange

A Boolean flag set by the M:1 Hold-off state machine and cleared by the Protection Segment Selection state machine indicating the value of SFH associated with a candidate Protection Segment has changed. An instance of the variable, identified by the notation stateChange[n], is specified per candidate Protection Segment.

26.11.5.4.5 pri

An integer value associated with each candidate Protection Segment and unique within the IPG indicating the selection priority of a candidate Protection Segment. Lower numeric values are associated with higher priority. An instance of the variable, identified by the notation pri[n], is specified per candidate Protection Segment.

26.11.5.4.6 crntPs

An integer value identifying the operational candidate Protection Segment having the highest (lowest numeric) selection priority. In the event that no candidate Protection Segment is available, the value is that of the last candidate Protection Segment to be available.

26.11.5.4.7 MWTRTime

The M:1 wait-to-restore (MWTR) period associated with reverting from a lower priority to a higher priority candidate Protection Segment, as provided by the corresponding managed object [item k) in 12.24.2.1.3]. May be configured by the operator in 1 min steps between 5 and 12 min; the default value is 5 min. A value of 0 indicates M:1 nonrevertive mode. The overall accuracy of the MWTR timer (e.g., <±25 ms) should be sufficient to allow both SEBs at the termination of the IPG to revert to the same value of the Protection Segment in less than 50 ms.

26.11.5.4.8 allPsSFH

The logical AND of the value of SFH[n] over the M candidate Protection Segments.

26.11.5.5 Procedures referenced by M:1 IPS state machines

The following procedures are referenced by the M:1 IPS state machines:

a) highestPriOperPs() (26.11.5.5.1)
b) setPs(n) (26.11.5.5.2) (26.11.5.5.2)
c) mapDataToProtection() (26.10.3.4.2)

26.11.5.5.1 highestPriOperPs()

Returns the identity of the highest priority candidate Protection Segment for which SFH[n] == FALSE or, in the event that SFH[n] == TRUE for all candidate Protection Segments, the value NULL.

26.11.5.5.2 setPs(n)

Establishes the n^{th} candidate Protection Segment as the Protection Segment referenced by the Service Mapping state machine.

26.11.5.6 M:1 Hold-off state machine

The M:1 Hold-off state machine is specified by the state diagram in Figure 26-25 and the variables in 26.11.5.4.

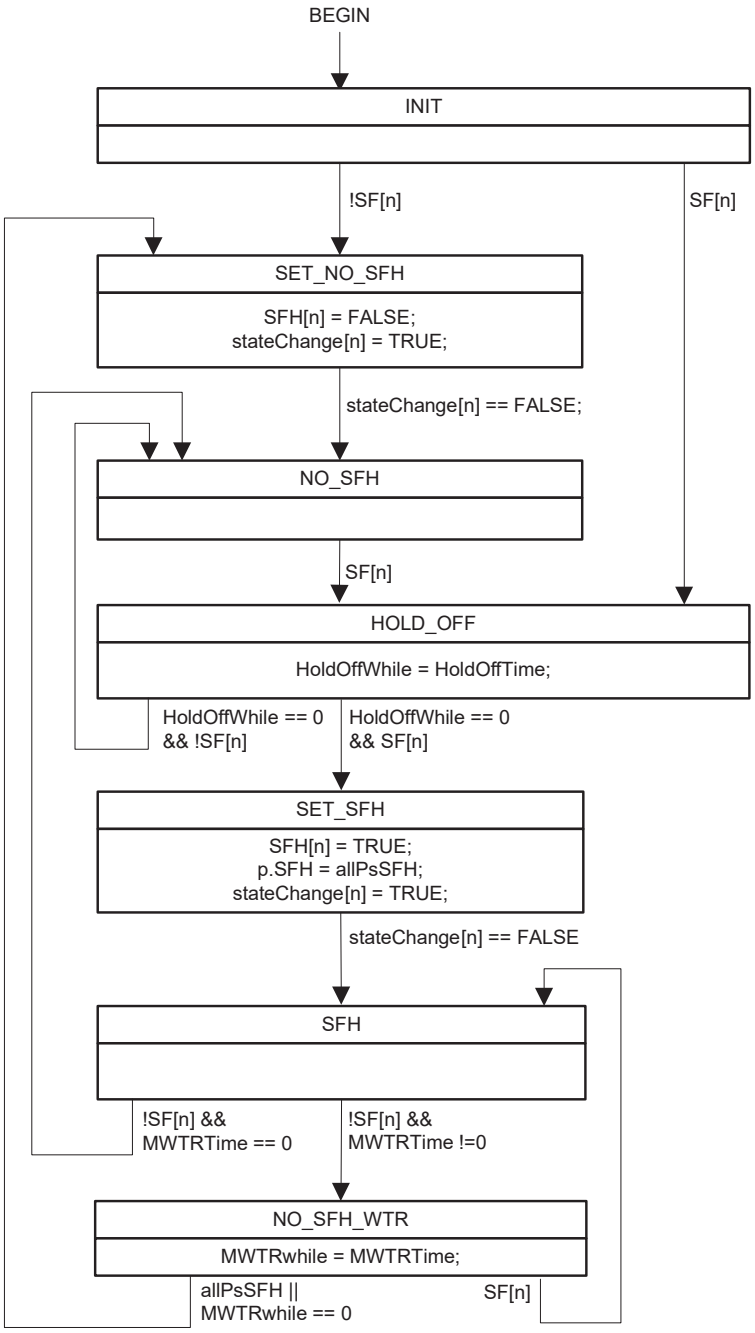


Figure 26-25—M:1 Hold-off state machine

NOTE—The state NO_SFH_WTR is entered only in the case that M:1 reversion has been provisioned (i.e., MWTRTime != 0) and the candidate Protection Segment “n” is operational (i.e., !SF[n]). The state allows the machine to wait a period of time (i.e., MWTRTime) before permitting the candidate Protection Segment “n” to become available for selection as the Protection Segment, thus increasing stability. If, during this time, it is determined that no candidate Protection Segments are available for selection (i.e., allPsSFH), but candidate Protection Segment “n” is operational, then it is prudent not to wait MWTRTime but instead to proceed directly to the selection of candidate Protection Segment “n” as the current Protection Segment. In other words, when no candidate Protection Segment has met the criterion for availability (i.e., allPsSFH), but there is a candidate Protection Segment that is operational (i.e., !SF[n]), then it is not necessary to wait MWTRTime before proceeding with selection.

26.11.5.7 Protection Segment Selection state machine

The Protection Segment Selection state machine is specified by the state diagram in Figure 26-26 and the variables in 26.11.5.4.

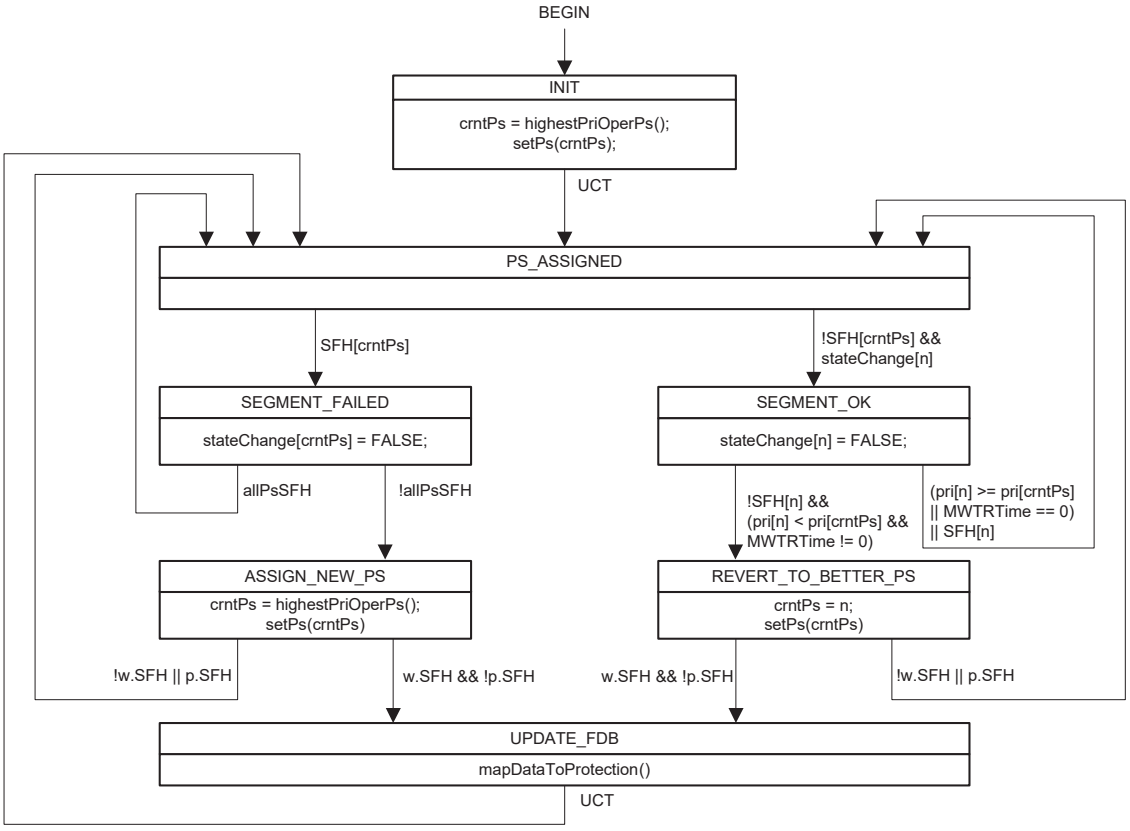


Figure 26-26—Protection Segment Selection state machine

26.12 Mismatch defect

Under equipment malfunction conditions and/or incorrect configuration, a mismatch between the mappings of the backbone service instances to the appropriate TESI at the terminating CBPs can happen. Similarly, a mismatch can occur in the mapping of a TESI to the appropriate Infrastructure Segment at the terminating PNP. To maintain the proper operation of the network, such a mismatch should be detected and reported. There can be two types of mismatch. They are as follows:

a) Protection switching incomplete
b) Working/protection configuration mismatch

An example of protection switching incomplete mismatch is when, due to equipment malfunction, the near end (East B-Component in Figure 26-13) fails to switch over but it sends a CCM with the RDI field set to the far end (West B-Component in Figure 26-13). The far end transmits to the protection TESI while the near end is still transmitting in the working TESI. Similarly a mismatch can also happen when the near end transmits to the protection TESI but the far end fails to start transmitting to the protection TESI when it receives a CCM with the RDI field set.

The mismatch can also happen because of incorrect configuration. For example, one end is configured to send traffic on working TESI while the other end is configured to send traffic on protection TESI. Or one end is configured as revertive mode while the other end is configured as nonrevertive mode. The mismatch occurs when a failure is cleared.

NOTE—Since a merging selector is used, in the case of TESI protection, there is not necessarily a traffic loss in all mismatch cases.

PBB-TE MEPs and Infrastructure Segment MEPs that support the Traffic field (21.6.1.4) can detect such a mismatch. The Mismatch state machine in 20.26 provides this capability.

26.13 Signaling VLAN registrations among I-components

A VIP is a Bridge Port. MVRP can therefore be enabled in an I-component and used to convey dynamic VLAN Registrations from I-component to I-component across a PBBN.

In the particular case of VIPs that do not emit an S-TAG, and thus use only the I-TAG to differentiate among service instances, the Multiple I-SID Registration Protocol (MIRP, Clause 39) can be enabled instead of MVRP (11.2) to signal the need to flush learned C-MAC address information from one Icomponent to another. The network administrator can select between using MVRP or MIRP to perform this signaling according to the need to minimize the number of control frames sent (MIRP) or the number of remote I-components affected by any given control frame (MVRP).

27. Shortest Path Bridging (SPB)

SPB provides shortest path communication for user data frames in SPT regions (Clause 3). ISIS-SPB interoperates with MSTP and RSTP (Clause 13) and STP (Clause 8 of IEEE Std 802.1D, 1998 Edition [B11]), exchanging BPDUs to determine the extent of each SPT Region and to configure full, simple, and symmetric connectivity throughout a network comprising arbitrarily interconnected Bridges and individual point-to-point LANs (13.6, 13.7). IS-IS supports point-to-point links and shared LANs; however, only point-to-point is considered for ISIS-SPB in this specification. A future revision may add shared media. The Clause 13 SPB description allows for both point-to-point links and shared media.

Within an SPT Region (7.4, 13.6), the active topology that supports the frames for any given Base VID can be chosen (27.4) by the network administrator to be one of the following:

— The Internal Spanning Tree (IST).
— A Multiple Spanning Tree Instance (MSTI).
— A set of Traffic Engineering service instances (TESIs).
— A set of shortest path trees (SPT Set), one SPT rooted at each SPT Bridge and supporting frames transmitted into the region through that Bridge.
— Multiple equal cost unicast paths and multicast trees that spread traffic rooted at each SPT Bridge over multiple SPTs. This ECMP connectivity is only supported by SPT Bridges using SPBM mode.
— A set of Explicit Trees (ETs).

Clause 28 specifies the use of ISIS-SPB to calculate the IST and multiple SPT Sets (supporting different ECTs) within an SPT Region. Clause 13 specifies the use of MSTP to calculate MSTIs, and state machines that use the results provided by ISIS-SPB for each SPT to prevent loops within and between regions while maintaining or recovering connectivity as the network reconfigures (13.12, 13.14–13.40, 27.5). The umbrella term ISIS-SPB refers to the coordinated use of the protocols and algorithms specified in Clause 28 and Clause 13 to support SPB.

Clause 45 specifies the use of IS-IS to establish explicit trees within an SPT Region. These trees can differ from the SPTs.

To allow SPB to support plug-and-play operation for some VLANs, while providing the administrative controls and scalability required for large scale operations, this standard specifies two complementary modes of SPT Bridges (SPBV and SPBM) for assigning each shortest path bridged frame to the correct SPT. All the Bridges in a given SPT Region agree on the method to be used to support any given VLAN. Subclause 27.19 describes network scenarios that use one or both of these methods.

If a VLAN is supported by an SPT Bridge using SPBV mode, Shortest Path VIDs (SPVIDs) are automatically allocated by ISIS-SPB and used in VLAN tags within an SPT Region. Each SPVID identifies both the VLAN and the SPT supporting transmission of a tagged frame, and Dynamic VLAN Registration Entries are created to provide connectivity while preventing loops (13.38.2). The SPVIDs for a given VLAN use a single FID that is associated with the Base VID for that VLAN (Shared VLAN Learning (SVL), 7.5, 8.8.8). VID translation (6.9) at the region boundary (7.4, 13.5, 13.12) maps SPVIDs to and from the associated Base VID.

If a VLAN is supported by an SPT Bridge in SPBM mode without ECMP, the Base VID is used in each frame's VLAN tag within the SPT Region and identifies the VLAN and the SPT Set. Each Bridge mitigates and prevents loops (6.5.4, 13.38.2) by using the source and destination MAC address of each frame with Dynamic Filtering Entries for the Base VID, MAC address tuples. The source MAC address identifies the particular SPT from the SPT Set, and supports active topology enforcement (13.38.2, 8.6.1). When forwarding unicast frames it is not necessary to consider the particular SPT since all the SPTs in a given set transiting a given Bridge en route to a destination take the same path from that given Bridge to the

destination (in other words, they are all reverse path congruent with the SPT rooted at that destination). Therefore, for unicast frames the destination MAC address is used for egress filtering as normal. SPT Bridging using SPBM mode requires the use of SPT-specific destination group MAC addresses, so loop-free multicast forwarding is also supported without requiring the source MAC address or source Bridge Port to be part of the FDB query. ISIS-SPB automatically allocates SPSourceIDs (27.10) that are used as part of each group address. Since an SPT Bridge using SPBM mode inspects source MAC addresses as a loop mitigation mechanism, those addresses have to be known before forwarding can take place and are advertised using ISIS-SPB. Learning of B-MAC addresses is not enabled when SPBM mode is used, and frames destined for unknown addresses are discarded and not flooded. The individual MAC addresses used are those of the SPT Bridges themselves, or are associated with functions provided by Provider Bridges or BEB functions that include an SPT Bridge component. SPBM group multicast addresses are local to the SPT Bridge domain [using the Locally administered (U/L) address MAC address flag (IEEE Std 802)], so the use of SPT-specific group MAC addresses does not intrude on the well known global multicast space.

With ECMP (Clause 44), ISIS-SPB can configure multiple potential forwarding Ports for each individual MAC address, and forwarding port selection is performed dynamically. Forwarding Port selection is controlled by a deterministic hash function whose inputs are the SPB System Identifier and the Flow Hash carried in an F-TAG. This tends to spread traffic flows over the set of equal cost paths between the source Bridge and destination Bridge in the SPT Region while preserving frame ordering of individual flows. As a substitute for the loop prevention and mitigation techniques mentioned above, an alternative loop quenching mechanism for ECMP is realized with a TTL field included in the F-TAG. With ECMP, bidirectional and unicast-multicast congruence is no longer guaranteed (since there is no longer a single path in use between a source and destination). This enables each Backbone Service Instance group address to be independently routed and multicast traffic to be spread over a set of equal cost SPTs.

ISIS-SPB uses the same mechanism to allocate SPVIDs (for SPBV) and SPSourceIDs (for SPBM) (27.10). The MST Configuration Identifier (MCID) (8.9, 13.8) is used to ensure that all the Bridges in an SPT Region agree on the method used to support each shortest path VLAN and on the pool of SPVIDs, as well as on the other uses of VIDs (27.4). An SPSourceID is allocated to each Bridge in an SPT Region, independently of SPBM mode VLANs, while an SPVID for a given SPBV VLAN is only allocated to the SPT rooted at a given Bridge if VLAN Registration Entries and controls allow that Bridge to transmit frames assigned to that VLAN into the region (8.8, 13.6).

An SPT Bridge using SPBV mode is typically used to support a C-VLAN or S-VLAN for a single customer. An SPT Bridge using SPBM mode is typically used to support B-VLANs in PBBNs (Clause 25). Each B-VLAN can support many backbone service instances, each requiring connectivity between a subset of the BEBs participating in the B-VLAN, and each identified by an I-SID that is not processed by BCBs. An SPT Bridge using SPBM mode does not use source address learning, so unicast B-MAC frames conveying customer data are never flooded throughout the B-VLAN. Multicast frames and flooding of unknown unicast frames for a given backbone service instance are confined to paths that reach the BEBs supporting that service instance by including the I-SID in the SPT-specific destination group MAC addresses (Figure 27-3). The destination address filtering in each BCB prunes transmission of the encapsulated customer multicast frames as well as preventing loops.

MVRP (11.2) is not used within SPT Regions, as ISIS-SPB communicates VLAN registration information for VLANs supported by SPB from the SPT Bridges that provide ingress to and egress from the region to the other Bridges, thus allowing SPT Bridges using SPBV and SPBM to configure Dynamic VLAN Registration Entries for Bridge Ports within the region to provide correct VLAN connectivity when SPTs are recalculated—instead of waiting for registration information to propagate on those SPTs. SPT Bridges can use the registration information communicated within the SPT Region to participate in MVRP with Bridges outside the region (27.13) by supporting MVRP interfaces on the Region boundaries.

This clause specifies the following:

a) Protocol design and support requirements (27.1, 27.2) and design goals (27.3).

This clause further specifies how:

b) Each Bridge's configuration mechanisms specify the supporting method (SPBV, SPBM, MSTI, CIST, or PBB-TE) and SPT Set (for SPBV and SPBM) for each VLAN (27.4).
c) The boundaries of each SPT Region and ISIS-SPB adjacencies are determined dynamically by ISIS-SPB (Clause 28).
d) The information exchanged by ISIS-SPB is used (27.5), including CIST calculation (27.6, 27.7), SPT calculations (27.8), allocating SPVIDs and SPSourceIDs (27.10), and controlling the connectivity supporting each VLAN (27.13) and backbone service instance (27.15, 27.16).
e) The results of ISIS-SPB's CIST and SPT calculations are used by the Clause 13 state machines to determine when to discard frames to ensure the calculated trees are loop-free (27.9).
f) SPVIDs are allocated to FIDs (27.11) and translated to and from Base VIDs at the boundary of an SPT Region (6.9, 13.6).
g) VLAN Registration Entries are used to forward or discard frames for each VLAN (27.13).
h) FDB entries for individual addresses are used to prevent or mitigate loops for VLANs supported by SPBM (27.14).
i) SPBM Group Addresses are assigned, and FDB entries for those addresses used to forward or discard frames for each backbone service instance for B-VLANs supported by SPBM (27.15, 27.16).
j) The SPT calculations choose between Equal Cost Trees (ECTs), making different choices for different SPT Sets, each associated with a different VLAN, enabling load spreading (27.17, 28.9.2).

This clause also:

k) Provides examples of when and how SPT Bridges using SPBV and SPBM modes can be used (27.19).

27.1 Protocol design requirements

ISIS-SPB configures entries in each SPT Bridge's FDB (8.8) to meet the following requirements:

a) The active topology will fully connect all physically connected LANs and Bridges, and stabilize (with high probability) within a short, known bounded interval after any change in the physical topology, maximising service availability (8.4).
b) Except in the case of ECMP, the active topology for any given frame remains simply connected at all times (6.5.3, 6.5.4).
c) The same symmetric active topology is used, in a stable network, for all frames for the same VLAN, i.e., between any two individual LANs those frames are forwarded through the same Bridge Ports.
d) The active topology supporting a given VLAN within an SPT Region can be chosen by the network administrator to be shortest path, the IST, an MSTI, or an ET.
e) Each active topology is predictable and reproducible, and may be influenced by management, thus allowing the application of Configuration Management following traffic analysis, to meet the goals of Performance Management (6.5 and 6.5.10).
f) The configured network can support VLAN-unaware end stations, such that they are unaware of their attachment to a single LAN or a bridged network, or their use of a VLAN (6.3).
g) The SPB mode, SPBV or SPBM, can be chosen by the network administrator independently for each VLAN using shortest paths.

SPBV mode meets the following requirements:

h) No additional constraint is placed on the values of the Individual or group MAC addresses used, and those addresses do not have to be known before being used in data frames.

i) SPVIDs are allocated to every SPT Bridge that is a potential source of frames on VLANs supported by SPBV.

j) FDB entries for a given SPVID will only be populated if they are on the shortest path to a participating boundary node.

SPBM mode meets the following requirements:

k) Multicast flooding for each backbone service instance supported by a PBBN is restricted to paths necessary to reach BEBs supporting that service instance.

l) ECMP operation enables multiple equal cost paths in the SPT Region to carry a share of unicast and multicast traffic.

NOTE—The ECMP ECT Algorithm supports multicast load spreading over up to 16 source trees per node and up to 16 shared trees.

Additionally, SPB algorithms and protocols meet the following goals, which limit the complexity of Bridges and their configuration:

m) The memory requirements associated with each Bridge Port are either a constant or a linear function of the number of Bridges and LANs in the network.

n) The communications bandwidth consumed by ISIS-SPB on any particular LAN is always a small fraction of the total available bandwidth (6.5.10).

o) Bridges do not have to be individually configured before being added to a network, other than having their MAC addresses assigned through normal procedures.

27.2 Protocol support

ISIS-SPB is configured to use one of the Group addresses from Table 8-16 to establish adjacencies and exchange PDUs. SPB running on C-VLAN components use the Customer Bridge address. SPB running on S-VLAN components use the Provider Bridge address. SPB running on B-VLAN components may use the Provider Bridge Address or one of the existing IS-IS addresses.

The use of the ISIS-SPB adjacency between Bridges is contingent on the Bridges inclusion within the same SPT Region, and thus requires they have an MCID and Auxiliary MCID (13.8, 28.12.2) where at least one matches on every adjacency in the Region (8.9.4, 13.8). MCID and Auxiliary MCID enable migration of the MCID definition allowing these Bridges to operate as one SPT Region under certain small changes. The operational set of Base VLANs and SPVIDs must be consistent during migration. This standard specifies default configurations resulting in a MCID that enables plug-and-play support of both the CIST and SPB using SPT Bridges using SPBV mode. No default recommendations are made for SPT Bridges using SPBM mode, since it is only expected to be used in managed environments.

This standard recommends defaults for Bridge and Bridge Port priorities and path costs to support the calculation of active topologies without further configuration. To allow management of those active topologies, a means of assigning values to the following are required:

a) The relative priority of each Bridge in the network (13.26.3)

b) The relative priority of each Port of a Bridge (13.27.47)

c) A Port Path Cost for each Port (13.27.25, 13.27.33)

Management of SPT topologies and of the use of SPBV or SPBM mode to support particular VLANs, also requires the following:

d) Management of the SPB objects (12.25)
e) Administrative agreement on the MCID Configuration Name and Revision Level (Clause 28)

27.3 Protocol design goals

It is highly desirable that the operation of ISIS-SPB allows the following:

a) Addition of Bridges to an existing SPT Region without disrupting existing communication
b) SPB support for additional VLANs without disrupting existing communication
c) Enabling or disabling SPB support for individual VLANs with minimum frame loss

27.4 ISIS-SPB VLAN configuration

The configuration mechanisms used by MST Bridges to allocate each VLAN to a specified MSTI or the IST within an MST Region and used to allocate VIDs for PBB-TE (25.10) can be summarized as follows:

a) The VID to FID allocation table (8.8.8, 12.12.2) is used to allocate each VID to a FID.
b) The FID to MSTID Allocation Table is used to associate an MSTID with a FID (8.9.3, 12.12.2):
    1) The IST is identified by the reserved MSTID value 0.
    2) The use of PBB-TE is identified by the reserved MSTID value TE-MSTID (0xFFE)
    3) Each MSTID in the MSTI List identifies an MSTI.
    The reserved MSTID values 0 and TE-MSTID, SPBV-MSTID, SPBM-MSTID, and SPVID-Pool-MSTID are never used in the MSTI List.

SPT Bridges extend these configuration mechanisms as follows:

c) The VID to FID allocation table is used to allocate Base VIDs to FIDs, and to allocate VIDs for use as SPVIDs. SPVIDs are allocated to the reserved FID value 0xFFF. SPVIDs in use are reported by management as allocated to a FID supported by the implementation (27.11).
d) The reserved FID value SPVID-Pool-MSTID is allocated to the reserved MSTID value 0xFFF.
e) The following MSTID values identify the SPT Bridge mode used by SPB:
    1) 0xFFC—SPBM
    2) 0xFFD—SPBV

This standard recommends default VID to FID and FID to MSTID allocations (27.2, 8.9.3) for SPT Bridges that enable plug-and-play support of both the CIST and SPB using SPBV mode.

Table 27-1 shows the VID to FID and the FID to MSTID allocation tables in a single table for the configuration example shown in Figure 27-1 for an SPT Region.

Base VID 1 is allocated to the IST and VIDs from 0x100 to 0x1FF form the SPVID Pool. Base VIDs 0x002, 0x003, and 0x004 are configured to operate in SPBM mode. Base VIDs 0x005, 0x006, and 0x007 operate in SPBV mode in the example.

Table 27-1—Allocation of VIDs to FIDs and FIDs to MSTIDs in an SPT Region (example)

VID	FID	MSTID
0x001	0x001	0x000
0x002	0x002	0xFFC
0x003	0x003	0xFFC
0x004		
0x005	0x005	0xFFD
0x006	0x006	0xFFD
0x007		
0x100–0x1FF	0xFFF	0xFFF

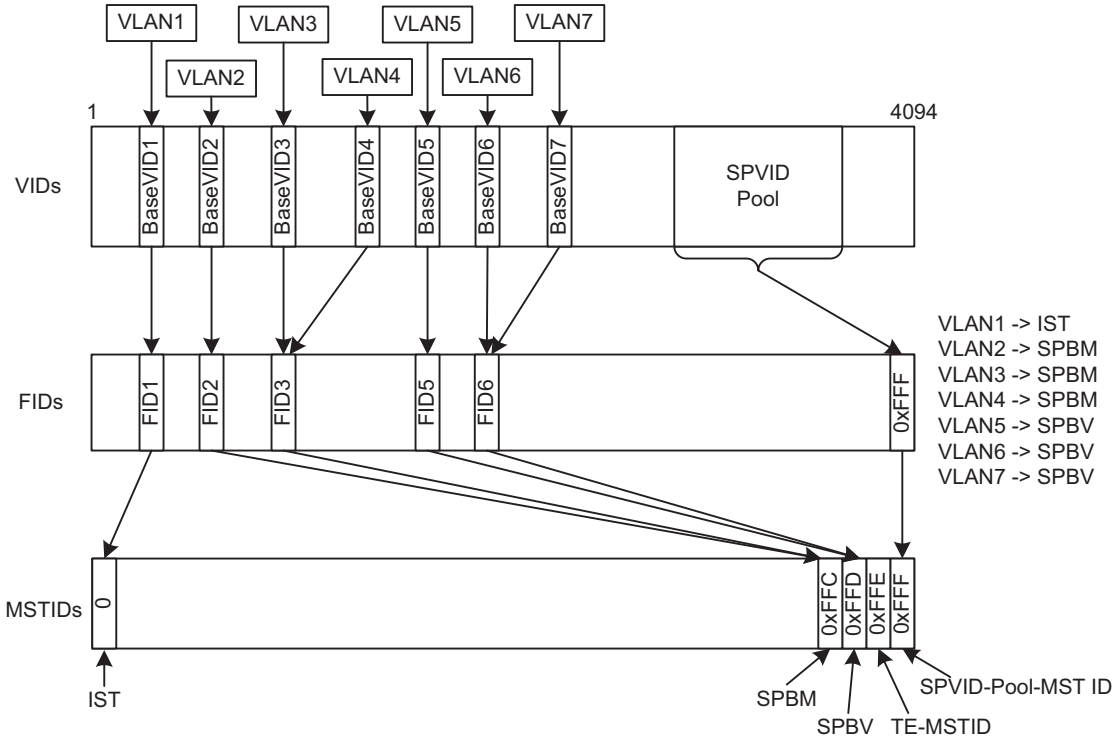


Figure 27-1—Configuring VLAN support in an SPT Region (example)

27.4.1 SPT Region and ISIS-SPB adjacency determination

It is essential that all Bridges within an SPT Region agree on the allocation of VIDs to spanning trees prior to transmission and reception of frames tagged with those VIDs. This configuration requirement is common to both SPB (13.6) and MSTP operation (13.5), and MSTP can coexist with ISIS-SPB within an SPT Region, supporting different VLANs with different VIDs. ISIS-SPB uses and extends MSTP's configuration mechanisms and use of the MCID (8.9, 13.5, 13.8). Note the MCID (13.8) includes a digest derived from the mapping of VIDs to MSTIDs. To allow dynamic manipulation of SPVIDs without impacting the MCIDs, the mapping of SPVIDs to the FID associated with the supported Base VID is not captured in this table.

SPB configuration is highly automated. An SPT Region is created by configuring at least two adjacent Bridges with compatible information. The region grows dynamically as more SPT Bridges with the same region configuration are introduced. Once a region has been created, other VLANs can also be created. ISIS-SPB will populate forwarding only between Bridges that support the same services. The SPT region is an interconnected set of Bridges supporting the Region configuration [MCID (13.8), ISIS-SPB Configuration (27.4)] but the forwarding for any one VLAN is simply the Bridges configured to support services on that VLAN or the Bridges that lie on the shortest path between those Bridges.

The same is true of SPT Bridges operating in SPBM mode that can be added to support new VLANs on a Bridge by Bridge basis. One common operation for SPT Bridges operating in SPBM mode is to create a new ECT for a new VLAN. To support a graceful migration of services to a new Base VID, SPB allows the configuration of the Base VID before configuring services on those Base VIDs. The new Base VIDs in SPT Bridges need to be configured on all Bridges where the services reside. The U-bit (28.12.5) and Use-flag (28.12.4) are used to identify configured Base VIDs that do not have active services associated with them.

In the cases where the allocation of Base VIDs is insufficient a graceful way to support an increase in the number of Base VIDs is supported by a second (auxiliary) MCID (13.26.8, 28.12.2). Two such Bridges consider themselves to be in the same MST Region provided that at least one of their MCIDs matches with one of their SPB neighbor's MCIDs. Non critical changes in the MCID, can be made while maintaining forwarding on the previous configuration. This is done by configuring a Bridge with a revised VID allocation that is compatible with the current allocation in use for SPB forwarding. The Bridge advertises this new MCID and continues to advertise the previous MCID as the Auxiliary MCID, maintaining its adjacencies.

When an adjacent Bridge is similarly configured, it also advertises the new MCID as its MCID to its adjacencies. The Auxiliary MCID is always the outgoing MCID. Bridges that have not been updated will continue to match their updated neighbors' Auxiliary MCID until they have been updated, whereupon their MCID values will match again. When a Bridge sees that all its adjacencies are advertising the value of its own new MCID as their MCID, then the Bridge shall start advertising the value of its new MCID as its Auxiliary MCID also. When all Bridges have been verified to have installed the new configuration, the transfer of services to use the new VLAN allocations may be administratively initiated.

NOTE 1—The MCID verifies that each Bridge in the region agrees how each and every Base VID is to be assigned to the IST, to an MSTI, for use by PBB-TE, for support by SPBV mode, for use as an SPVID, or for support by SPBM mode. The MCID does not specify the SPT Set for VLANs supported by SPB, or preallocate SPVIDs to SPT Sets as disagreement on the former or temporary differences in the latter will not cause permanent loss of connectivity, loops, or protracted flooding. ISIS-SPB verifies that SPT Bridges agree on the SPT Set to be used to support any given SPB supported VLAN, and the Agreement Digest ensures that new connectivity is not created until that agreement has been reached.

NOTE 2—The MCID and the Agreement Digest (13.8, 28.4) can both influence the connectivity provided, and their respective roles need to be clear. MCID differences identify configuration mismatches that could cause network malfunction (e.g., data loops) if connectivity were to be created, and that are not amenable to timely resolution by normal protocol operation. MCID differences act as a fail-safe mechanism, forcing lowest common denominator connectivity (to a single spanning tree, the CST) so at least some connectivity is provided, albeit with lower throughput. The fallback connectivity can be used to investigate or correct configuration issues. The Agreement Digest and related mechanisms simply verify that delays in propagating and using protocol information do not cause loops in permitted connectivity.

SPT Regions are similar to MST Regions, and can also be modeled as single Bridges (13.5.3). They do not overlap, superset, or subset other regions but participate in the same active topology solely through the CST. Each region can be identified by its Master Port, i.e., the Bridge Port that provides connectivity from the region to a CIST Root that lies outside the region, or, in the case where the CIST Root lies within the region, by the CIST Root Bridge itself. The Master Port is uniquely and globally identified by its Bridge Identifier and Port Identifier on an SPT Bridge, and is communicated by the CIST Regional Root Identifier and its associated CIST Port Identifier fields in SPT BPDUs.

IS-IS adjacencies are formed according to IS-IS protocol rules independent of ISIS-SPB. ISIS-SPB forwarding is only allowed on a more strict basis when the MCID, Base VID, and ECT Algorithm information lines up in the SPB Hello PDUs.

When two SPT Bridge Ports attached to the same LAN have no match between their primary or Auxiliary MCIDs in transmitted SPT BPDUs, each is a Boundary Port (13.12) for its SPT Region, and forwards user data frames only if it is a CST Root Port or Designated Port. Such a network configuration is usually temporary and infrequent, a result of as yet incomplete administrative action, or simply a configuration error (13.6). To minimize network disruption during such administrative episodes, ISIS–SPB communicates information throughout an SPT Domain comprising a transitive closure of SPT Bridges attached to individual LANs.

Each SPT Bridge Port uses BPDUs and/or SPB Hello PDUs to transmit and receive MCIDs and Agreements. BPDUs also carry currently calculated CIST Information, so that all the Bridges (not just SPT Bridges) attached to each individual LAN can be detected and can participate in the information exchange required at SPT Region boundaries. SPT BPDUs or SPB Hello PDUs also convey the CIST Agreement and Agreement Digest information that SPB uses to prevent temporary loops (28.4). This Agreement information can only be sent after the Bridge's ISIS-SPB calculations have been used to modify its FDB entries, and is thus not naturally tied to the transmission of the ISIS-SPB Link State PDUs (LSP)s that convey the adjacency information that makes those calculations possible (LSPs can be disseminated throughout the SPT Domain without waiting for any single Bridge to complete its calculations—each proceeding in parallel). Including the Agreement information in the SPT BPDUs helps determine the SPT Region's extent, ensuring backwards compatibility to non SPT Bridges. Exchanging SPB Hello PDUs (to establish adjacencies) and transmitting ISIS-SPB LSPs (to propagate information for SPT Identifier allocation and SPT calculation throughout the SPT Domain) as soon each Bridge Port is MAC_Operational is supported in parallel with BPDUs. Bridges that are not SPB-capable will not support SPB Hello PDUs and it is up to the SPT BPDU logic to determine what type of spanning tree protocol the non-SPT Bridges support. In most networks the SPT Region's boundary will coincide with that of the SPT Domain, in other cases LSPs for those Bridge Ports that bound a region but lie within the domain might have to be transmitted.

NOTE 3—Clause 13 specifies the state machines and procedures that determine each SPT's region boundaries, including interoperability with Bridges implementing STP (Clause 8 of IEEE Std 802.1D, 1998 Edition [B11]), RSTP, or MSTP as well as the use of SPT BPDUs to address other error conditions that can occur (e.g., disputes with other Bridges due to one-way connectivity).

27.5 ISIS-SPB information

ISIS-SPB can be viewed primarily as a means of sharing information between nodes in a network, providing each node with a copy of a common database of information contributed by each and every node, and ensuring (with high probability) that the copies are kept up to date though not necessarily in lock step synchronization. Each node can then execute its own independent copy of one or more previously agreed algorithms that use that node's copy of the database to compute results that are common to all the nodes, or that are part of a common or complementary set. The result is a set of forwarding tables for each node. ISIS-SPB shares information throughout an SPT Domain so that any given SPT Bridge in the domain can calculate or identify the following:

a) The CIST connectivity provided to each SPT Bridge in the domain (27.6, 27.7). This calculation identifies each of the SPT Regions within the domain (if more than one, 8.9, 13.6), the Bridges in each region, and the CST connectivity between regions.
b) The SPB connectivity provided by each SPT Set between Bridges in the given Bridge's region (27.8).
c) The SPVIDs (for SPBV mode) and SPSourceIDs (for SPBM mode) used to support SPB connectivity (27.10).
d) The VLAN connectivity provided for each Base VID over the calculated tree(s) (27.13).
e) The connectivity provided for each I-SID by the SPT Bridge over the calculated tree(s) (27.16).

27.6 Calculating CIST connectivity

ISIS-SPB calculates CIST connectivity (13.4.1, 13.5.3) using the following information from each Bridge in the SPT Domain:

a) The Bridge Identifier and, if the Bridge has currently selected its CST Root Port using information received from a Bridge that is not in the SPT Domain:
   1) The CIST Root Identifier and CIST External Root Path Cost.
b) The Port Identifier and the following information for each of the Bridge's Ports:
   1) Its IS-IS adjacencies, i.e., a list of the Bridge Identifier, Port Identifier tuples that identify each of the other SPT Bridges attached to the same LAN.
   2) Whether the Bridge Port is or is not a Boundary Port (13.12).
c) For each of the Bridge's Ports that is not a Boundary Port:
   1) The Internal Port Path Cost.
d) For each of the Bridge's Ports that is a Boundary Port:
   1) The External Port Path Cost.

If the restrictedDomainRole (13.27.63) parameter is set for an SPT Bridge Port, then that port will not be selected as a CIST Root Port if the Designated Bridge for the attached LAN is not in the SPT Domain. Used arbitrarily restrictedDomainRole and restrictedRole (13.27.64) can cause lack of connectivity. If used to support the network design these parameters can speed network convergence and protect against disruption if inappropriately configured Bridges are attached. If configured for all SPT Bridge Ports, restrictedDomainRole ensures that the CIST Root and all connectivity to and from that CIST Root will be provided solely by Bridges within the SPT Domain, thus simplifying CIST calculation. An SPT Bridge implementation may choose to always set restrictedDomainRole, managing it as a read only parameter. This choice restricts network design, but can include all scenarios intended for the implementation (27.19).

The CIST calculation uses the Dijskstra algorithm to compute the same active topology that would be produced by the distributed distance vector calculation specified in 13.10. Computation begins with the best priority CIST Bridge priority vector from those that represent each of the Bridges within the domain as a potential root and from those reported as received from a Bridge outside the domain [item a1) above]. If the External Path Cost accumulated during the computation would exceed that for a Bridge selecting its CST Root Port using information from a Bridge outside the domain, then that Bridge is also marked as having been reached in spreading computation and can be the best path to further Bridges, indicating that the CST path between SPT Regions lies outside the domain (not always a temporary or undesirable result, 27.19).

NOTE 1—The purpose of defining *priority vectors* (13.9) is to allow all the components that contribute to the choice of one path or another to reach a given Bridge or LAN from the CIST Root to form part of a single metric.

Each Bridge in the SPT Domain performs the CIST calculation independently, computing and retaining the following information for use by the state machines specified in Clause 13 (13.10, 13.17, 13.36, 13.29.34):

e) The CIST root path priority vector for every Bridge Port on the Bridge and the CIST root priority vector for the Bridge.
f) The IST Port Role for each of the Bridge's Bridge Ports that is not a Boundary Port.
g) The CIST designated priority vector for each of the Bridge's Bridge Ports.

Each Bridge's CIST calculation also identifies the following:

h) The SPT Region for itself, and for each of the other Bridges in the domain.
i) The CST Port Role for each Bridge Port that is a Boundary Port for a region.

NOTE 2—Each SPT Region can be identified by the region's Master Port. Connectivity from all Bridges in a given region, R_1 say, passes through the same Boundary Port BP_{12}, to reach any Bridge in a region R_2. Recording the region and boundary port information during CIST calculation facilitates identification of the boundary Bridges.

27.7 Connectivity between regions in the same domain

If the SPT Domain has been found to comprise more than one region, then, prior to computing shortest paths, each Bridge uses the SPT Region and CST Port Role information [item h) and item i) in 27.6] computed for each Boundary Port together with the adjacency information for those ports to determine the following:

a) For each of the regions (R_2, R_3, ... say) other than the computing Bridge's own region (R_1, say), the Boundary Bridge (B_{12}, B_{13}, ...) within R_1 that provides CST connectivity to that region.

If the connectivity between regions lies outside the domain and either has (or has IST connectivity to a region that has) more than one Bridge that provides connectivity to a Bridge outside the domain, then ISIS-SPB does not have the information necessary to select a particular Boundary Bridge. Address learning (for SPBV) or registration protocols can provide the necessary information. If more than one possibility remains, an SPT Bridge using SPBM mode cannot provide connectivity between the regions.

NOTE—SPBM mode will often be configured to permit connectivity only if the entire path lies within the domain.

27.8 Calculating SPT connectivity

Each SPT Bridge uses ISIS-SPB to calculate the shortest paths from each of the Bridges [item h) in 27.6] in its own SPT Region including itself, to each of the other Bridges in that region. The information used by ISIS-SPB to perform the necessary Dijkstra calculations is a subset of that used for the CIST calculation [item a), item b1), item c1) in 27.6]. The following information is computed for each SPT and retained for use by the state machines specified in Clause 13 and 27.9, 13.17, 13.36, and 13.29.34:

a) The root priority vector for the Bridge.

and for each of the Bridge's ports that is not a Boundary Port:

b) The Port Role.
c) The designated priority vector.

and for each of the Bridge's ports that is not a Boundary Port and has a Port Role of Designated Port:

d) The best root path priority vector out of those that would be calculated, using the same ISIS-SPB information, by the other SPT Bridges.

There can be several equal cost shortest paths between any given pair of Bridges, but unless ECMP is in use, only one path between the pair can be used in a given SPT Set. Ties are broken using an algorithm (27.17, 28.5) that is independent of the order of SPT computation, that ensures that the SPTs in each SPT Set are symmetric, that allows path selection to be managed using the same variables that are used to manage active topologies in the absence of multiple paths, and that is likely to select different equal cost paths for different SPT Sets if configuration defaults are used.

When a VLAN is supported by an SPT Bridge using SPBM mode and loop mitigation (6.5.4.2, 27.14) is being used, each of the FDB entries that control forwarding for unicast frames can be created or modified as soon as the port providing the shortest path to the Bridge or end station using that address is known, without the need to use additional protocol or to complete the SPT computation. In that case, restoration of unicast connectivity after a physical topology failure is most rapidly achieved by beginning the SPT (re)computation with the SPT rooted at the calculating Bridge.

27.8.1 ISIS-SPB overload

IS-IS has an overload capability that applies to a node that does not allow transit traffic through this node for various operational reasons. This capability has also been added to ISIS-SPB [item c in 28.12.1] TLVs. Just as in normal IS-IS Overload modifies the shortest path results by not allowing Bridges with the overload bit set to be eligible to forward transit traffic. For the purpose of computing paths, any paths through Bridges with overload set are not considered shortest paths and the computation uses the remaining topology and the next shortest paths. Use of the overload condition is typically reserved for edge devices that would not benefit the network if they were to become transit switches.

In ISIS-SPB if overload were set in the only Bridge connecting an SPT Region this would result in a region split where the overload Bridge was connected to both halves of the region but traffic could not transit through the overload Bridge. Each section of the SPT Region that is split would behave normally but there would be incomplete connectivity between the split sections. ISIS-SPB would have a complete view of the region and this condition is relatively easy to detect.

27.9 Loop prevention

The state machines in Clause 13 use the calculated priority vectors and Port Roles for each tree (27.6, 27.8) to determine the tree's Port State (i.e., the setting of the per port learn (13.27.34) and forward (13.27.29) variables), and exchange SPB BPDUs or SPB Hello PDUs to convey Agreements (13.17) that allow these variables to become set for Root Ports, Designated Ports, and Master Ports without the risk of temporary loops.

The Port State Transition state machine (13.38) signals changes to the learn and forward variables for a port for the CIST through calling disableLearning(), disableForwarding(), enableLearning(), and enableForwarding() procedures. These implementation-dependent procedures prompt changes to the mechanisms that perform forwarding and/or learning for frames assigned to the CIST.

Similarly changes to forward for a port for an SPT prompt changes in the FDB entries that allow (or prevent) the ingress or egress of frames assigned to that SPT (27.13, 27.14, 27.16). In turn these prompt changes to the implementation-dependent mechanisms that use the entries to control forwarding.

These mechanisms can take time to respond to changes in learn or forward, and report their current state to the state machines (by setting the learning (13.27.35) and forwarding (13.27.30) variables) so that new connectivity on some ports can be made contingent on other ports not forwarding frames. The forwarding variable (for any given tree) is only cleared if frames assigned to that tree neither ingress nor egress the port.

27.10 SPVID and SPSourceID allocation

Each SPT Bridge uses ISIS-SPB to support the distributed allocation of SPVIDs (used by SPBV mode) and the 20-bit SPSourceIDs (used by SPBM mode), ensuring that all Bridges in the SPT Domain agree on the allocated values. The allocation protocol for these two types of identifier differs slightly, as a consequence of the differences in the number of values available and the number required for each Bridge.

Candidate values for these identifiers may be pre-configured, in some or all of the Bridges in the domain, but by default they are allocated dynamically. Each Bridge attempts to allocate the following values:

a) An SPSourceID for the Bridge.
b) An SPVID for each VLAN that is supported by an SPT Bridge using SPBV mode and for which:
    1) The Bridge is a potential source of frames, either from a protocol entity within the Bridge or by forwarding from a port on the Bridge that is a Boundary Port; or
    2) The Bridge has a pre-configured allocation, even if conflict resolution means that this allocated value is not used.

NOTE 1—Each SPT Bridge allocates an SPSourceID even if no VLANs are to be supported by SPBM mode, or the Bridge is configured not to transmit frames for those VLANs. The number of available SPSourceIDs is much greater than the number to be allocated; therefore, there is no need to complicate allocation scenarios by attempting to optimize some cases, however frequent.

NOTE 2—If the SPT Bridge does not have a pre-configured SPVID for a VLAN supported by SPBV mode, and has no need to transmit frames for that VLAN (possibly because there is no other Bridge in the domain that wishes to receive frames for the VLAN or because a VLAN Registration Entry does not allow the Bridge to transmit frames for that VLAN), then an SPVID is not allocated. These conditions can arise even if the Base VID to FID to MSTID configuration for the Bridge, and the resulting MCID, identifies the VLAN as supported by SPBV mode.

The allocation protocol resolves conflicting attempts by different Bridges. Pre-configured or dynamic allocations are communicated by the setting of the Configuration Flags in the ISIS-SPB TLV used for allocation. Conflicts for allocations of a given type are resolved by granting the allocation to the Bridge with the best priority (numerically least) Bridge Identifier (14.2.5). When the conflict occurs on an auto allocated value, the other Bridges attempt to satisfy their need for a value by changing their allocation to a new dynamically allocated value. In the case that two configured values conflict, these must be resolved by operator action. All Bridges are aware of these conflict resolution rules, so there is no need for additional protocol to confirm or announce the allocation.

Candidate values for dynamic allocation are chosen using a pseudo-random function of each Bridge's Bridge Identifier (thus reducing the chance of only one identifier being allocated each time all the Bridges transmit fresh allocation information). Values that the allocating Bridge knows to be already in use are excluded (thus ensuring that an allocation that has been in existence long enough to be included in the IS-IS database of all Bridges in the domain will not be disrupted). Assuming that the unallocated values are arranged as an ordered list, the Bridge performs a modulo operation on its Bridge Identifier by the number of free values, and selects the indicated value from the list. This operation is repeated to select the next candidate value.

NOTE 3—When a Bridge changes its allocations, i.e., allocates new values to itself as required for (a) or (b) above or releases existing values, ISIS-SPB will communicate the updated information to the other Bridges in the domain. However, the detailed transmission timing and the other contents of IS-IS PDUs is under the control of ISIS-SPB itself, and is not directly controlled by the allocation protocol. A single PDU will usually convey a number of allocation changes.

NOTE 4—SPT Bridges can use different pseudo-random candidate selection functions, without imperiling the eventual success of the protocol. Nonetheless, SPVID allocation conflicts are likely to be fewer, and more quickly resolved, if the Bridges in a domain use the same algorithm.

On first discovering an ISIS-SPB adjacency (27.2, Clause 3) an SPT Bridge does not perform any allocation before acquiring the IS-IS database. The SPT Bridge becomes aware of existing allocation through normal IS-IS operation. While acquiring the full IS-IS Database, the Bridge advertises SPSourceID = 0 in its LSPs, to indicate to other Bridges that it shall not be included in Shortest Path First (SPF) calculations. As soon as the Bridge has successfully allocated itself an SPSourceID, this allocated value shall be advertised in ISIS-SPB. If the Bridge is aware of dynamic allocations that it has been granted in the past, it may begin by retrying those allocations rather than performing a pseudo-random selection for each that is free.

Each SPT Bridge ages out the allocations, both configured and dynamic, made by other Bridges exactly as the allocation information ages out or is replaced in the IS-IS database.

Each SPT Bridge's SPSourceID can be any one of the possible 2^{20} values, of which a small number (less than 2^{10}) are expected to be used, and no exceptional provision is made for the case of a Bridge not being able to allocate an SPSourceID. If an SPSourceID is not available, frames for VLANs supported by SPBM mode are discarded.

The pool of SPVIDs are those available for allocation and reserved in the MST Configuration Table. The MCID (13.8) communicated in SPT BPDUs ensures that each Bridge in an SPT Region has agreed to the same pool of SPVIDs. A quantity of 400 SPVIDs are pre-configured for auto allocation (13.8) for small SPT networks running SPBV. Additional SPVID allocations can be made out of the remaining free VIDs. An MST Configuration Table change that extends the available SPVID pool does not disturb existing allocations, but will affect the MCID—so the connectivity between adjacent Bridges will revert to the CST representing a region boundary, unless the procedures for hitless migration of MCIDs using Auxiliary MCID (27.4.1) are followed. If a Bridge is added to a region or a new SPBV VLAN configured and there are not enough SPVIDs to satisfy the demand, any SPBV VLAN that does not have a full allocation of SPVIDs falls back to CST operation using its Base VID. When enough SPVIDs become available, either by being freed from other SPBV VLANs or by increasing the size of the SPVID pool, and an SPBV VLAN obtains a full allocation of SPVIDs it advances to SPBV operation using the SPVID set. During periods when there are insufficient SPVIDs to satisfy all SPBV VLANs, Bridges that have successfully obtained allocations of SPVIDs to SPBV VLANs must maintain them to ensure stable behavior.

27.11 Allocation of VIDs to FIDs

The allocation of SPVIDs to FIDs (8.8.8) for SPBV is a local decision, subject to the following constraints:

a) All SPVIDs (if any) supporting a given VLAN (identified by Base VID V_1, say) shall be allocated to the same FID (F_{SV1}, say).
b) SPVIDs shall be allocated to FIDs (F_{SV1}, F_{SV2}, ..) that are different from those allocated to any VLAN's Base VID (F_{V1}, F_{VN} ..).
c) VLANs supported by different SPT Sets always use different FIDs (both for SPBV and SPBM modes).
d) If the VID to FID allocation table (8.8.8) has been configured to allocate two different Base VIDs to different FIDs (F_{V1}, F_{V2}), then the SPVIDs used to support each of the VLANs identified by those Base VIDs shall be allocated to different FIDs (F_{SV1} != F_{SV2}).
e) If the VID to FID allocation table (8.8.8) configuration allocates two different Base VIDs to the same FID ($F_{V3} = F_{V4}$), then the SPVIDs shall also be allocated to the same FID ($F_{SV3} = F_{SV4}$). This is shared VLANs where two or more VLANs can share the same topology.
f) SPVIDs allocated to FID in this manner do not show up in the MCID as changed.

NOTE 1—Frames for VLANs supported by SPBM mode are always assigned to an SPT Set within an SPT Region, never to the IST, and are always identified by each VLAN's Base VID.

NOTE 2—Constraint (b) allows the active topology for any SPBV supported VLAN to be changed from the IST to an SPT Set without requiring topology change signaling.

These constraints, and the fact that the MST Configuration Table's entries for VLANs supported by SPB are not configured directly but are a consequence of configuring the relationship between Base VIDs and FIDs (8.8.8) and between FIDs and MSTIDs (8.9.3), also ensure the following:

g) SPT Bridges using SPBV and SPBM modes always use different FIDs, so SPBV learning cannot disrupt SPBM operation.
h) VLANs with shared learning constraints (expressed by allocation of a common FID) are assigned to the same SPT Set.

If all the MAC addresses for a VLAN supported by SPBM mode are those of BCBs and BEBs, then the use of different FIDs for B-VLANs supported by the same SPT Set can seem unnecessary. However, the constraints could support additional capabilities and shall be followed.

27.12 SPBV SPVID translation

An SPT Bridge Port that is a Boundary Port (13.12) translates, on both ingress and egress, the VID assigned to a VLAN that is supported by SPBV. On reception, the Boundary Port uses the VID Translation Table (6.9) to translate the Base VID received in the tag to the SPVID for the SPT rooted at that Bridge. On transmission, the Boundary Port uses the Egress VID Translation Table (6.9) to map all of the SPVIDs for that VLAN to one Base VID. The Boundary Port's VID Translation Table is also configured to prevent any local VID from being translated to a relay VID within the SPVID range.

NOTE 1—One way to prevent local VIDs within the SPVID range from being translated to relay VIDs in the SPVID range is to change the default relay VID value for these entries to the reserved value 0xFFF, which would cause these frames to be discarded.

If it has not been possible to allocate SPVIDs to support a given VLAN, no translation is performed and the frame is carried on the IST within the region using the unmodified Base VID.

If a Boundary Port's untagged or priority tagged frames belong to a VLAN supported by SPBV, the PVID for that port is set to the SPVID for the SPT rooted at that Bridge, and the port should belong to the untagged set for each of the SPVIDs for that VLAN.

Frames received on ports internal to the region are not translated, whether they carry SPVIDs or Base VIDs.

NOTE 2—A frame within any Bridge within an SPT Region is considered as being forwarded within that region. Consequently a frame that is forwarded between two Designated Ports at the boundary of a region can have its VID translated on reception, from the VLAN's Base VID to the SPVID for the VLAN and SPT rooted at the Bridge, and on transmission, back to the Base VID. Translation is not dependent on forwarding, so the frame could have been equally forwarded through a port within the region.

27.13 VLAN topology management

An SPT Bridge using SPBV mode uses Dynamic VLAN Registration entries, for each VLAN it supports, to create a VLAN topology that is the pruned subset of the active topology that connects participants in that VLAN. The VLAN registration entries thus serve to prevent both loops and unnecessary flooding of frames through Bridge Ports and LANs that cannot provide connectivity to their destinations.

Each SPT Bridge uses ISIS-SPB with the information calculated for the CIST and each SPT (27.6, 27.7, 27.8), and the following information from each Bridge in the SPT Domain with one or more Boundary Ports:

a) VLAN membership registration for each VLAN registered on a Boundary Port, subject to the registration controls defined for MVRP (11.2.3.2.3).

For each of its Bridge Ports that is not a Boundary Port, and for each VLAN supported by SPBV mode, the SPT Bridge computes the following potential values of control in VLAN registration entries:

b) Forwarded or Filtered, for the IST, for each port that is a Root Port or a Designated Port
c) Filtered, for the IST, for each port that is an Alternate Port or Backup Port
d) Forwarded or Filtered, for each SPT, for each port that is a Designated Port
e) Forwarded, for each SPT, for each port that is a Root Port
f) Filtered, for each SPT, for each port that is an Alternate Port or Backup Port

The potential control element for the CIST specifies that frames for the VLAN are to be Forwarded, if the port provides CIST connectivity to a Boundary Port that has registered the VLAN. Similarly the potential control element for an SPT Designated Port specifies Forwarded if that port provides the shortest path to a Bridge with a Boundary Port that has registered the VLAN, either directly (if that Bridge is in the same region) or via a Boundary Port that provides CST connectivity to the Bridge in another region in the domain.

VLAN Registration Entries support ingress filtering, so the potential control element always specifies Forwarded for each SPT's Root Port, thus supporting Open Host Groups (10.10.1). However, an SPVID is only allocated (27.10), to support a given VLAN over a given SPT, if frames for that VLAN can enter the SPT Region at the root of that SPT, so the potential control element might not be used.

Each SPT Bridge creates Dynamic VLAN Registration Entries using the potential control elements and the Port State variable forward (27.9) for each tree for each VLAN supported by SPBV as follows:

g) An entry for the Base VID specifies Registered for a port if:
   1) forward is True for the IST for the port and
   2) the potential control element for the port for the IST and the VLAN specifies Forwarded

   and specifies Not Registered for the port otherwise.

h) An entry for each SPVID specifies Registered for a port if:
   1) forward is True for the port for the SPT identified by the SPVID and
   2) the potential control element for the port for the SPT and the VLAN specifies Forwarded

   and specifies Not Registered for the port otherwise.

These Dynamic VLAN Registration control elements for each of the SPT Bridge's ports are subject to restrictions imposed by Static VLAN Registration Entries. Static VLAN Registration Entries shall not be administratively created for any SPVID, so the controls applied to shortest path forwarding are solely those determined at the boundaries of each SPT Region.

VLAN topology management for an SPT Bridge using SPBV, as specified in this subclause (27.13), makes use of Static and Dynamic VLAN Registration Entries that can be used with MVRP. However, their use in this clause is independent of whether MVRP is implemented or used, and does not require the Bridges in an SPT Domain to agree on its use. If MVRP is implemented and used on Boundary Ports, then MVRPDUs are transmitted and received on those ports (as permitted by the controls specified for MVRP) to exchange registration information with Bridges or end stations outside the SPT Domain.

Since SPBM mode only forwards frames whose destination and source addresses are known to ISIS-SPB, the filtering entries installed for these addresses can be used to control all forwarding for each SPBM supported VLAN. SPBM mode creates a Dynamic VLAN Registration Entry for the VLAN used by the SPT Bridge. Operators should not create Static VLAN Registration Entries for the VLAN used by SPBM mode.

27.14 Individual addresses and SPBM

Each SPT Bridge that supports SPBM mode may be configured to use loop prevention (6.5.4.1) and/or loop mitigation (6.5.4.2) for unicast frames assigned to VLANs supported by the SPT Bridge. Loop prevention is always used for multicast frames. Both loop prevention and loop mitigation use Dynamic Filtering Entries for individual MAC addresses for each VLAN supported by SPBM mode. These filtering entries serve both to implement ingress checking, effectively assigning each received frame to an SPT and ensuring that the frame is only forwarded if received on the Root Port of that tree, and to implement egress checking, ensuring that the frame is only forwarded through the port providing the shortest path to its destination.

SPBM mode uses VLAN membership configuration information distributed by ISIS-SPB to reduce the number of individual address filtering entries, i.e., {VID, Individual MAC Address} tuples that need to be made in each SPT Bridge. Entries for a given VID are made only for ports that are in the pruned subset of the active topology that connects participants in the VLAN with that Base VID.

NOTE—The reduction in individual address entries is most effective in very large SPBM-capable networks, using hundreds (or thousands) of Bridges, and hundreds of B-VLANs each covering a small subset of the Bridges, each subset supporting a number of backbone service instances. Using a large number of B-VLANs in such a network could significantly reduce the scope of the control flows used to create and maintain backbone service instances.

27.14.1 Loop mitigation

If loop mitigation is selected, each SPT Bridge can create or modify an individual address filtering entry (for a given VLAN) once the calculation of the SPT rooted at that Bridge (and in the SPT Set for that VLAN) has associated the address with one of the Bridge's ports, subject to satisfying constraints that prevent multicast loops. These constraints are those that govern the Port State transition of a Root Port to Forwarding (i.e., on setting the Port State variable forward true for SPT's Root Port, as specified in Clause 13). This subclause (27.14.1) specifies a sufficient, though not necessary way to meet those constraints. If any discrepancy exists between this summary and the Clause 13 specification, the latter takes precedence.

The Port Role Transition machine ensures that there are no disputes with the adjacent Bridge(s) with respect to the active topology, such as might arise from partial or one-way connectivity (13.21). Otherwise, the Dynamic Filtering Entry can be created or modified provided:

a) The entry was previously unused, or the operation of changing the entry ensures that no two ports can be receiving frames from or sending frames to the same {VID, Individual Address} tuple at the same time; and
b) The Static Filtering Entries that limit the propagation of the SPBM SPT-specific group addresses for that SPT have been deleted or specify Filter on all ports (27.15).

NOTE—Where a large number of SPT-specific group addresses are used, the effectiveness of loop mitigation as a strategy (for more rapidly restoring unicast connectivity after a component failure than might be achieved by using loop prevention) depends on the ability of the implementation to rapidly suspend multicast connectivity, as required by (b) above, possibly by distinguishing unicast and multicast forwarding.

27.14.2 Loop prevention

If loop prevention is selected, Dynamic Filtering Entries for individual MAC addresses for VLANs supported by SPBM mode reflect SPT Port States for both Root Ports and Designated Ports, for different SPTs in the SPT Set for each VLAN. The state machines specified in Clause 13 attempt to minimize the changes to filtering entries necessary following a network component failure by identifying conditions when the change in active topology constitutes a loop-free alternative. Otherwise, Dynamic Filtering Entries are removed as necessary as part of making the forwarding variable False, so that an Agreement Digest can be transmitted to adjacent Bridges and full connectivity restored.

NOTE—The Clause 13 state machines specify necessary conditions for creating new connectivity. These conditions can be satisfied in a number of ways, by processes that can execute in parallel in adjacent Bridges and in the same Bridge. The most effective way (time taken, resource expended) is implementation dependent, and is not specified as a set of fixed steps. For example, Static VLAN Registration Entries (or an implementation-dependent equivalent) could be used to disable forwarding to allow a fresh Agreement Digest to be sent at the earliest opportunity. Alternatively, where SPBM mode uses a large number of SPT-specific group MAC addresses to support many backbone service instances between rather fewer SPT Bridges, removing (or disabling) Dynamic Filtering Entries for individual addresses entries being used as an ingress check may be more expedient.

27.15 SPBM group addressing

When a B-VLAN is supported by an SPT Bridge using SPBM, the individual destination and source MAC addresses of each frame are those used by entities within SPT Bridges or within systems that include an SPT Bridge Component, such as BEBs (Clause 3, Clause 25). SPBM mode assigns group addresses of local significance to the SPT Domain for use by those entities. For symmetric ECT Algorithms (28.8), group addresses are assigned to source rooted trees and include an SPSourceID (27.10). Taken together each frame's B-VID and SPSourceID identify the source rooted SPT used to forward the frame. For the ECMP ECT Algorithm (44.1.2), group addresses may be assigned to one of 16 source rooted trees per bridge or to one of 16 shared trees. Group addresses assigned to source rooted trees include an SPSourceID and I-SID, and the I-SID may be associated with a Tie-Break Mask. Together the B-VID, SPSourceID, and Tie-Break Mask identify the source rooted SPT used to forward the frame. Group addresses assigned to a shared tree include the Tie-Break Mask used in root node selection, and the I-SID. The B-VID and Tie-Break Mask

together identify a particular shared tree used to forward the frame. In all cases ISIS-SPB's knowledge of the addressed group and its assigned tree allows it to create a MAC Address Registration Entry (8.8.4) for the address, restricting propagation to the pruned subset of the tree that reaches the group's members.

In particular, a distinct group MAC address is assigned to each VIP (Clause 3) for use as the B-DA of the multicast frames that it transmits into an SPT Domain. Each VIP supports a single backbone service instance, so the B-DA identifies the I–SID for each customer frame that is multicast and its transmission is confined to LANs providing connectivity between BEBs supporting that service instance.

Figure 27-2 illustrates the general format of SPBM group MAC addresses. The octet and bit ordering and identification conventions used in this figure follow those of Figure 10 of IEEE Std 802-2014 [B5]. The conventions used to encode parameters with numeric values, such as the SPSourceID or I–SID, are those used elsewhere in this standard (14.1.1): the number is encoded as an unsigned binary numeral with bit positions in lower octet numbers having more significance. The least significant and the next to least significant bits of the first octet of the address, the Individual/Group and Universally/Locally administered bits, are both set denoting a locally administered group address. The two next most significant bits compose an SPBM address type, permitting alternative uses of the remaining bits of the address.

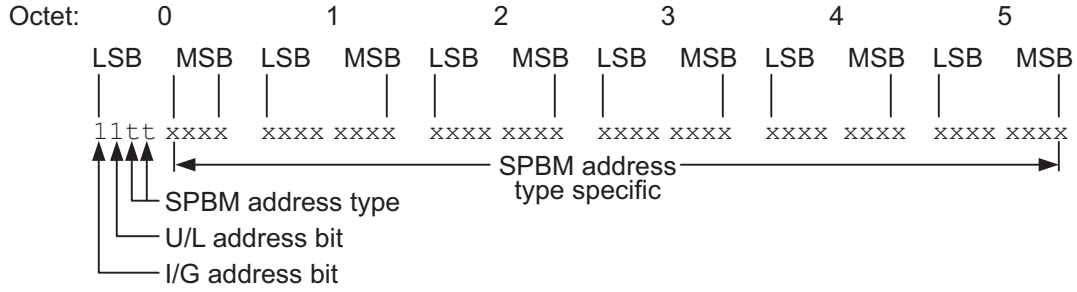


Figure 27-2—SPBM group MAC address—general format

This standard encodes the I–SID in the last three octets, and the value 0 or 1 in the address type field. Other values (2 and 3) are reserved for future standardization. The address format for group addresses assigned to a source rooted SPT is shown in Figure 27-3. In this format the SPSourceID is encoded in the first three octets.

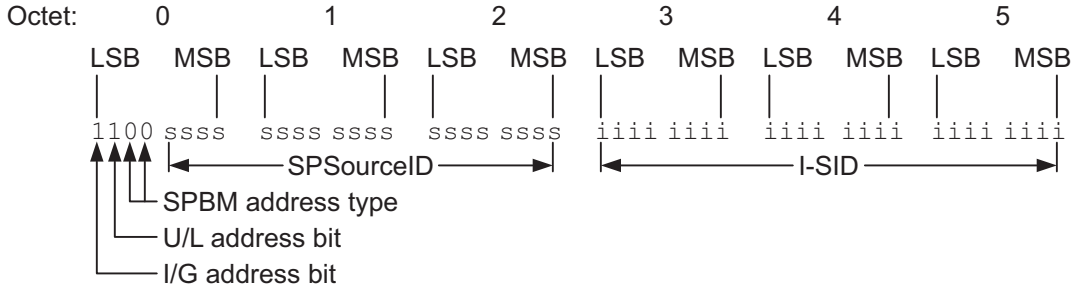


Figure 27-3—SPBM group MAC addresses—source rooted SPT

Figure 27-4 shows the format for group addresses assigned to a shared tree. Four bits of octet 2 are used to encode the Tie-Break Mask identifying the shared tree. If the same group address were to be used in two shared trees, forwarding loops could be created. The Tie-Break Mask is included in the group address so that the addresses used in different shared trees are distinct and forwarding loops are not created. The remaining bits are set to zero, leaving a substantial portion of the SPBM type 1 address space available for future use.

The use of locally assigned group MAC addresses by SPBM mode does not affect the use of the same or different group MAC addresses for other VLANs. In addition to creating and managing the required FDB entries for each specific group address (GA_{SPBM}) for any given Base VID (V_{SPBM}, say) that identifies an SPBM mode supported VLAN, an SPT Bridge using SPBM mode also manages the following entries:

— If the FDB contains a static entry specifying Forward (for any Bridge Port) for the wildcard VID and any specific group MAC address not required by this subclause (27.15) then an entry specifying Filter (for all Bridge Ports) is also created for that group address and each Base VID supported by SPBM mode.

— A Static Filtering Entry for All Group Addresses (for which no more specific Static Filtering Entry exists, (8.8.1) is created for each Base VID supported by SPBM mode, specifying that those addresses are to be filtered.

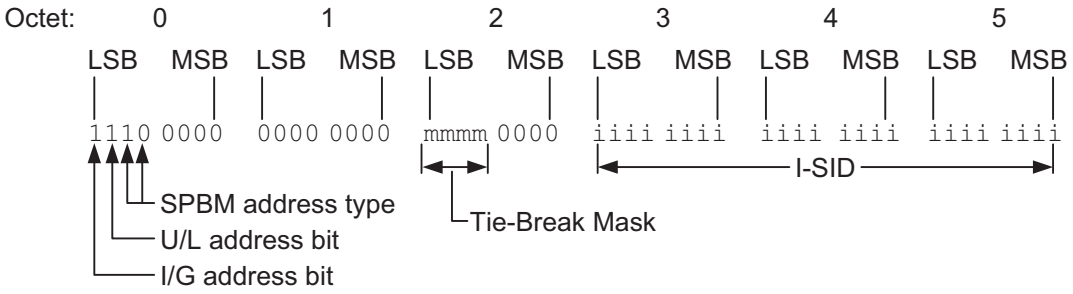


Figure 27-4—SPBM group MAC addresses—shared tree

27.16 Backbone service instance topology management

An SPT Bridge using SPBM mode uses Dynamic Filtering Entries to explicitly permit unicast communication between stations, thus restricting that communication to the shortest path between those stations. SPBM mode also uses Static Filtering Entries, for each VLAN it supports, to create a multicast topology that is the pruned subset of the active topology that connects BEBs supporting the same backbone service instance using that VLAN.

Each SPT Bridge uses ISIS-SPB with the information calculated for the CIST and each SPT (27.6, 27.7, 27.8), and the following information from each BEB in the SPT Domain:

a) I-SID membership registration for each VLAN supported by SPBM mode

For each of its Bridge Ports, for each I-SID and each SPT supporting the VLAN supporting that I-SID, the SPT Bridge computes the potential filtering control element values, Forward or Filter, for each port that is a Designated Port or Root Port. The potential control element specifies Forwarded if that port provides the shortest path to a BEB that has registered the VLAN, either directly (if that Bridge is in the same region) or via a Boundary Port (if the Bridge is in another region in the domain). A value of Filter is associated with each port that is an Alternate Port or Backup Port for the SPT.

The SPT Bridge creates a Static Filtering Entry for the VLAN's B-VID and SPBM Group Address (27.15) for the I-SID and SPT, with a control element that specifies Forward if both the potential control element specifies Forward and the Port State variable forward (27.9) is True for the SPT for the port.

27.17 Equal cost shortest paths, ECTs, and load spreading

There can be several equal cost shortest paths between any given pair of Bridges, and the paths used by the SPTs in a given SPT Set are required to be symmetric (13.1), so the local tie-breaker [the lowest ISIS Local Circuit ID on the Bridge with the best (numerically least) SPB System Identifier (Clause 3)] is only used to select between links providing alternative connectivity between immediately adjacent Bridges. Equal cost tie breaking between paths that traverse different sets of Bridges is performed by calculating a unique identifier for each path that is independent of order used to compute trees. See 28.5 for a description of the Algorithm and the tie breakers.

The capability to support multiple VLANs using different ECTs allows a network administrator to choose different equal cost paths for different services by assigning services to selected VLANs. ECMP (Clause 44) provides the capability to spread load across equal cost shortest paths using a single SPBM VID.

A set of ECT Algorithms (28.8) is specified, each using a different tie breaker. The tie-breaking rules have been selected to provide a reasonable probability that different ECT Algorithms will choose different paths from a set of equal cost paths. ECT path selection can be controlled by selection of ECT Algorithm and by adjustment of Bridge Priorities.

SPB makes use of all nodes in the SPT region for forwarding.

27.18 Connectivity Fault Management for SPBM

Connectivity Fault Management (CFM) as specified in Clause 18 through Clause 22 provides capabilities useful in detecting, isolating, and reporting connectivity faults in VID-based service instances, backbone service instances, and TESIs. As with PBB-TE, SPBM disables flooding of frames with unknown destination address. This and other changes in behavior with SPBM require some modification to VLAN CFM functions. The modifications related to SPBM are summarized here.

In particular, this subclause summarizes SPBM considerations related to the following:

a) SPBM MA types (27.18.1)
b) SPBM MEP placement in a Bridge Port (27.18.2)
c) SPBM MIP placement in a Bridge Port (27.18.3)
d) SPBM modifications of the CFM protocols (27.18.4)

27.18.1 SPBM MA types

SPBM CFM uses three types of MA: SPBM VID MAs, SPBM path MAs, and SPBM group MAs.

An SPBM VID MA operates like a VLAN MA. For example, SPBM MEPs multicast CCM frames to all other MEPs and expect to receive CCM frames from all other MEPs in an SPBM VID MA. There are minor differences from VLAN MAs, primarily in the destination addresses used for CFM frames. SPBM VID MAs can be used to monitor and diagnose SPBM connectivity.

SPBM specifies two MA types for testing forwarding state installed by ISIS-SPB for specific addresses. In SPBM path MA CCMs are used to test the path for an individual destination MAC address between a pair of endpoints. This type of MA has only two MEPs, at two SPT Region boundary ports. An SPBM path MA is identified by a TE-SID comprising an ESP in each direction between the two endpoints. In an SPBM group MA CCMs are used to test a set of multicast trees used by a backbone service instance. This type of MA has multiple MEPs, each located at a CBP supporting the backbone service instance whose multicast trees are to be tested. An SPBM group MA is identified by the I-SID whose multicast trees it tests. The path taken by CCM frames depends on the current state of the network (i.e., paths are subject to rerouting triggered by

topology changes). A CCM defect detected by an SPBM path MA or SPBM group MA may indicate a problem with the forwarding state for the MAC addresses being tested. This standard does not specify the mechanisms that would be necessary to support Loopback and Linktrace on an SPBM path MA or SPBM group MA since full Loopback and Linktrace coverage can be provided by an SPBM VID MA. Therefore, there are no MHFs associated with an SPBM path MA or SPBM group MA.

27.18.2 SPBM MEP placement in a Bridge Port

SPBM MEPs are always Up MEPs and can only be placed on CBPs as these correspond to the demarcation points of the SPT Region. The SPBM MEPs are placed between the Frame filtering entity (8.6.3) and the Port filtering entities (8.6.1, 8.6.2, and 8.6.4) in the VID space identified by the EISS Multiplex Entity (6.17). An SPBM VID MEP is placed in the same location as a VLAN MEP as shown in Figure 27-5.

Since SPBM path MEPs and SPBM group MEPs must only see traffic using specific addresses, these MEPs need to be further differentiated by the TESI Multiplex Entity (6.19). This locates an SPBM path MEP or SPBM group MEP so that it receives CCMs only from the other MEPs in its MA. Figure 27-5 also shows an example of an SPBM path MEP and SPBM group MEP on a CBP.

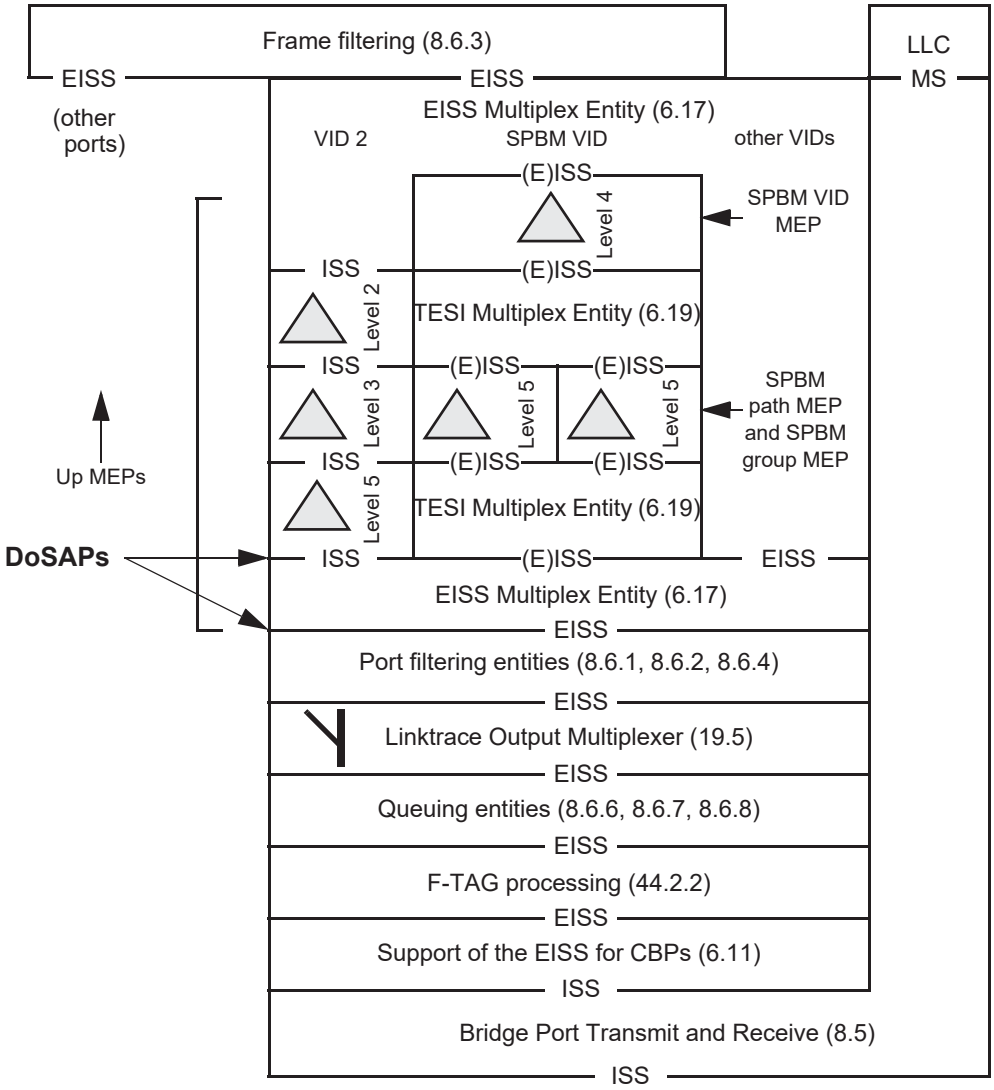


Figure 27-5—SPBM MEP placement in a CBP

27.18.3 SPBM MIP placement in a Bridge Port

SPBM MIP creation is based on the algorithm described in 22.2.3. SPBM MIPs are created per identified VIDs on PNPs. Figure 22-9 depicts an example of a pair of SPBM MHFs on a PNP.

27.18.4 SPBM modifications of the CFM protocols

27.18.4.1 Continuity Check protocol in an SPBM MA

The Continuity Check protocol is described in 20.1, and the corresponding state machines are presented in Clause 20. The modifications required to realize SPBM MAs include the following:

a) In the case of an SPBM VID MEP, the destination_address parameter is set to the group MAC address for the SPBM default I-SID (Table 9-3) for the Bridge on which the MEP is configured. In the case of an SPBM path MEP, the destination_address parameter is set to the MAC address indicated by the ESP-DA field of the ESP having in its ESP-SA field the MAC address of the MEP. In the case of an SPBM group MEP the destination_address parameter is set to the SPBM group MAC address assigned to the source MEP's CBP for the SPBM group MA's I-SID [item a) in 20.11.1].
b) In the case of ECMP with flow filtering, the flow_hash and time_to_live parameters are set [item e) in 20.11.1].

All other Continuity Check processes are the same as those for a VID-based MA.

27.18.4.2 Loopback protocol in an SPBM MA

The Loopback protocol is described in 20.2 and the corresponding state machines in Clause 20. The modifications required to realize the SPBM MA are summarized below:

a) To enable MIPs to selectively intercept LBMs that are targeting them, the PBB-TE MIP TLV (21.7.5) is inserted as the first TLV [item g) in 20.31.1] in an LBM. The format of the PBB-TE MIP TLV is described in 21.7.5 and is constructed as follows:
    1) The MIP MAC address field contains the MAC address of the MIP to which the LBM is targeted [item b) in 12.14.7.3.2].
    2) The Reverse VID field and Reverse MAC field are not used in SPBM.
b) An SPBM MHF forwards all received LBMs except those carrying a PBB-TE MIP TLV containing in their MIP MAC address field the MAC address of the MIP associated with that SPBM MHF [item f) in 20.28.1].
c) In the case of ECMP with flow filtering, the flow_hash and time_to_live parameters are set [item d) in 20.31.1].

NOTE—The MIP MAC address for an LBM does not have to be advertised by ISIS-SPB since it is only used locally to match the value provided in a PPB-TE MIP TLV.

All other Loopback processes are the same as those for a VID-based MA.

27.18.4.3 Linktrace protocol in an SPBM MA

The Linktrace protocol is described in 20.3 and the corresponding state machines in Clause 20. The modifications required to realize the SPBM MA are summarized as follows:

a) The LTMs transmitted by a MEP associated with an SPBM MA use as the destination_address parameter the MAC address indicated in the LTM management request [item c) in 12.14.7.4.2].
b) No special destination_address validation tests are performed by the ProcessLTM() procedure in the case of SPBM MAs [item c) in 20.47.1].

c) To identify a possible egress port, an SPBM MIP queries the FDB of its associated bridge using the destination_address and the vlan_identifier of the LTM as the parameters for the lookup (20.47.1.2). In the case of ECMP with flow filtering, the flow_hash value of the LTM is also used for the lookup, if required. For group addresses, LTMs can be further forwarded by SPBM MIPs even if the lookup identifies more than one Egress port.

d) In the case of ECMP with flow filtering, the flow_hash and time_to_live parameters are set [item d) in 20.42.1].

All other Linktrace processes are the same as those for a VID-based MA.

27.19 Using SPBV and SPBM modes

This subclause provides one example topology of SPT Bridges using SPBV mode and one example topology of SPT Bridges using SPBM mode.

27.19.1 Shortest Path Bridging—VID

The primary advantage SPT Bridges operating in SPBV mode bring over spanning tree protocols is the more flexible shortest path forwarding. SPBV accomplishes this by using SPVIDs and VID translation (6.9) at SPT Region boundaries. All traffic within an SPT Region always takes a shortest path. Loops are prevented by never allowing traffic to be accepted on a non symmetric shortest path and enforced with loop prevention (13.17, 6.5.4.1).

An example campus network using SPBV is illustrated by Figure 27-6. The SPT Region contains eight SPT Bridges with two RST Bridges connected to the SPT Region. All VLANs within the SPT Region are supported by the SPT Bridges. The dashed lines represent the SPT for the SPVID of a Base VID (VID10) for which Access Bridge 1 is source (root of the SPT). The solid lines to the RST Bridges indicates spanning tree forwarding. VID translation from and to the respective SPVIDs occurs on the region boundary ports SPT Bridge D port 5 and SPT Bridge E port 3. SPT forwarding makes better use of a mesh network; however, it only will use a single path per Base VID. For example the Bridge D port 2 to Bridge B port 4 link is not used by access Bridge 1 because the ECT Algorithm has chosen paths through Bridge C. If another VLAN is supported in this network the recommendation is to use a different ECT Algorithm that could choose D-B over C-B by using an appropriate tie breaker (28.8).

ISIS-SPB uses SPB Hellos to establish adjacencies within the SPT region and BPDUs to establish peering with RST Bridges. BPDUs from legacy Bridges L1 and L2 will indicate that they are able to use RSTP. Therefore, RSTP would be enabled and SPB Hello would be transmitted periodically but dropped. The ports connected to the legacy Bridges are enabled and block according to RSTP logic.

SPT Bridges using SPBV mode use the same principles as MSTP to form a logical Bridge with a CIST root port on Bridge A, which has the best (numerically least) Bridge Identifier in the SPT Region. The CIST in Figure 27-6 is a spanning tree rooted on Bridge A (not illustrated).

a) The eight Bridges in the SPT Region have the same MCID (13.8) or Auxiliary MCID (28.9).

b) The CIST is computed in the SPT Region and maintains the spanning tree root costs (13.17).

c) SPT BPDUs are exchanged by the SPT Bridges within the SPT Region (13.17).

d) VLANs identified by other than the Base VIDs are supported by the CIST (13.17).

Legacy Bridges L1 and L2 can be aware of the SPB operation of Bridges but they only support RSTP and interface to the aggregation Bridges D and E using RST BPDUs. L1 and L2 learn from the received BPDUs that aggregation Bridge A is the Designated Bridge for VLAN 10 while a Bridge somewhere above the SPT region is the CIST Root for the network. Aggregation Bridge D receives traffic from L1 but uses an SPVID and the corresponding SPT from D to reach all nodes within the region and beyond. Normal learning of MAC addresses occurs.

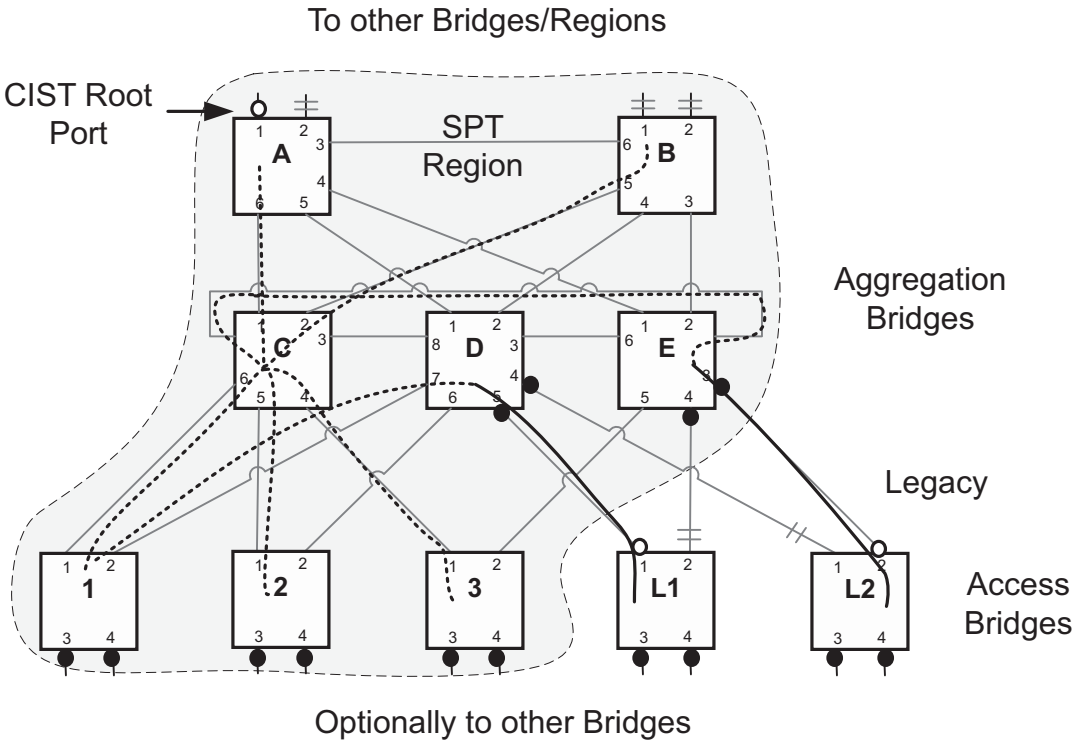


Figure 27-6—SPBV campus network example

Dynamic VLAN Registration capabilities are supported natively for Base VIDs by utilizing the link state to auto enable forwarding on intermediate Bridges. Referring to Figure 27-6, if access Bridge 1 and aggregation Bridge A were the only Bridges with VID 10 registered on their boundary ports forwarding would automatically be setup on aggregation Bridge C to complete the data path between Bridge 1 and Bridge A. Only Bridges configured with the Base VID, Bridge 1 and Bridge A require SPVIDs. MVRP for other VLANs is supported on the CIST.

MAC Address Registration (8.8.4) is supported for the Base VIDs as outlined in 28.10. Group addresses for Base VIDs are distributed in ISIS-SPB. At the region boundaries MMRP is required to propagate registration to and from the SPT Region.

Since the SPT Region follows very similar design rules as the MST Region, RSTP and STP interwork with both. SPB interworks with MSTP and other SPT Regions with MSTP.

27.19.2 Shortest Path Bridging—MAC

An example SPT Bridge network using SPBM mode is illustrated by Figure 27-7. The SPBM mode example network is divided into two major areas: the customer equipment area, which is owned by the “customer” and is connected to the SPT BEBs using C-tagged or S-tagged interfaces; and the SPT Region, which is owned by the backbone provider and interconnects to the customer equipment and possibly to other SPT Bridges. There is no visibility of either backbone topology or B-MAC addresses outside the SPT Region, and consequently connections to other SPB or PBB areas will be identical to those to customer equipment. While this is primarily leveraging the capabilities of the PBBN the emphasis is that the separation of the address spaces proved by the PBB encapsulation provided useful capabilities of scaling even larger enterprise or data center networks (DCNs) where bridging and delivery of optimized unicast and multicast frames on an S-VLAN basis is desired.

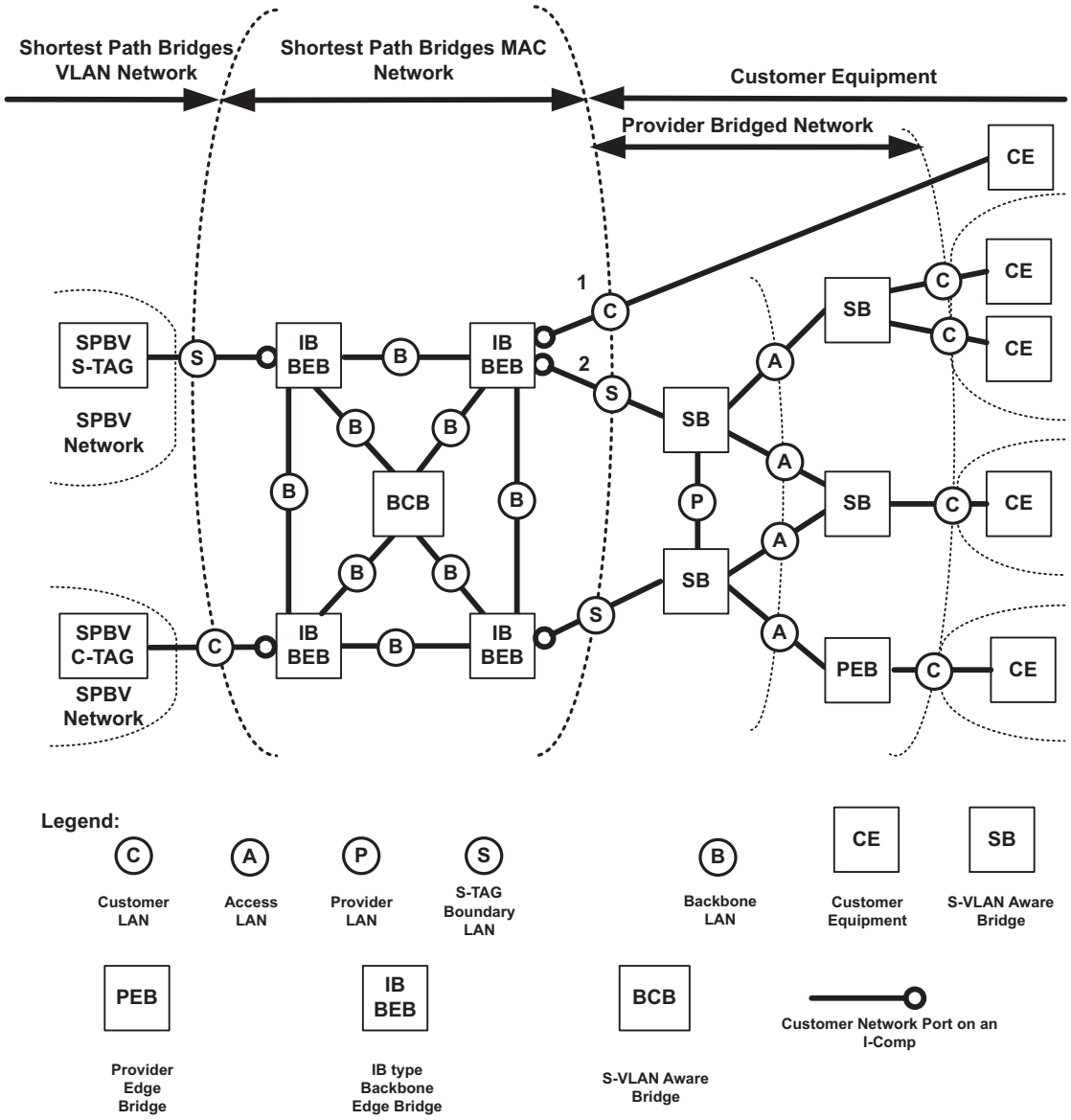


Figure 27-7—SPT Bridge Network using SPBM example

The interface between an IB BEB and a customer Bridge is a CNP of an I-Component as specified in 6.10. The interfaces between BEBs and BCBs and between BCBs and other BCBs are PNPs. In Figure 27-7, these interfaces are over LANs labeled S and B. All exterior interfaces from a SPT Bridge network using SPBM mode are over S, or C LANs; whereas all interior interfaces within a SPT Bridge network support appropriate segments of SPB SPTs, each set of which is identified by one Base VID per forwarding topology. Each individual SPT within a set is identified by the B-MAC address of its source Bridge. The S and C VLANs (exterior interfaces) are at the boundary between the SPT Bridge network and the attached customer networks.

Within the network example, BEBs, BCBs, and the SPTs for each Base VID are secured so that only the network administrator operating the SPT Bridge network can manage the reception, transmission, and relay of frames between BEBs and BCBs. The arbitrary physical network topology of the SPT Bridge network and the connectivity that it provides to support segregated instances of the MAC Service is designed and managed by the network administrator to meet bandwidth and service availability requirements at the CBPs

and PIPs. Application of the service instance ingress and egress rules at these Ports in support of service instance selection and identification ensures that frames cannot be transmitted or received on any backbone service instance by any customer's equipment without prior agreement with the administrator of the SPT Bridge network.

The active topology of the SPT Bridge network is separated from the active topology of the customer equipment area. This is accomplished by isolating the BPDUs for each customer network from the SPT Bridge network at the BEBs that surround the perimeter of the SPT Region. The ISIS-SPB LSPs and SPT BPDUs, that support the active topology of the SPT Bridge network, are only exchanged on PNPs and hence are not leaked into the customer bridged area.

B-MAC addresses are used to identify the destination BEB's PIP. These B-MAC addresses are advertised by each BEB to all other BEBs and BCBs in the SPT Bridge area in LSPs as part of the IS-IS routing exchanges. I-SID instances associated with each PIP are also advertised using the same mechanism. To perform the encapsulation and de-encapsulation of service frames, BEBs use the connection identifier stored in the FDB (8.8) to correlate C-MAC addresses to B-MAC addresses. At startup, after convergence of ISIS-SPB, the BEBs are aware of the location of B-MAC addresses in the topology, but have not learned the C-MAC addresses yet. When the C-MAC address is unknown, the BEB encapsulates the service frames using an SPBM Group address, which is analogous to the Backbone Service Instance Group address (26.4). This address is then multicast to the set of registered receivers that are those BEBs where that I-SID has been configured. The same holds true for the service frames having a group or broadcast destination address. An individual B-DA is used for forwarding unknown or group frames when the service is point-to-point and where the far end individual address is known. C-MAC addresses are learned by the provider BEB against the B-MAC address associated with the service interface on the BEB that sourced them (see Clause 25).

27.20 Security considerations

This clause contains no exceptional provisions for securing the operation of ISIS-SPB. ISIS has a number of optional capabilities that may be utilized. For example, ISIS-SPB does not prevent the use of the IS-IS Authentication TLV. If stronger security is required, IEEE 802.1AE™ MAC Security should be deployed on all SPT Bridge Ports, and the configuration of the controls provided by this standard to regulate the acceptance of spanning tree protocol information [e.g., restrictedRole and restrictedTcn (13.27.64, 13.27.65)] should be set to reflect the degree of trust (i.e., authorization) accorded to the mutually authenticated securely communicating peer Bridges. SPT BPDUs include a flag that indicates that the attached LAN is not considered to be a part of the transmitting Bridge's SPT Region: this avoids one way participation in a region if one Bridge considers the authorization of another inadequate. Use of MAC Security in this way can ensure that only authenticated and authorized (i.e., trusted) Bridges participate in a region, as well as preventing unauthorized transmission of ISIS-SPB information or user data on LANs within the region.

28. ISIS-SPB Link State Protocol

Intermediate System to Intermediate System (IS-IS) is the link state routing protocol used for SPB (Clause 27). IS-IS is easily extended to carry the required Ethernet addresses, VLAN and Service membership information introduced by SPB. IS-IS is defined in ISO/IEC 10589:2002. When used for SPB, IS-IS has no IP dependencies. IS-IS also supports Multi-Topology (MT) and logical instances for easy virtualization of the link state protocol. This subclause specifies extensions to IS-IS for SPB. IS-IS extended for SPB will be referred to as *ISIS-SPB*. The SPB extensions are additive to IS-IS and do not preclude the IS-IS protocol being used for other purposes at the same time.

In VLANs that are configured to use SPB, ISIS-SPB controls forwarding (Clause 8) of individual and group addressed MAC frames. The Agreement Protocol (13.17), utilizes the ISIS-SPB link state database along with a synchronization mechanism carried in SPT BPDUs or SPB Hello PDUs. Locally on each Bridge, the Agreement Protocol logic is used to control the ISIS-SPB FDB updates and implement loop prevention logic. ISIS-SPB uses normal IS-IS procedures to update the link state database.

IS-IS uses SPB Hello PDUs and Link State PDUs (LSPs) to communicate between SPT Bridges. This clause (Clause 28) describes the relevant TLVs in the ISIS-SPB PDUs. Note that ISIS-SPB does not add any new PDU's to IS-IS it extends the currently defined PDUs.

Figure 28-2 through Figure 28-12 (in 28.12) illustrate the new TLVs and sub-TLVs for SPBV and SPBM. Note that SPBM, since it derives from PBB has the capability to indicate Service instance membership using the 24-bit I-SIDs. A default I-SID (I-SID 0x0000ff) maps to all SPT Bridges operating in SPBM mode allowing a default broadcast and group address capability for ISIS-SPB. The default I-SID is assigned to the default ECT Algorithm (LowPATHID, 28.7). I-SID group registrations via ISIS-SPB are similar to the MMRP capability but because they are delivered by IS-IS they involve no additional messaging. Group addresses are constructed by SPBM for each service instance/source and therefore do not require explicit advertisement.

The I-SID value of 0 is reserved by SPBM and is used as a deleted or free I-SID value in the TLVs. This reserved value may be used to avoid reorganizing LSPs when only one or a few I-SIDs are changed. This provides an optimization by allowing actual deletion (shuffling of the LSP contents) to be decoupled from the ISIS-SPB updates triggered by topology changes. LSPs may be reorganized during periodic updates thereby minimizing impacts.

SPBV and SPBM will operate either within an IS-IS level 1, or an ISIS level 2. As a result the TLVs specified here may propagate either in level 1 OR level 2 LSPs. IS-IS SPBM implementations shall support level 1 and may support level 2 operations. Multi-level ISIS-SPB is, however, for further study.

NOTE—IS-IS supports point-to-point links and shared LANs; however, only point-to-point is considered for ISIS-SPB in this specification. A future revision may add shared media. Clause 13 SPB description allow both point-to-point links and shared media.

28.1 ISIS-SPB control plane MAC

ISIS-SPB makes no changes to the IS-IS control plane addressing principles. However, ISIS-SPB defines two further addresses for the propagation of LSPs besides the three addresses already reserved by ISO (see Table 8-16). ISIS-SPB differentiates itself from IS-IS for Ipv4 etc. by the contents of the SPB Hello PDUs. The most important differentiation is the NLPID value for SPB (0xC1) [Annex W] which is carried in the SPB Hello protocols supported TLV and used to decide if a given adjacency should support SPB. ISIS-SPB carries this value in the Protocols Supported TLV (129) of IS-IS.

SPB operates either stand alone within an IS-IS instance, or shares an IS-IS instance and its adjacencies with other protocols as distinguished by the appropriate Network Layer Protocol Identifiers (NLPIDs). In order to

accomplish this, ISIS-SPB may as one option use the same control plane MAC addressing as the other NLPIDs.

SPB does not advertise its NLPID on shared media interfaces.

28.2 Formation and maintenance of ISIS-SPB adjacencies

ISIS-SPB uses the IS-IS three-way handshake for IS-IS point-to-point adjacencies described in IETF RFC 5303 to form adjacencies when they can be formed. This subclause specifies the conditions under which they may be formed, and the conditions under which the link may be used for forwarding after an adjacency has formed.

a) The initial exchange of SPB Hello PDUs between a pair of IS-IS instances advertises the NLPID value(s) supported by each Bridge. If any NLPID values match, it is anticipated that an adjacency will be established to support the matched Network Layer Protocol(s).

This standard specifies subsequent behavior only for adjacencies that support SPB (NLPID value 0xC1). ISIS-SPB supports MTs, and if more than one topology is instantiated, the procedures below are applied independently to each topology instance.

b) The link supporting the adjacency is initialized to “SPB Operationally down.” This is signaled by setting the SPB Link Metric in the Link Metric Sub TLV (28.12.7) to the value $(2^{24} – 1)$. All SPB Link Metric values $< (2^{24} – 1)$ signify “SPB Operationally up,” and the value advertised is that to be used in path computation.

c) The SPB Hello PDUs exchange MCID and Auxiliary MCID (28.4) values to determine whether VLANs are consistently allocated to an operational mode. If a Bridge detects that neither its MCID nor its Auxiliary MCID match the adjacency’s MCID or Auxiliary MCID, then the adjacency cannot be put into service, and no further tests are performed until an acceptable match has been achieved.

d) After an acceptable MCID match is achieved, configuration consistency for each Base VID in the topology is verified. The SPB Base VLAN-Identifiers sub-TLV (28.12.4) carried in SPB Hello PDUs carries, for each Base VID supported,

   1) The Base VID value.
   2) The ECT-ALGORITHM identifier (OUI or CID/Index) for that Base VID.
   3) The SPB Hello Use-Flag (1-bit), set if this Bridge or any Bridge in the SPT Region is using this Base VID for traffic.
   4) The M-Bit (1 bit), which indicates SPBM mode or SPBV mode.

   Consistency is determined as follows:

   — If either the local end or the far end SPB Hello Use-Flag of the adjacency are set, then only if the respective Base VID, ECT-ALGORITHM, and Mode bits match exactly is “matched” set for that Base VID.
   — If both local end and far end SPB Hello Use-Flags are clear, then “matched” is set (to allow maintenance of the adjacency during ECT Algorithm and mode reassignment).

Only if “matched” is true for all Base VIDs in the topology is the link supporting the adjacency set to “SPB Operationally up,” and usable for forwarding.

e) Once the link supporting the adjacency has advanced to “SPB Operationally up” as above, a Bridge shall only modify the ECT-ALGORITHM or Mode bit associated with any Base VID when both the local end and far end SPB Hello Use-Flags are clear. A Bridge shall not modify the ECT-ALGORITHM or Mode bit associated with any Base VID when either local or far end SPB Hello Use-Flag is set. To do so is indicative of a serious error condition.

f) If a Bridge detects that an adjacent Bridge has altered its advertisement of the ECT-ALGORITHM or Mode bit associated with any Base VID while either the local or far end SPB Hello Use-Flags is set, it shall declare the link supporting the adjacency "SPB Operationally down."

NOTE—If the error condition arises because of aberrant behavior by a single Bridge, the condition described will be detected by all its adjacencies, and the behavior specified will cause the aberrant Bridge to be isolated from the SPT Region. This is the least damaging mitigation of such a condition.

28.3 Loop prevention

The Group Address FDB entries for SPBV and SPBM are under the control of the ISIS-SPB database exchange. Group address entries can be ensured to be loop-free when two neighboring Bridges agree never to install potentially loop-forming state derived from an unsynchronized topology in the FDB (13.17, 6.5.4.1). This occurs by allowing ISIS-SPB to exchange link state messages and remove any older FDB entries that are no longer valid to any destination. Native IS-IS does not have a method for synchronizing the removal of state from the forwarding but it does have a method for synchronizing databases. ISIS-SPB augments this by using a digest of the database and adding the FDB condition. ISIS-SPB needs two modifications from regular IS-IS.

a) ISIS-SPB needs to remove any potential loop causing forwarding entries if its link state database is not synchronized with its neighbor Bridges.
b) ISIS-SPB needs to synchronize with its neighbors Bridges before installing Group Address FDB entries to prevent any potential loops.

The Agreement Protocol (13.17) specifies how this applies to ISIS-SPB.

28.4 The Agreement Digest

The Agreement Digest specified in this clause includes a Computed Topology Digest used to determine whether a neighboring Bridge is operating with identical network topology information and thereby determine whether frames may be safely forwarded to the neighbor.

The Agreement Digest field (Figure 28-1) comprises six elements:

— The Agreement Digest Format Identifier
— The Agreement Digest Format Capabilities
— The Agreement Digest Convention Identifier
— The Agreement Digest Convention Capabilities
— The Agreement Digest Edge Count
— The Computed Topology Digest

The Agreement Digest is carried as a structured 32-byte field in the ISIS-SPB Digest sub-TLV. Byte 1 is the most significant, Byte 32 is the least significant byte.These and all parameters carried in ISIS-SPB TLVs and sub-TLVs are encoded using the "big-endian" convention, in which lower numbered bits within each byte (those to the left) have higher significance.

28.4.1 Agreement Digest Format Identifier

The Agreement Digest Format Identifier (4 bits) is carried in the most significant 4 bits of Byte 1 of the Agreement Digest field. Its purpose is to allow alternative digests to be defined at some time in the future. This release of the standard defines Digest Format 0. All future upgrades to the standard protocol will require recipients to be able to receive and process digests of this format.

	Octet	Length
Agreement Digest Format Identifier	1	4 bits
Agreement Digest Format Capabilities	1	4 bits
Agreement Digest Convention Identifier	2	4 bits
Agreement Digest Convention Capabilities	2	4 bits
Agreement Digest Edge Count	3–4	2
Reserved (set to 0)	5–12	8
Computed Topology Digest	13–32	20

Figure 28-1—Agreement Digest field format

The Agreement Protocol (13.17) will not declare a topology match if the recipient does not support the Format value of this field, but otherwise it will operate as normal, so that the transmitter will receive an indication of the Digest Format Identifier and Capabilities of the receiver as a result of normal protocol operation.

28.4.2 Agreement Digest Format Capabilities

The Agreement Digest Format Capabilities (4 bits) is carried in the least significant 4 bits of Byte 1 of the Agreement Digest field. Its purpose is to allow alternative digest Formats to be defined and advertised at some time in the future. In this version of the standard it is transmitted as value 0 and ignored on receipt.

28.4.3 Agreement Digest Convention Identifier

The Agreement Digest Convention Identifier (4 bits) is carried in the most significant 4 bits of Byte 2 of the Agreement Digest field. Its purpose is to advertise the set of loop-free forwarding rules, for which the link state database information identified by the Digest acts as input, which are currently in use by the transmitter (13.17). The following rules are defined in this version of the standard:

— 1. indicates no digest match. Digests are exchanged but match is not required. Configured as off (Clause 17).

— 2. means the transmitter will continue loop-free forwarding of both multicast and unicast traffic either only after any change which occurs has been reflected in matched digests (strict agreement); or up to the limits of change specified by the rules in this version of the standard. This is the default. Configured as loopFreeBoth (Clause 17).

— 3. means the transmitter will continue loop-free forwarding of multicast traffic up to the limits of change specified by the rules in this version of the standard, and will continue forwarding of unicast traffic unconditionally. Configured as loopFreeMCastOnly (Clause 17).

NOTE—While it is recommended that all Bridges use the same convention, Bridges operate independently and the conventions can be different on individual Bridges. For loopFreeBoth and loopFreeMCastOnly as indicated, a Bridge may block all the respective traffic on change or allow “safe” traffic during change. Individual Bridges can have different definitions of “safety” applied to the forwarding allowed during digest mismatch.

28.4.4 Agreement Digest Convention Capabilities

The Agreement Digest Convention Capabilities (4 bits) is carried in the least significant 4 bits of Byte 2 of the Agreement Digest field. Its purpose is to advertise the set of loop-free forwarding rule conventions that are understood by the transmitter. The value 0 declares that the transmitter understands conventions 1 to 3 (above). Bridges conforming to this version of the standard transmit the value 0 and ignore this field on receipt.

28.4.5 Agreement Digest Edge Count

The Agreement Digest Edge Count (16 bits) is an unsigned integer carried in Byte 3 and Byte 4 of the Agreement Digest field. Its purpose is to provide one component of the Agreement Digest, which is simple to compute and powerful in detecting many simple topology mismatches.

This value is the sum modulo 2^{16} of all Edges in the SPB topology. Each point-to-point physical link is counted as two Edges, corresponding to its advertisement by ISIS-SPB in an LSP flooded from either end of the link.

If more that one ISIS-SPB topology is configured, the Agreement Digest Edge Count accumulates all Edges in all configured topologies. If Edges are absent in a particular topology, they have the value 0 for this summation.

NOTE—MT SPB allows different Link Metrics to be used in different topologies. The Agreement Digest format specified here can only achieve a match between topologies when exactly the same set of Bridges are present in all topologies but the requirement that MCIDs match for all Bridges in an SPT Region means that this is not an additional constraint.

28.4.6 The Computed Topology Digest

The overall procedure for constructing the Computed Topology Digest is to:

— Form a signature of each Edge in the topology by computing the MD5 hash (IETF RFC 1321 [B20]) of the significant parameters of the Edge, as defined below.

— Compute the Digest as the arithmetic sum of all Edges in the topology.

If more than one topology is declared in ISIS-SPB, the Computed Topology Digest covers all topologies declared, and this single value is advertised in the ISIS-SPB Digest sub-TLV. The SPB Digest sub-TLV is carried within the MT-Port-Cap TLV [IETF RFC 6165] with the MTID value of 0, which in turn is carried in an SPB Hello PDU.

NOTE 1—MD5 is widely reported to be cryptographically weak. This is not relevant in this application. What is required is a function exhibiting good avalanche properties such that signatures with potentially very similar input parameters have an infinitesimal probability of collision.

NOTE 2—This strategy allows the Digest to be incrementally computed when the topology changes, by subtracting the signatures of vanished Edges from the Digest and adding the signatures of new Edges. In general, the signature of an Edge therefore needs only to be computed once, when it is first advertised.

The input message to the MD5 hash for each Edge is constructed by concatenating the following fields in order, with the first field being the beginning of the message.

a) The Bridge Identifier (13.26.2) of the Bridge advertising the Edge with the greater Bridge Identifier value (8 bytes).
b) The Bridge Identifier of the Bridge advertising the Edge with the lesser Bridge Identifier value (8 bytes).
c) A variable number of 8-byte 3-tuples, one 3-tuple for each MTID (Clause 3) declared in ISIS-SPB. The 3-tuples are declared in descending order of MTID value, with the largest MTID declared first.

Each 3-tuple is constructed by concatenating the following fields in the order below:

d) A 2-byte field containing the 12-bit MTID value [IETF RFC 5120] in the least significant bits, with the most significant 4 bits of the field set to zero.
e) The SPB Link Metric [item c) in 12.25.6.1.2] for the Edge in this topology that has been advertised by the Bridge with the greater Bridge Identifier value (3 bytes).
f) The SPB Link Metric for the Edge in this topology that has been advertised by the Bridge with the lesser Bridge Identifier value (3 bytes).

If an Edge is not present in a topology, its SPB Link Metric is set to zero in that topology.

The value of the Computed Topology Digest is the arithmetic sum of all of the signatures returned by presenting every Edge message to MD5, treating the signature as an unsigned 16-byte integer and accumulating into a 20-byte integer. Every physical link is seen as two Edges, one advertised by each Bridge comprising the adjacency, and formally the Computed Topology Digest includes both.

NOTE 3—Although the Computed Topology Digest contains signatures for both Edges associated with each link, the construction defined above means that these are always identical. An implementation may choose to compute a single signature per link, and then double it before accumulating it into the Computed Topology Digest.

The value of the Computed Topology Digest is placed in Bytes 13 to 32 of the Agreement Digest field for transmission in the ISIS-SPB Digest sub-TLV.

Bytes 5 to 12 of the Agreement Digest field are unused in this version of this standard. They are set to zero on transmission and ignored on reception.

28.5 Symmetric shortest path tie breaking

When performing shortest paths computation there may be several equal cost shortest paths between the same Bridge pairs (27.17). In order to meet the congruency requirements, SPB requires that the computation produces a deterministic unique shortest path per SPT set independent of order or direction of computation.

The SPB symmetric (Clause 3) shortest path tie-breaking algorithm needs to be accurately specified or different versions of SPB would compute different SPTs. SPB requires symmetry and congruence in its unicast and multicast routing, so the operation of the algorithms defined for the base specification and constraints on their future extension are specified unambiguously.

NOTE—Exploration of path computation that produces various types of ECTs is beyond the scope of this standard.

Two mechanisms are used to provide for symmetric and congruent SPT calculation. The first mechanism addresses the possibility that different ends (nodes) of an adjacency advertise different values for the SPB Link Metric (28.12.7). To maintain determinism, the SPB shortest path calculation always uses the maximum of the two advertised SPB Link Metric values when accumulating path costs. The second mechanism addresses the situation in which two equal cost paths are found. To maintain determinism in this case, a tie-breaking algorithm is required that achieves the same result regardless of order of computation.

SPB is designed to support many tie-breaking algorithms for ECTs, and SPBM can assign traffic by I-SID to different B-VIDs assigned to different ECTs. SPB defines one required tie-breaking algorithm and an open framework for the creation of a very large number of additional algorithms. As part of the base standard, a number pre-defined tie-breaking algorithms are described using this framework with extensions for expansion in the future.

SPB accomplishes basic equal cost tie breaking by logically assigning a computation-order-independent identifier to each possible equal cost shortest path that it computes. This tie breaking is symmetric because it is independent of which direction the selection is done and it preserves reverse path congruency. This is referred to as the Path Identifier (PATHID). A PATHID is defined as the sorted list (ascending lexicographic order) of Bridge IDs that the path traverses including the endpoints.

When there are different equal cost shortest paths output by the SPF computation, each of them will have a unique PATHID. The PATHID for each distinct path will be the same whichever Bridge computes that PATHID. The PATHID will be the same for both the forward and reverse of a path (because they are sorted lists of Bridge-IDs). PATHIDs may be ranked and compared by successively comparing the sorted list of Bridge-IDs they contain. PATHID A is ranked “less than” PATHID B if it contains fewer Bridge-IDs:

e.g.: {9,15,22} < {7,8,9,10,22}

PATHID A is ranked “less than” PATHID B (of equal length) if its i’th Bridge-ID is less than B’s i’th Bridge-ID and all other Bridge-IDs up to the i’th are equal (lexicographic order).

e.g.: {9,15,22,99} < {9,15,22,100}

Both SPBV’s and SPBM’s default tie-breaking algorithm picks the equal cost path with the lowest PATHID as defined in the above ranking.

The above algorithm can be easily implemented efficiently by simply back tracking the two or more competing equal cost paths and picking the path that has the minimum PATHID between the fork and join points of the competing paths. A path selected in this manner will also be part of any longer shortest paths that transit the fork and join points, and so intermediate resolution of shortest path permutations can be performed and the state for discarded permutations need not be carried forward.

The Bridge Priority by default is the middle value equal to 8 of the 4-bit priority in the most significant part of the 2-byte field [8 × 4096 = 32 768 middle of the priority range] on all Bridges, and so does not affect the tie-breaking results. Bridge Priority can be tuned by the operator and will therefore affect the pre-defined tie-breaking algorithm(s) in a deterministic manner.

28.6 Symmetric ECT framework

Each tie-breaking method is uniquely identified by an ECT Algorithm. The ECT Algorithm is a 32-bit number that contains an OUI or CID and an index. This document specifies an initial set of SPB ECT Algorithms together with a framework for a large number of other algorithms. The OUI or CID allows organizations to specify and manage their own algorithms and behaviors and to document them independently either through the IEEE, or through other SDOs, or to keep them proprietary/experimental should they desire. The different SPB ECT Algorithms defined in this document use the IEEE 802.1 OUI (00-80-C2). Index values 1 through 16 are associated with symmetric ECT Algorithms while one additional non-ECT spanning tree algorithm is defined with Index value 0.

The ECT Algorithm is unique for an SPT Set. One or more Base VIDs may be associated with an ECT Algorithm; and this association is advertised both in LSPs to all other Bridges in the SPT region and also is exchanged in the SPB Hellos. A Base VID should not be used within the SPT region until all Bridges agree on the relationship. Temporary disagreement between the Base VIDs assigned is expected and permitted between Bridges as Base VIDs with new ECT Algorithms are configured. Disagreements are allowed when the Base VIDs is not in use. Base VIDs may share the same ECT Algorithm regardless of mode.

In SPBM, an I-SID is associated with a Base VID and thus by inference with an ECT Algorithm as well. This permits an operator to assign traffic to a certain ECT-ALGORITHM and to move it as required to achieve a degree of traffic balancing. In SPBM mode this Base VID is the B-VID directly.

In SPBV mode the Base VID shall be used to lookup and find the proper SPVID for the source under consideration during the setting of VLAN Registration Entries. A VLAN supported by SPBV can be forced to use the spanning tree of the IST in cases where the Bridges do not agree on the configuration or are short on SPVID resources.

Bridges must consider all SPT sets and populate forwarding even if they do not define a VID. An ECT Algorithm can be defined to operate using only data already advertised by ISIS-SPB (for example the Low and High PathID algorithms), or, it may require additional tuning parameters that cannot be foreseen. To accommodate a future ECT Algorithm need for tuning parameters SPB supports the concept of Opaque ECT data.

To allow for nodal- and link-based ECT behavior in future requirement the Opaque ECT data may be advertised under both SPB nodal and/or link data. The Opaque ECT data begins with the 32-bit ECT-ALGORITHM identifier but the remainder of the data format is specific to future ECT Algorithms and is therefore opaque to this document.

An example use of this framework could be as follows. Consider the tie breaking that can be done by using a minimum sum over a secondary link metric and a hash-based but deterministic assignment of such secondary metrics to every link in the network. Further consider these secondary link metrics as tunable. Initially a new value for this ECT Algorithm is assigned and registering it with the appropriate numbering authority for the OUI or CID. The hash functions that create the secondary link metrics based for example on the two Bridge-IDs at each end of the link, could be defined. Then a format for a 32-bit opaque secondary metric could be defined which would be advertised as opaque data under the link data and prefixed with the ECT-ALGORITHM index for the new tie breaker. Migration to this new tie breaker would proceed in a manner consistent with any ECT Algorithm (28.9).

28.7 Symmetric ECT

In the case of multiple equal cost paths, multiple ECTs may be computed, in fact most efficient shortest path computations like Dijkstra actually produce all shortest paths from a root, i.e., an SPF tree, and different unique trees emerge depending on the tie breaking employed at the branch points. These different trees are distinguished in the forwarding plane by using SPVIDs (SPBV) or B-VIDs and B-MAC SAs (SPBM) for each “active topology”. In order to be repeatable a unique tie breaker (ECT Algorithm) is chosen for each SPT set as described in 28.5. Typically a small number of B-VIDs would satisfy most requirements for equal cost routes in the case of SPBM.

SPBV and SPBM support a set of symmetric (Clause 3) equal cost paths between any pair of Bridges for a given SPB instance/MTID. The symmetric shortest path algorithms are identified by the ECT Algorithm using the IEEE 802.1 OUI=00-80-C2 and with Index values 0..16. Index value 0 is somewhat special in that it relates the VID used for the CIST and is not a shortest path algorithm but is instead the spanning tree algorithm. The remaining algorithms are shortest path algorithms: The LowPATHID algorithm (index = 1) is the default SPT path computation tie breaker. SPB uses LowPATHID as the default SPT tie-breaking algorithm. SPB can use any alternate tie-breaking algorithm for another ECT when it is configured. The other defined algorithms use a computed shuffle of the LowPATHID algorithm. For example the HighPATHID ECT-ALGORITHM=<OUI=00-80-C2:index = 2> is just a rank inversion, which ones-complements the Bridge-IDs prior to doing the same comparisons as the LowPATHID algorithm. The remaining 14 pre-defined algorithms have indexes 3..16 and are defined in terms of a bit mask that they XOR the Bridge-IDs with prior to finding the minimum PATHID. Since they XOR over all 8 bytes, which include the Bridge-Priority and the SPB System Identifier, these algorithms can be tuned in deterministic ways by adjusting the Bridge-Priority. SPBM can advertise a Base VID for each of these unique symmetric shortest paths through the ECT SPB Instance sub-TLV (28.12.5).

SPB assigns a unique ECT Algorithm to a Base VID in the Base VID sub-TLV (28.12.4) and the SPB Instance sub-TLV (28.12.5). To allow migration between different ECT Algorithms, further ECT Algorithm and Base VID bindings may be advertised, unused, without interfering with the operation of currently used ECT Algorithms and Base VIDs. Once Bridges are configured to support the new ECT Algorithm and share a consistent Base VID for this algorithm, the algorithm may then be used by mapping I-SIDs to the Base VID for the desired ECT Algorithm.

SPBV also assigns a unique Base VID to each ECT Algorithm; however, the actual data path VID used depends on the source. Therefore, an SPVID shall be specified in the SPVID field in conjunction with the Base VID and ECT Algorithm in the SPB Instance sub-TLV. A similar procedure can be used with SPBV to introduce a Base VID that would not carry traffic until fully configured. Then services could be switched to the new VLAN. This is no different than introducing a new VLAN on RSTP for example.

28.8 Symmetric ECT Algorithm details

The exact method applied for computing the active topology of a VLAN assigned to ISIS-SPB control is determined by the ECT Algorithm configured for the given VLAN. A set of symmetric ECT Algorithms is defined to calculate SPT Sets for SPBV or SPBM VLANs. Two ECMP ECT Algorithms (44.1.2) are defined to calculate SPTs and shared trees for ECMP (Clause 44). Five explicit ECT Algorithms (45.1) are defined for VLANs associated with Explicit Trees (Clause 45).

Each of the standard symmetric ECT-ALGORITHM values is formed using the OUI=00-80-C2 and the Index=1..16. An Algorithm Mask is specified for each Index, and is exclusive-ORed with each octet of each of the Bridge Identifiers (2 octet Bridge Priority concatenated with the 6 octet SPB System Identifier) to generate Masked Bridge Identifiers for each of the candidate paths. Given any two paths, the one chosen for a given ECT Algorithm has the lowest PATHID formed from the ranked masked Bridge Identifiers, which will necessarily include a lowest masked Bridge Priority, excluding those common to both paths. This comparison gives the greatest weight to the (masked) Bridge Priority of each Bridge Identifier, allowing the path selection to be managed/tuned without creating additional identifiers or identifier components for each Bridge. The ECT-ALGORITHM values and corresponding Masks and their effects, in terms of prioritizing path selection by Bridge Priority, are given in Table 28-1.

Table 28-1—Bridge Priority Masking

ECT-ALGORITHM	Algorithm MASK	Effect of using MASK on priority nibble
00-80-C2-01	0x00	The selected path includes Bridge with best (numerically lowest) Bridge Identifier after masking. In this case the masking 0x00 no effect and original administered Bridge priority values apply. When Bridge priority value is equal for two Bridge identifiers the lower system identifier determines the priority. (0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15).
00-80-C2-02	0xFF	The selected path includes Bridge with best priority (numerically lowest) Bridge Identifier after masking. In this case the masking 0xFF reverses the original administered Bridge priority values. When Bridge priority value is equal for two Bridge identifiers the lower system identifier determines the priority. (15,14,13,12,11,10,9,8,7,6,5,4,3,2,1,0). Read vector as administered priority 0 equals 15, administered priority 15 equals 0 and so on.
00-80-C2-03	0x88	Bridges with Bridge Priority 8 will be treated as best priority for path selection, followed by Bridge Priorities of 9, 10, 11, and so on. (8,9,10,11,12,13,14,15,0,1,2,3,4,5,6,7). Read vector as administered priority 0 equals 8, administered priority 8 equals 0.
00-80-C2-04	0x77	Bridges with Bridge Priority 7 will be treated as best priority for path selection, followed by Bridge Priorities of 6, 5, 4, and so on. (7,6,5,4,3,2,1,0,15,14,13,12,11,10,9,8). Read vector as administered priority 0 equals 7, administered priority 7 equals 0.
00-80-C2-05	0x44	(4,5,6,7,0,1,2,3,12,13,14,15,8,9,10,11)
00-80-C2-06	0x33	(3,2,1,0,7,6,5,4,11,10,9,8,15,14,13,12)
00-80-C2-07	0xCC	(12,13,14,15,8,9,10,11,4,5,6,7,0,1,2,3)
00-80-C2-08	0xBB	(11,10,9,8,15,14,13,12,3,2,1,0,7,6,5,4,)
00-80-C2-09	0x22	(2,3,0,1,6,7,4,5,10,11,8,9,14,15,12,13)
00-80-C2-0A	0x11	(1,0,3,2,5,4,7,6,9,8,11,10,13,12,15,14)
00-80-C2-0B	0x66	(6,7,4,5,2,3,0,1,14,15,12,13,10,11,8,9)

Table 28-1—Bridge Priority Masking *(continued)*

ECT-ALGORITHM	Algorithm MASK	Effect of using MASK on priority nibble
00-80-C2-0C	0x55	(5,4,7,6,1,0,3,2,13,12,15,14,9,8,11,10)
00-80-C2-0D	0xAA	(10,11,8,9,14,15,12,13,2,3,0,1,6,7,4,5)
00-80-C2-0E	0x99	(9,8,11,10,13,12,15,14,1,0,3,2,5,4,7,6)
00-80-C2-0F	0xDD	(13,12,15,14,9,8,11,10,5,4,7,6,1,0,3,2)
00-80-C2-10	0xEE	(14,15,12,13,10,11,8,9,6,7,4,5,2,3,0,1)

NOTE 1—In these algorithms, the Algorithm Mask is applied to all octets of each Bridge Identifier. Thus if two alternative paths include only Bridges with one or a few Bridge Priorities, the Algorithm Mask will still reorder their priorities for inclusion on the path as it acts on the rest of the SPB System Identifier component of the Bridge Identifier field.

NOTE 2—If the two priority bytes in the 8-byte Bridge Identifier are all equal, then all Bridges have equal priority and ECT-ALGORITHM values 00-80-C2-01 and 00-80-C2-02 are exactly Low and High PATHID as described in 28.5.

28.9 ECT Migration

For orderly migration, each Base VID to ECT Algorithm assignment also has associated flags indicating active usage of the Base VID by services. The Use-Flag in the SPB Base VLAN-Identifiers sub-TLV (28.12.4) indicates a Bridge's awareness of use of the Base VID somewhere in the SPT Region, and the U-bit in the SPB Instance sub-TLV (28.12.5) indicates local use of this Base VID. The Use-Flag in the SPB Base VLAN-Identifiers sub-TLV is carried in the SPB Hello PDU, and is set once the Bridge advertising the algorithm has started either using or seeing the use of that ECT-ALGORITHM. ISIS-SPB enforces the following rules with respect to ECT Algorithms and their usage in order to protect the SPB network from outages created by incorrect configuration. If neighbors disagree on a Base VID to ECT-ALGORITHM assignment, then use of the adjacency for SPB traffic is permitted (i.e., the SPB Link Metric may be set less than $2^{24} - 1$) only if both neighbors' Use-Flags associated with the Base VID are cleared (28.2).

If a new ECT Algorithm is implemented in all Bridges of an SPT Domain and intended to be used by a Base VID, then the assignment of the Base VID to the new ECT-ALGORITHM with Use-Flag cleared is first configured in the SPT Domain on a Bridge by Bridge basis. As soon as this configuration is complete, services (I-SIDs in SPBM or SPVIDs in SPBV) may be assigned to the given Base VID, which causes the local U-bit to be set, which will in turn cause the Use-Flag to be set for the given Base VID.

SPBV and SPBM have different migration capabilities after the introduction of a new ECT Algorithm. The following subclauses describe how SPBV and SPBM use a newly introduced ECT Algorithm.

28.9.1 Use of a new ECT Algorithm in SPBV

A new ECT Algorithm, which is implemented by each Bridge of an SPT Domain, gets to be used if it is configured to support a VLAN. In SPBV mode, the application of a new ECT Algorithm typically coincides with the introduction of a new VLAN supported by SPBV. That is, the Base VID of the new VLAN is assigned to the new ECT-ALGORITHM in the SPB Hello PDU Base VID and SPB Instance sub-TLVs (28.9). ISIS-SPB then allocates (27.10) the SPVIDs necessary for the support of the new VLAN. To support in-service upgrade from one set of VID / ECT Algorithm allocations to another, SPT Bridges allow graceful configuration of those services. Provided there is an operating SPBV or SPBM VLAN in a region, SPT Bridges can be configured within the Region for a new VLAN on a Bridge by Bridge basis. As long as the SPT Region is connected the Bridges supporting the new VLAN do not need to be directly connected.

Intermediate Bridges are capable of populating forwarding without terminating services allowing them to participate in the VLAN.

The migration of a VLAN from an old ECT Algorithm to a new ECT Algorithm can be performed by the reassignment of the Base VID of the VLAN. That is, the Base VID is assigned to the new ECT-ALGORITHM instead of the old ECT-ALGORITHM on a Bridge by Bridge basis. In SPBV the forcing of one of the Bridges Base-VIDs to use the spanning tree algorithm as opposed to another algorithm forces all of the Bridges in the SPT region using that Base VID to spanning tree. Migration can then proceed to the new Base VID assignment until the last Bridge is configured to use the new ECT-ALGORITHM. The new assignment is then propagated in SPB Hello PDU Base VID and SPB Instance sub-TLVs (28.9) by ISIS-SPB within the SPT Domain. As soon as each SPT Bridge is configured with the Base VID assignment to the new ECT-ALGORITHM, the spanning tree assignment on the last Bridge is cleared.

NOTE 1—ISIS-SPB automatically performs the allocation and release of SPVIDs during the migration. The SPVIDs allocated for the Base VID old ECT-ALGORITHM assignment are released as soon as the assignment has been broken. These SPVIDs might be then allocated for the Base VID new ECT-ALGORITHM assignment. That is, there is no need for additional SPVID allocations if a Base VID supported by SPBV is migrated from an old ECT-ALGORITHM to a new one.

NOTE 2—SPBV does not support hitless migration. That is, the migration of a VLAN from an old ECT-ALGORITHM to a new ECT-ALGORITHM may cause traffic outage.

28.9.2 Use of a new ECT Algorithm in SPBM

SPBM offers the ability to map I-SIDs to Base VIDs as a load balancing option. In topologies with multiple equal cost paths the ability to spread traffic on a per I-SID basis comes from using the Base VIDs with different algorithms as specified in this clause.

When an I-SID is configured to be associated with a Base VID, that Base VID shall be consistently associated with the same ECT-ALGORITHM throughout the SPT Domain. Once at least one I-SID has been assigned to a Base VID the U-bit is set and advertised in subsequent LSPs, which also causes the Use-Flag to be set in SPB Hello PDUs.

SPBM supports in-service migration of an I-SID from an old ECT Algorithm to a new ECT Algorithm supported by each Bridge of an SPT Domain. In order to accomplish this, two complete Base VIDs must be configured in the SPT Domain. Then an I-SID under migration can be assigned to two Base VIDs at the same time: the old Base VID (old ECT-ALGORITHM), and the new Base VID (new ECT-ALGORITHM). The U-bit (in the SPB Instance sub-TLV, 28.12.5) is set by the advertising Bridge when there is at least one service using this VID. This propagates throughout the SPT domain, and any Bridge seeing at least one U-bit set in received LSPs (signifying that the indicated Base VID is being used by a service somewhere) sets the Use-Flag in its SPB Base VLAN-Identifiers sub-TLV (28.12.4).

I-SIDs will have originally been configured to be associated with the old Base VID (28.12.10). No filtering entry is set for the new Base VID in the FDBs as there is no Transmitter set on the new Base VID yet. I-SIDs can be configured to be associated with the new Base VID. Care must be taken to ensure the new Base VID is configured in all the required places. When a particular I-SID has been added to a new Base VID, ISIS-SPB detects that the I-SID is now associated with two Base VIDs and at each location that I-SID may receive traffic on either Base-VID. During this period individual addresses are available under both Base VIDs. The setting of the R and T bits still determines whether the group addresses are populated for each Bridge supporting that I-SID in either Base VID. In other words the same rules for a single Base VID are followed but two base VIDs are temporarily in use for received traffic. Traffic is “rolled” from the old Base VID to the new one by administrative reassignment of the I-SID at each service end-point from the old to the new B-VID. This can be an atomic action, and so at any instant only one Base VID will be used by any service originating frames. The association of the I-SID to the old Base VID is removed once all I-SIDs are configured to one Base VID. Furthermore, if this is the last I-SID removed from a Base VID the U-bit is cleared (in the SPB Instance sub-TLV) for the old Base VID to ECT-ALGORITHM assignment. Eventually the Use-Flag carried in the SPB Hello PDU will be cleared when all the Bridges have been configured.

28.10 MAC address registration

ISIS-SPB creates MAC Address Registration Entries (8.8.4) for group addresses in order to reach the members of a group. The group addresses are locally administered in case of SPBM (27.16), thus, they are only significant inside the SPT Region.

ISIS-SPB also installs MAC Address Registration Entries for universally administered group addresses as they might be used by SPBV. Furthermore, ISIS-SPB provides interworking with MMRP at the Boundary Ports of an SPT Region. That is, ISIS-SPB interprets MMRPDUs received at a Boundary Port and assembles the proper ISIS-SPB TLVs in order to advertise the corresponding MAC address registration inside the SPT Region. Furthermore, ISIS-SPB assembles and issues MMRPDUs on Boundary Ports if MAC address registration needs to be propagated outside of the SPT Region.

When an MMRPDU is received on a Boundary Port, ISIS-SPB disseminates the registration by sending LSPs with an SPBV MAC Address sub-TLV (28.12.9) filled according to the registration received from the MMRPDU. The MAC Address and Base VID values shall be copied from the MMRPDU, with the R bit set and T bit cleared. The SR bits (28.12.9) are set according to the Group service requirement information carried in the MMRPDU. When processing received SPBV MAC Address sub-TLVs that have the R bit set, SPT Bridges at the boundary of an SPT Region shall check whether they should filter or forward the frames received on their Boundary Port in the VLAN for which the registration applies. If the option is to forward frames, then they also send the SPBV MAC Address sub-TLV into the SPT Region for the MAC address under registration; but set the T bit, clear the R bit and for the VID value use the SPVID allocated to the given VLAN. ISIS-SPB then creates MAC Address Registration Entries inside the SPT Region based on the SPBV MAC Address sub-TLVs. Furthermore, if the Boundary Port is in the given VLAN's member set, then ISIS-SPB assembles the proper MMRPDU and issues it on the Boundary Port.

Besides interworking with MMRP at Boundary Ports, ISIS-SPB also takes into account the Registrar Administrative Control parameters (10.7.2).

NOTE—Creation of unnecessary MAC Address Registration Entries can be prevented by using the "Registration Forbidden" parameter for the proper Ports and VLANs.

28.11 Circuit IDs and Port Identifiers

IS-IS allows the formation of multiple adjacencies between two routers. ISIS-SPB supports only a single logical adjacency per MTID. Link Aggregation allows a single ISIS-SPB adjacency to cover multiple links, and this is the only method defined in this version of this standard by which multiple links between neighbors are supported. In cases where multiple potential adjacencies exist, each pair of peers using ISIS-SPB should choose the link with the lowest Local Circuit ID on the Bridge with the better (numerically lower) SPB System Identifier as the link over which to send and receive frames.

Procedures for using multiple adjacencies are not specified by this standard.

28.12 ISIS-SPB TLVs

All SPB TLVs and sub-TLVs are described. SPBV and SPBM share most of the same TLVs. Multi-Topology (MT) [Annex W] is introduced as well, but multiple SPT instances, each supporting a different VLAN, and each using either SPBV or SPBM can be described in a single topology instance. MT instances allow different topologies to be advertised, for example if there is a desire to use different metrics since there is only a single metric scheme within a topology.

SPB adds one new TLV and several new sub-TLVs that can be added to IS-IS PDUs, as described below. The new ISIS-SPB data have been organized to support multiple topologies within a single IS-IS instance. Each of the new sub-TLVs can be included in a TLV containing a topology instance identifier (MTID) value (as per [MT]) so that the computations can operate only on sub-TLVs specific to their topology instance. The intent of MT is to support the use of multiple metric sets when required. The construction of the MCID and the Agreement Digest (13.17, 28.4) requires that all SPT Bridges in an SPT region appear in all MT instances.

All parameters carried in the ISIS-SPB (sub-)TLVs defined below are encoded using the "big-endian" convention, in which higher significance bytes and bits within each byte appear to the left of and above bytes and bits of lower significance.

28.12.1 MT-Capability TLV

The MT-Capability TLV (Figure 28-2) is a top-level TLV for LSPs that provides Multi-Topology context. It identifies the MTID for sub-TLVs in LSPs.

	Octet	Length
Type (144)	1	1
Length (2)	2	1
Overload Bit	3	1 bit
reserved	3	3 bits
MTID	3–4	12 bits

Figure 28-2—MT-Capability TLV

a) Type (8 bits) Value 144
b) Length (8 bits)

   Total number of bytes contained in the value field.
c) Overload Bit (1 bit)

   The overload bit is an ISIS-SPB MT instance-specific overload bit.
d) MTID (12 bits)

   This is used to provide the ISIS-SPB Multi-Topology context for SPB sub-TLVs. This should be 0 when there is only one topology instance.

28.12.2 SPB MCID sub-TLV

This sub-TLV (Figure 28-3) shall be included in an MT-Port-Cap TLV [IETF RFC 6165] with MTID equal to 0 in SPB Hello PDUs to announce the Bridge's MCID (13.8). This information should be the same on all Bridges in the topology being controlled by this ISIS-SPB instance. The MCID is controlled solely by configuration and is a digest of the protocol assignments for all possible VIDs. Two MCIDs are carried to allow transitions between configurations when the changes are non-critical. If neither MCID advertised by a neighbor matches either MCID on this Bridge the adjacency is a Region boundary.

	Octet	Length
Type (4)	1	1
Length (102)	2	1
MCID	3–53	51
Aux MCID	54–104	51

Figure 28-3—SPB MCID sub-TLV

a) Type (8 bits) Value 4

b) Length (8 bits)

Total number of bytes contained in the value field.

c) MCID (51 bytes)

The complete MCID defined in (13.8) that identifies an SPT Region.

d) AUX-MCID (51 bytes)

In the case of migration and where the MCID will change but in a non-critical way, this MCID contains the previous advertised MCID. The neighbor will not drop an adjacency if at least one of these MCIDs matches either of its MCIDs.

28.12.3 SPB Digest sub-TLV

This sub-TLV (Figure 28-4) shall be included in an MT-Port-Cap TLV with MTID 0 in SPB Hello PDUs. The ISIS-SPB Agreement Digest (13.26.1, 28.4) is computed based on current topology and it changes when significant topology changes. The Agreement Digest is a key input into the Agreement Protocol (13.17), which provides multicast loop prevention. During the propagation of LSPs the Agreement Digest will vary between neighbors until the LSPs are common. The digest is a summarized means of determining agreement between nodes on the distance to all multicast roots, hence is essential for loop prevention. For each SPT where it has been determined the distance to the root has changed, unsafe multicast forwarding is blocked until the exchanged digests match.

	Octet	Length
Type (5)	1	1
Length (33)	2	1
reserved	3	3 bits
V	3	1 bit
A	3	2 bits
D	3	2 bits
Agreement Digest	4–35	32

Figure 28-4—SPB Digest sub-TLV

a) Type (8 bits) Value 5

b) Length (8 bits)

Total number of bytes contained in the value field.

c) V (1 bit)

The Agreed Digest Valid Bit (13.27.7, 13.27.9). This bit is populated and read from the Agreement Logic.

d) A (2 bits)

The agreement number 0–3, which aligns with BPDUs agreement number concept (13.27.11). When the Agreement Digest for this node changes this number is updated and sent in the SPB Hello.

e) D (2 bits)

The discarded agreement number 0–3, which aligns with BPDUs agreement number concept (13.27.12). When the Agreement Digest for this node changes this number is updated. Once an Agreement has been sent it is considered outstanding until a matching or more recent Discarded Agreement Number is received.

f) Agreement Digest (32 bytes)

An Agreement Digest as described in 28.4.

28.12.4 SPB Base VLAN-Identifiers sub-TLV

This sub-TLV (Figure 28-5) is included in an MT-Port-Cap TLV in an SPB Hello PDU to indicate the ECT Algorithms for the Base VIDs (and by implication the VID(s) used on the forwarding path for each SPT Set for a VLAN identified by a Base VID) that are in use. This information should be the same on all Bridges in the topology identified by the MT-Port-Cap TLV in which it is carried. Discrepancies between neighbors with respect to this sub-TLV are temporarily allowed during reconfiguration but at all times the active Base-VIDs (as determined by the state of the Use-Flag carried in this sub-TLV) shall agree and use the same ECT-ALGORITHM.

In the case of SPBM, the Base VID is the B-VID used to forward frames. In the case of SPBV, each source uses a different SPVID and a Base VID is used for frames transmitted on the IST. One or more Base VIDs are associated with an ECT Algorithm. This structure supports multiple SPT Sets within an IS-IS topology instance for both SPBV and SPBM. It also allows ECMP (Clause 44) for SPBM and the use of Explicit Trees (Clause 45) both for SPBV and SPBM within the same IS-IS topology instance supporting the SPT Sets.

		Octet	Length
	Type (6)	1	1
	Length (6n)	2	1
ECT-VID Tuple 1	ECT Algorithm	3–6	4
	Base VID	7–8	12 bits
	U	8	1 bit
	M	8	1 bit
	reserved	8	2 bits
...			
ECT-VID Tuple n	ECT Algorithm	(6n–3)–6n	4
	Base VID	(6n+1)–(6n+2)	12 bits
	U	6n+2	1 bit
	M	6n+2	1 bit
	reserved	6n+2	2 bits

Figure 28-5—SPB Base VLAN-Identifiers sub-TLV

a) Type (8 bits) Value 6

b) Length (8 bits)

The size of the value is ECT-VID Tuples*6 bytes. Each 6-byte part of the ECT-VID tuple is formatted as described below.

c) ECT-ALGORITHM (4 bytes)

The ECT-ALGORITHM is advertised when the Bridge supports a given ECT-ALGORITHM (by OUI or CID/Index) on a given Base VID.

d) Base VID (12 bits)

The Base VID that is associate with the SPT Set.

e) Use-Flag (1 bit)

The Use-Flag is set if this Bridge, or any Bridge in the SPT Region is currently using this ECT-ALGORITHM and Base VID. The Use-Flag is calculated as the logical OR of the

U-bit values of all Bridges in the region, as found in their SPB Instance sub-TLV (28.12.5) in the link state database. This definition includes the U-bit value of this Bridge.

f) M-Bit (1 bit)

The M-bit indicates if this is SPBM when set to 1 or SPBV mode when set to 0.

g) 2 Reserved Bits set to 0.

28.12.5 SPB Instance sub-TLV

This sub-TLV (Figure 28-6) is carried within an MT-Capability TLV in the fragment ZERO LSP. It identifies the Bridge uniquely and identifies the ECT-ALGORITHM values supported by the Bridge and the Base VIDs and SPVIDs assigned to those algorithms. For SPBM, only the Base VID is valid and the SPVID is set to zero. In the case of SPBV, the Base VID is associated with the SPVID used for forwarding by the Bridge originating the TLV. There can be multiple ECT-ALGORITHM values specifying a number of ECTs. Alternatively, the ECT-ALGORITHM value can indicate that the VLAN is assigned to ECMP operation (Table 44-1) or to explicit path control (Table 45-1).

		Octet	Length
	Type (1)	1	1
	Length	2	1
	CIST Root Identifier	3–10	8
	CIST External Root Path Cost	11–14	4
	Bridge Priority	15–16	2
	reserved	17–18	11 bits
	V	18	1 bit
	SPSourceID	18–20	20 bits
	Number of Trees	21	1
VID Tuple 1	U	22	1 bit
	M	22	1 bit
	A	22	1 bit
	reserved	22	5 bits
	ECT Algorithm	23–26	4
	Base VID	27–28	12 bits
	SPVID	28–29	12 bits
...			
VID Tuple n	U	8n+14	1 bit
	M	8n+14	1 bit
	A	8n+14	1 bit
	reserved	8n+14	5 bits
	ECT Algorithm	(8n+15)–(8n+18)	4
	Base VID	(8n+19)–(8n+20)	12 bits
	SPVID	(8n+20)–(8n+21)	12 bits

Figure 28-6—SPB Instance sub-TLV

a) Type (8 bits) Value 1

b) Length (8 bits)

Total number of bytes contained in the value field.

c) CIST Root Identifier (64 bits)

The CIST Root Identifier is for SPB interworking with RSTP and MSTP at SPT Region Boundaries. This is an imported value from a spanning tree.

d) CIST External Root Path Cost (32 bits)

The CIST External Root Path Cost is the cost from the spanning tree algorithm to the Root.

e) Bridge Priority (16 bits)

Bridge priority is the 16 bits that together with the low 6 bytes of the SPB System Identifier form the Bridge Identifier. The Bridge Identifier is the spanning tree compatible Bridge identifier. This is configured exactly as specified in IEEE Std 802.1D-2004 [B12]. This allows SPB to build a

compatible spanning tree using link state by combining the Bridge Priority and the SPB System Identifier to form the 8-byte Bridge Identifier. The 8-byte Bridge Identifier is also the input to the 16 pre-defined ECT tie-breaker algorithms.

f) V bit (1 bit)

The V bit (SPBM) indicates this SPSourceID is auto allocated (27.10). If the V bit is clear the SPSourceID has been configured and shall be unique. When a Bridge joining an SPT Region has formed at least one SPB adjacency, it can discover the previously allocated SPsourceIDs and it will allocate a SPSourceID according to the allocation logic (27.10).

g) SPSourceID (20 bits)

The SPSourceID (SPBM) is a 20-bit value used to construct group MAC address (27.15) for multicast frames originating from the origin (SPT Bridge) of the LSP that contains this sub-TLV. SPSourceID may be 0 if it has not been allocated (27.10) or if there is no SPBM service configured. When SPSourceID is 0 all information pertaining to this MTID SPB instance will be distributed but not acted upon until a valid SPSourceID is populated. If the SPSourceID conflicts with another SPSourceID from another Bridge the tie-breaker rules determine the winning Bridge (27.10).

h) Number of Trees (8 bits)

The Number of Trees is set to the number of VID tuples that follow (minimum one). The following seven fields make up a VID tuple. A sequence of VID tuples can occur in any order.

1) U-Bit (1 bit)

The U-bit is set if this Bridge is currently using this ECT-ALGORITHM for I-SIDs it sources or sinks or the SPVIDs it sources. This is importantly different from the Use-Flag found in the SPB Hello, which is set if a Bridge sees other nodal U-bits are set OR it sources or sinks itself.

2) M-Bit (1 bit)

The M-bit indicates if this is SPBM when set to 1 or SPBV mode when set to 0.

3) A bit (1 bit)

The A bit (SPB) when set declares this is an SPVID with auto allocation (27.10). If the SPVID value is zero, VID will be allocated once the Bridge has synchronized the IS-IS LSPs. Neighbor Bridges can distribute the LSPs but shall not populate FDBs (forwarding) for traffic from a Bridge that has an SPVID of 0. When the Bridge allocating is synchronized with the IS-IS adjacency, it will allocate one or more SPVIDs according to the allocation logic (27.10).

4) Reserved (5 bits)

Five bits reserved for future use shall be set to 0.

5) ECT-ALGORITHM (4 bytes)

ECT-ALGORITHM is advertised when the Bridge supports a given ECT-ALGORITHM (by OUI or CID/Index) on a given VID. This declaration shall match the declaration in the SPB Hello PDU originating from the same Bridge. When migrating from one algorithm to another discrepancies between algorithm and Base VID on different Bridges are allowed if the Use-Flag is clear.

6) Base VID (12 bits)

The Base VID that associated the SPT Set via the ECT-ALGORITHM.

7) SPVID (12 bits)

The SPVID is the Shortest Path VID when using SPBV mode. In SPBM mode it is not used and should be set to 0.

28.12.6 SPB Instance Opaque ECT Algorithm sub-TLV

There are multiple ECT Algorithms defined for SPB, and in the future additional algorithms may be defined. These algorithms may use this optional sub-TLV (Figure 28-7) to carry new algorithm parameters, for example, tie-breaking data. There are two broad classes of ECT Algorithm: one which uses nodal data to break ties and one which uses link data to break ties. This sub-TLV can associate opaque data with a node.

This sub-TLV is carried in an MT-Capability TLV in an LSP (along with a valid SPB Instance sub-TLV). Multiple copies of this sub-TLV may be carried for different ECT-ALGORITHM values related to the node.

	Octet	Length
Type (2)	1	1
Length	2	1
ECT-ALGORITHM	3–6	4
ECT Information	7–(Length+2)	variable

Figure 28-7—SPB Instance Opaque ECT-ALGORITHM sub-TLV

a) Type (8 bits) Value 2

b) Length (8 bits)
Total number of bytes contained in the value field.

c) ECT-ALGORITHM (4 bytes)
ECT-ALGORITHM is advertised when the Bridge supports a given ECT-ALGORITHM (by OUI or CID/Index) on a given VID.

d) ECT Information (variable)
ECT-ALGORITHM Information of variable length.

28.12.6.1 ECMP ECT Algorithm sub-TLV

This TLV (Figure 28-8) is not required for SPBM symmetric ECT operation and is optional for SPBM ECMP. This sub-TLV can be used to advertise a Bridge Priority value (most significant 2 bytes of the Bridge Identifier) to be used in shared tree root Bridge selection (44.1.2) when using the normal Bridge Priority (13.26.2) will not produce the desired result. Since Bridge Priority influences both source rooted tree structure and shared tree root selection, this optional sub-TLV is provided for situations in which the desired outcome for both of these selections cannot be achieved using a single Bridge Priority. This sub-TLV associates an alternate Bridge Priority [item c) in 12.25.14.1.2] with a node for use with a particular Tie-Break Mask. The alternate Bridge Priority is used instead of the normal Bridge Priority when the associated Tie-Break Mask is used to select a shared tree root Bridge. This enables greater control over root Bridge selection for shared trees, when needed. This sub-TLV is carried in an MT-Capability TLV in an LSP (along with a valid SPB Instance sub-TLV).

		Octet	Length
	Type (2)	1	1
	Length	2	1
	ECT-ALGORITHM (00-80-C2-11)	3–6	4
Tuple 1	Tie-Break Mask	7	4 bits
	reserved	7	4 bits
	Bridge Priority	8–9	2
...			
Tuple n	Tie-Break Mask	(3n+4)	4 bits
	reserved	(3n+4)	4 bits
	Bridge Priority	(3n+5)–(3n+6)	2

Figure 28-8—ECMP ECT-ALGORITHM sub-TLV

a) Type (8 bits) Value 2

b) Length (8 bits)
Total number of bytes contained in the value field.

c) ECT-ALGORITHM (4 bytes)
ECT-ALGORITHM is 00-80-C2-11 for ECMP.

d) Tie-Break Mask (4 bits)

A 4-bit mask that is repeated to form a 64-bit mask used in selecting the low Bridge Identifier from a set of Bridge Identifiers. This selection process is used to select a shared tree root Bridge.

e) Bridge Priority (16 bits)

Bridge priority is the 16 bits that together with the low 6 bytes of the SPB System Identifier form the Bridge Identifier. This Bridge Priority is used to form the Bridge Identifier used to select a shared tree root bridge using the mask identified by the accompanying Tie-Break Mask field.

28.12.7 SPB Link Metric sub-TLV

This sub-TLV (Figure 28-9) is included in an Extended IS Reachability TLV (type 22) [IETF RFC 5305] or MT Intermediate Systems TLV (type 222) [IETF RFC 5120]. If this sub-TLV is not present for an IS-IS adjacency then that adjacency must not carry SPB traffic for the given topology instance. The maximum metric value ($2^{24} - 1$) signifies that the link shall not be used for SPB traffic (it is to treated as "SPB operationally down").

NOTE—In ECMP the elimination of symmetry requirements could allow the use of a different metric for each link direction; however, to maintain consistency ECMP shortest path algorithms continue to use the maximum metric value in cases where the metrics advertised by adjacent nodes for a given link are different.

	Octet	Length
Type (29)	1	1
Length (6)	2	1
SPB Link Metric	3–5	3
Number PORTs	6	1
Port Identifier	7–8	2

Figure 28-9—SPB Link Metric sub-TLV

a) Type (8 bits) Value 29

b) Length (8 bits)

Total number of bytes contained in the value field.

c) SPB Link Metric (24 bits)

This indicates SPB Link Metric the administrative cost or weight of using this link as a 24-bit unsigned number. Smaller numbers indicate lower weights and are more likely to carry SPB traffic. Only one metric is allowed per SPB instance per link. If multiple metrics are required multiple SPB instances are required, either within IS-IS or within several independent IS-IS instances. If there are multiple links the metric for all links are the same.

d) Number PORTs (8 bits)

Number PORTs is the number of Port identifiers associated with this link.

e) Port Identifier (16 bits)

Port Identifier is the unique Port identifier comprising two parts, the Port Number and the Port Priority field (13.27.47).

28.12.8 SPB Adjacency Opaque ECT Algorithm sub-TLV

There are multiple ECT Algorithms defined for SPB, and in the future additional algorithms may be defined. The SPB Adjacency Opaque ECT Algorithm sub-TLV (Figure 28-10) may be included in an Extended IS Reachability TLV (type 22) or MT Intermediate System TLV (type 222) to carry new algorithm parameters associated with an adjacency. Multiple copies of this sub-TLV may be carried for different ECT Algorithms related to the adjacency.

	Octet	Length
Type (30)	1	1
Length	2	1
ECT-ALGORITHM	3–6	4
ECT Information	7–(Length+2)	variable

Figure 28-10—SPB Adjacency Opaque ECT-ALGORITHM sub-TLV

a) Type (8 bits) Value 30

b) Length (8 bits)

Total number of bytes contained in the value field.

c) ECT-ALGORITHM (4 bytes)

ECT-ALGORITHM is advertised when the Bridge supports a given ECT-ALGORITHM (by OUI or CID/Index) on a given VID.

d) ECT Information (variable)

ECT-ALGORITHM Information of variable length.

28.12.9 SPBV MAC address sub-TLV

The SPBV MAC Address sub-TLV (Figure 28-11) is carried in an MT-Capability TLV in an LSP. It should be used for advertisement of group MAC addresses in SPBV mode. Individual MAC addresses will normally be distributed by reverse path learning, but carrying them in this sub-TLV is not precluded. It has the following format:

		Octet	Length
	Type (4)	1	1
	Length	2	1
	reserved	3	2 bits
	S-R	3	2 bits
	SPVID	3–4	12 bits
MAC Address Tuple 1	T	5	1 bit
	R	5	1 bit
	reserved	5	6 bits
	MAC Address	6–11	6
...			
MAC Address Tuple n	T	(7n–2)	1 bit
	R	(7n–2)	1 bit
	reserved	(7n–2)	6 bits
	MAC Address	(7n–1)–(7n+4)	6

Figure 28-11—SPBV MAC Address sub-TLV

a) Type (8 bits) Value 4

b) Length (8 bits)

Total number of bytes contained in the value field.

c) SR bits (2 bits)

The SR bits are the service requirement parameter from MMRP. The service requirement parameters have the value 0 (Forward all Groups) (10.12.1.7) and 1 (Forward All Unregistered Groups) defined. However, this attribute may also be missing. So the SR bits are defined as 0 not declared, 1 Forward all Groups and 2 Forward All Unregistered Groups.

d) SPVID (12 bits)

This is the SPVID and by association Base VID and the ECT-ALGORITHM and SPT Set that the MAC addresses defined below will use. If the SPVID is not allocated the SPVID Value is 0.

NOTE—If the ECT algorithm in use is a spanning tree algorithm, this value should be populated with the Base VID.

e) T Bit (1 bit)

This is the Transmit allowed Bit for the following group MAC address. This is an indication that SPBV group MAC address with SPVID of source should be populated (for the Bridge advertising this Group MAC), and installed in the FDB of transit Bridges, when the Bridge computing the trees is on the corresponding ECT-ALGORITHM shortest path between the Bridge advertising this group MAC address with the T bit set, and any receiver of this group MAC address. A Bridge that does not advertise this bit set for a group MAC address should have no forwarding state installed for traffic originating from that Bridge on other transit Bridges in the network.

f) R Bit (1 bit)

This is the Receive allowed Bit for the following group MAC address. This is an indication that SPBV group MAC addresses as receiver should be populated (for Bridges advertising this group MAC address with the T bit set) and installed when the Bridge computing the trees lies on the corresponding shortest path for this ECT-ALGORITHM between this receiver and any transmitter on this group MAC address. An entry that does not have this bit set for an group MAC address is prevented from receiving on this group MAC address because transit Bridges will not install multicast forwarding state towards it in their FDBs or the traffic is explicitly filtered.

g) MAC Address (48 bits)

The MAC Address is either a group address or an individual address. When the MAC address is a group address it declares this Bridge as part of the multicast interest for this destination MAC address. Multicast trees can be efficiently constructed for destination by populating Group Address FDB entries for the subset of the SPT that connects the Bridges supporting the multicast address. This replaces the function of MMRP for SPTs. The T and R bits above have meaning if this is a group address. Individual addresses are populated only as if the R bit was set. (Note that individual addresses could also be learned normally.)

28.12.10 SPBM Service Identifier and Unicast Address (ISID-ADDR) sub-TLV

This sub-TLV (Figure 28-12) declares an individual B-MAC address and maps I-SIDs in the context of a B-VID to that B-MAC, allowing automatic creation of efficient group trees that are subsets of the SPT rooted at the node identified by that individual B-MAC address. In a symmetric ECT environment, the I-SIDs are mapped to a B-VID that is associated with a symmetric ECT Algorithm specifying the SPT Set. In ECMP the I-SIDs are mapped to a B-VID that is associated with the ECMP ECT Algorithm, which may specify a source rooted SPT or a shared tree for group addressed frames. Multicast trees can be selected per I-SID for maximum diversity. In the case of explicit trees, the I-SID is mapped to a B-VID allocated to one of the explicit ECT Algorithms (Table 45-1), and the B-MAC can be either an Individual MAC address or null. The null value indicates that the Backbone Service Instance Group address (26.4) is used by all sources of multicast traffic onto the given I-SID in (*,G) mode on one simple tree as specified in 45.1.5. This sub-TLV is carried in an MT-Capability TLV in an LSP.

a) Type (8 bits) Value 3

b) Length (8 bits)

Total number of bytes contained in the value field.

c) B-MAC Address (48 bits)

B-MAC Address is an individual MAC address on this Bridge. It may be either the single nodal address, or may address a port or any other level of granularity relative to the Bridge. In the case where the Bridge only has one B-MAC address this may be the same as the MAC address portion

		Octet	Length
	Type (3)	1	1
	Length	2	1
	B-MAC Address	3–8	6
	reserved	9	4 bits
	Base VID	9–10	12 bits
I-SID Tuple 1	T	11	1 bit
	R	11	1 bit
	Ts	11	1 bit
	reserved	11	1 bit
	Tie-Break Mask	11	4 bits
	I-SID	12–14	3
...			
I-SID Tuple n	T	(4n+7)	1 bit
	R	(4n+7)	1 bit
	Ts	(4n+7)	1 bit
	reserved	(4n+7)	1 bit
	Tie-Break Mask	(4n+7)	4 bits
	I-SID	(4n+8)–(4n+10)	3

Figure 28-12—SPBM Service Identifier and Unicast Address sub-TLV

SPB System Identifier of the Bridge. To add multiple B-MAC addresses, this sub-TLV shall be repeated for each additional B-MAC address.

Each individual MAC address has one or more I-SIDs that are associated with this address. In PBB terms this corresponds to a PIP B-MAC address. All B-MAC addresses that are used for individual MAC addresses and for the Sources of Group MACs shall be associated with at least one I-SID. This sub-TLV is initiated by IB-BEBs.

d) Base VID (12 bits)

The Base VID identifies the B-VID and by association the ECT-ALGORITHM and SPT Set that the I-SIDs defined below will use.

e) T Bit (1 bit)

This is the Transmit allowed Bit for the following I-SID. This is an indication that a group MAC Address Registration Entry (8.8.4) for this I-SID as source should be constructed and installed in the FDB of a Bridge, if the Bridge is on the corresponding ECT-ALGORITHM path between the Bridge advertising this I-SID with the T bit set and any receiver of this I-SID. A Bridge that does not advertise this bit or the Ts bit set for an I-SID should have no forwarding state installed for traffic originating from that Bridge on other Bridges in the network.

f) R Bit (1 bit)

This is the Receive allowed Bit for the following I-SID. This is an indication that a group MAC Address Registration Entry (8.8.4) for this I-SID as receiver should be constructed and installed (for Bridges advertising this I-SID with the T bit or Ts bit set) if a Bridge lies on the corresponding path for this ECT-ALGORITHM between this receiver and any transmitter on this I-SID. An entry that does not have this bit set for an I-SID is prevented from receiving on this group MAC addresses for this I-SID because Bridges will not install multicast forwarding state towards it in their FDBs.

g) Ts Bit (1 bit)

The Ts bit indicates that this I-SID source uses a shared tree for multicast frames. The group MAC address for this I-SID source is constructed using the Tie-Break Mask and the I-SID (27.15, Figure 27-6). A group MAC Address Registration Entry (8.8.4) is installed in any bridge on the

shared tree, selected by the Tie-Break Mask, between the advertising bridge and bridges that have the R bit set for the same I-SID. If both the T bit and Ts bit are set, the Ts bit takes precedence. This bit is ignored by ECT-ALGORITHM values in Table 28-1.

h) Tie-Break Mask (4 bits)

A 4-bit mask that is repeated to form a 64-bit mask used in selecting the low Bridge Identifier from a set of Bridge Identifiers. This selection process is used in multicast tree calculations to select a shared tree root Bridge and parent nodes in SPTs where equal cost paths are available. This field is ignored by ECT-ALGORITHMs in Table 28-1.

i) I-SID (24 bits)

I-SID is the 24-bit group service membership identifier. If two Bridges have an I-SID in common, intermediate Bridges on the unique shortest path between them will create forwarding state for the related B-MAC addresses. They will also construct multicast forwarding state using the I-SID and the Bridge's SPSourceID to construct a multicast DA. Each I-SID has a Transmit (T) and Receive (R) bit that indicates if the membership is as a Transmitter/Receiver or both (with both bits set). In the case where the Transmit (T) and Receive (R) bits are both zero, the I-SID is ignored (this forces a point-to-point capability that does not require Group address installation, but the advertised individual B-MAC address shall be processed and installed if required on the SPT). If more I-SIDs are associated with a particular B-MAC address than can fit in a single sub-TLV, this sub-TLV can be repeated with the same B-MAC address and MTID but with additional I-SID values. I-SID values can be in any order. Duplicate I-SIDs for a B-MAC address are allowed (within a sub-TLV, across two or more sub-TLVs, across two or more LSP fragments, or even across two or more LSPs). If the duplicates are in different B-VIDs, they are processed; otherwise, the T and R bits processed are the logical OR of the T and R bits of the two entries and it is processed as a single entry. (I-SID=0 is an exception that is always ignored, and allows a fast method to remove an I-SID without restructuring all the LSPs). Repacking an LSP (when I-SID=0 entries should be collapsed) can be done by moving entries from the high end into the empty I-SID=0 entries. To avoid outages temporary duplicates are allowed during this repacking and the entry further up in the LSP may later be removed without impact. The I-SID value 0x0000ff is reserved for SPB broadcast to all Bridges.

Item d), item h), and item i) are set to zero on transmit and ignored on receipt for SPBM symmetric ECT operation.

29. DDCFM operations and protocols

29.1 Principles of DDCFM operation

Data-driven and data-dependent connectivity fault management (DDCFM) comprises tools to facilitate the diagnosis and isolation of data-driven and data-dependent faults (DDFs) in Virtual Bridged Networks. This clause describes the functions of DDCFM and how they can be operated and managed. DDCFM is an extension to CFM specified by Clause 18 through Clause 22. As in the case of CFM, DDCFM capabilities can be used in networks operated by multiple independent organizations, each with restricted management access to others' equipment.

29.1.1 Data-driven and data-dependent faults (DDFs)

There are two broad types of faults in Virtual Bridged Networks that affect only certain frames or sequences of frames. Simple data-dependent faults are those that result in the repetitive loss or misdirection of each of those frames, independently of any other frames, and are usually the result of simple misconfiguration or of a failure to appreciate the consequences of a configuration option (installing protocol-specific filters, for example). Data-driven faults are more complex: the presence (or absence) of some data frames causes or contributes to the loss of other frames. While the services supported by Virtual Bridged Networks are conceptually data independent, the use of data-driven techniques enables enhanced service delivery. To give three examples: multicast frame filtering and consequent bandwidth saving is facilitated by Internet Group Membership Protocol (IGMP) snooping; stateful firewalls are used to protect users connected to managed services; and efficient allocation of frames to the individual links of an aggregation (IEEE 802.1AX Link Aggregation) is often based on spotting conversations by looking at frame data.

29.1.2 Basic principle to diagnose and isolate DDFs

The basic principle to diagnose DDFs is to isolate them to a small enough segment of the network, such as a Bridge Port, a member port of Link Aggregation Group (LAG) within a Bridge Port, or a LAN. Once DDFs are isolated, understanding the cause of the fault at this location becomes much easier.

The basic procedure to achieve isolation of a DDF is to divide the network into segments and determine whether certain data frames can traverse through each segment as expected. When a network segment is identified as faulty, the segment is further divided into smaller segments until a Bridge, a Bridge Port, or a member port of LAG within a Bridge Port is identified as not passing data frames as expected.

A DDF may not be apparent in the absence of live traffic (that is, when test data are used). DDCFM is designed to carry out the diagnosis while live traffic is being exchanged.

DDCFM facilitates diagnosis and consequent isolation of DDFs with the following two techniques: forward path test (FPT) and return path test (RPT).

29.1.2.1 Forward path test (FPT)

The goal of FPT, as depicted in Figure 29-1, is to determine whether specified data frames (frames associated with a service instance, or data frames with certain destination addresses or VID, etc.) can reach a particular location (which could be a Bridge Port, or a member port of LAG within a Bridge Port) without error. FPT's Reflection Responder (RR) (29.2.2) reflects the identified data frames (e.g., a service instance or selected data frames) to a specific target location, which could be an end station, a Bridge, or a test device. The data frames to be reflected can also be continued to their original destination(s). This option, called the Continue option throughout this standard, is to support testing of a data stream in a manner transparent to the application sourcing or sinking that data stream.

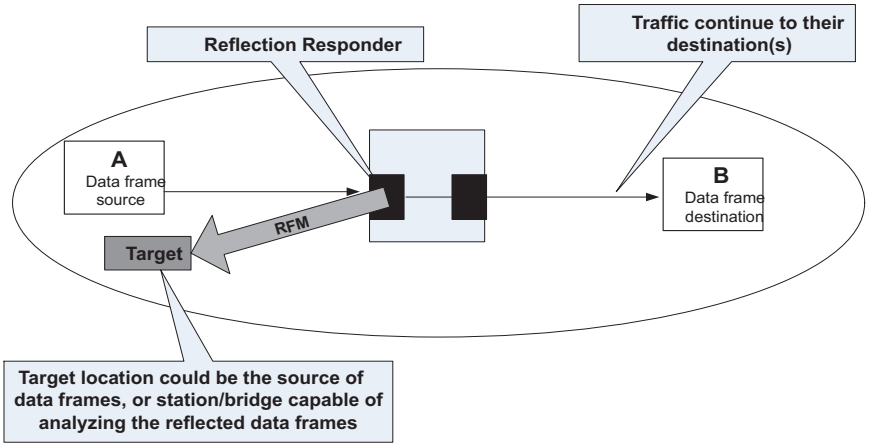


Figure 29-1—Forward path test (FPT)

FPT can be configured on ports where no MPs exist. However, when they are implemented within MPs or configured on ports with MPs, better fault isolation can be achieved. For example, if the target location does not receive the expected reflected data frames in the specified time span, it can send a LBM (21.7) to verify the connectivity between the Target location and the MP on which the RR (29.2.2) is configured. For a network that supports MEPs but not MIPs, FPT can be used to diagnose segment connectivity by configuring an RR on an intermediate node to encapsulate the received CCM in RFM format (29.4.2) and forward them to a target location.

The receiver at the target location records the reflected frames for examination by the operator and may also transfer the reflected frames to an analysis function. Some examples of target location analyzers are as follows: comparing the reflected frames with the original ones to verify if there are any errors, running a proxy application at the target location to simulate the handshakes as if those frames actually reach their original destinations, etc.

As in CFM (Clause 18 through Clause 22), a network operator can only set or activate FPT's RR within its own maintenance domain. At the customer's request, a network provider may use DDCFM to verify whether DDFs occur within its domain. FPT's RR (29.2.2) can only be created or activated by a network provider's own Network Management System via secure interface. Therefore, customers or other operators cannot set an FPT RR (29.2.2) in a maintenance domain that does not belong to them.

In order for intermediate Bridges and/or a target location to distinguish the reflected data frames from other traffic, each reflected frame is encapsulated with an RFM header. The RFM header added to the reflected data frame carries the same Maintenance Domain level associated with the RR, so that the reflected data frames, each encapsulated with a proper RFM header, are contained within the same Maintenance Domain. The target location has to be in the same maintenance domain to receive the RFMs.

Depending on the conditions specified for selecting data frames to be reflected, some conditions can cause large amount of data frames to be reflected. If there are multiple locations within a network reflecting a large number of data frames simultaneously, excessive traffic could be added to some segments of the network, which may impact network performance. To avoid excessive traffic being added to the network by an RR, this standard recommends only one RR be activated at a time within one maintenance domain.

FPT consists of RR configuration, the action to reflect identified data frames, and the analysis of the reflected data frames. The last step, i.e., analysis of the reflected data frames, is beyond the scope of this standard.

29.1.2.2 Return path test (RPT)

The RPT is to determine whether a flow of data frames can be sent without error from a specific location within a network to a station or stations specified by the destination_address associated with each of the frames under test. The RPT is achieved by an originating station encapsulating each frame of the flow under test with an SFM header, a DR (29.2.6) removing the SFM header, optionally placing its own MAC in the source_address field of the decapsulated data frames, and sending the data frames to a station or stations as specified by the destination_address field. By default, RPT's DR places its own MAC address in the source_address field of the decapsulated data frames before sending them out. However, a network operator can force a DR not to change the source_address field of the decapsulated data frame before sending it out to conduct special purpose testing.

The RPT allows a network operator to inject specific data frames into the network for testing purposes. To prevent one network operator from injecting traffic to other networks, it is necessary for the associated managed object to be created under secure mode and for SFM originator to be in the same Maintenance Domain as the MP on which DR is defined.

The Figure 29-2 illustrates a simple case of injected traffic from Node B to reach Node A. Multiple data frames can be injected and injected data frames could have different addresses or multicast addresses in their corresponding destination_address field.

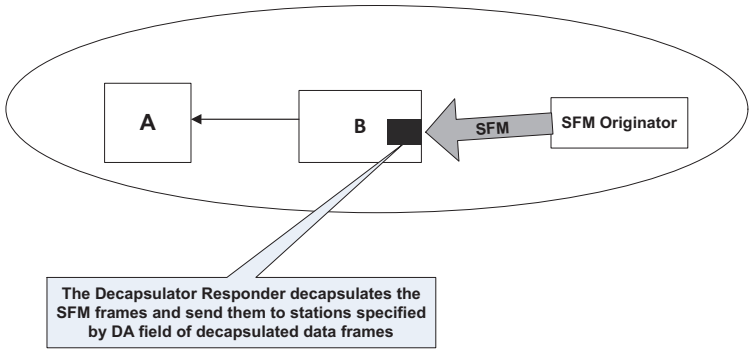


Figure 29-2—Return path test (RPT)

The RPT consists of the DR configuration, the sending of SFMs, the action to decapsulate and forward, and the analysis of the received data frames at their destination(s). The last step, i.e., the analysis of the received data frames at their destination(s), is beyond the scope of this standard.

29.1.2.3 Derived testing scenarios

FPT and RPT can be used together in various ways to achieve more sophisticated testing to diagnose and isolate DDFs. It is beyond the scope of this standard to elaborate different ways of combining FPT and RPT. This subclause only illustrates one example of using both FPT and RPT.

Figure 29-3 shows how to achieve segment fault isolation in the middle of a network using FPT and RPT together. By creating a DR and RR on two Bridge Ports in the middle of a network, a network operator can test whether the specified data frames can traverse through the segment. This type of testing is especially useful to diagnose DDFs out of firewall. This type of testing can also be used to diagnose a connectivity fault between two intermediate Bridge Ports (or two MIPs) by setting the RR filter (29.2.2.1) to the specified CCMs.

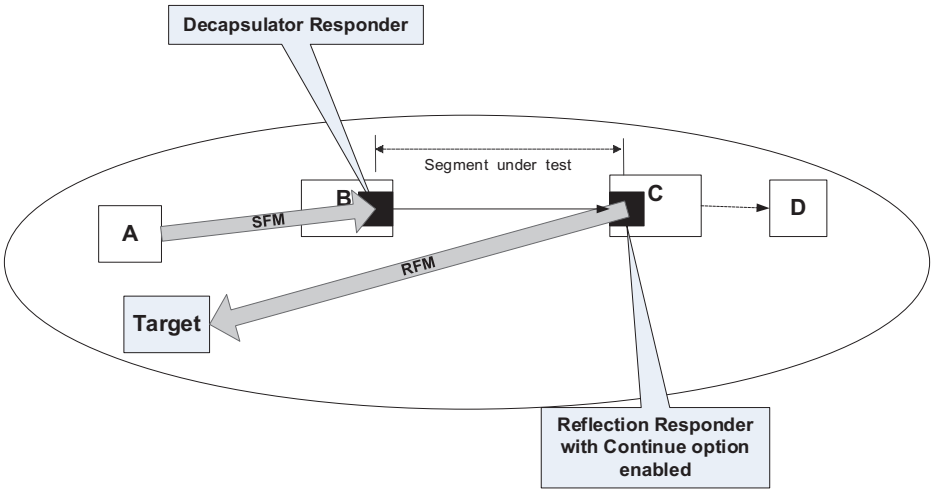


Figure 29-3—Combination of FPT and RPT

29.2 DDCFM Entity operation

This subclause specifies the following:

a) FPT RR
b) FPT RFM Receiver
c) RPT DR
d) RPT frames' SFM Originator

29.2.1 DDCFM implementation

The DDCFM protocol is performed by the RR, the DR, the RFM Receiver, and the SFM Originator. All of these entities are created and activated by operator commands. The operation of RR, DR, and SFM Originator are timer limited.

Both RFMs and SFMs are CFM PDUs and their format is described in 21.4 and 29.4. They are forwarded in the same way as regular CFM messages. An MEP at higher MD level shall drop the received RFMs and SFMs. An MEP at the same level shall process, but not forward, RFMs and SFMs received from its Active SAP, and shall drop RFMs/SFMs received from its Passive SAP. An MHF shall always forward RFMs/SFMs received from its SAPs and shall also process those at the same MD level received from its Active SAP.

The RR, RFM Receiver, DR, and SFM originator are CFM entities that are associated with a specific MD, enabling access only to the administrators of this MD. They can be placed at any point in the network that is bounded by any DoSAP of their corresponding MDs. Their relationship to MPs is guided by the MP component entities that the DDCFM entities also require. In particular, the RR does not require any of the MP's sub-functions (19.2 and 19.3) and correspondingly it is defined as an independent CFM shim. It can be placed at any Bridge Port bounded by the DoSAP of the RR's associated MD. It does not even require the EISS Multiplex Entity (6.17) or Backbone Service Instance Multiplex Entity (6.18). The same holds true for an SFM Originator. Note that both of them transmit CFM frames that are associated with a specific MA but the creation of these DDCFM entities themselves is not associated with an MA. This in practice means that one RR or SFM Originator can send RFMs or SFMs (respectively), which are associated with different MAs than the encapsulated frames. The other two DDCFM entities have a number of common subentities to the MPs. In particular, on top of their unique (MP) RFM Receiver and (MP) Decapsulator Responder state

machines, they require the functions provided by the Type Demultiplexer, Level Demultiplexer, and the OpCode Demultiplexer. In addition if the service is VLAN based, they also require the EISS Multiplex Entity. All of these make the implementation of the RFM receiver or the DR very simple in the case of an MP where they can reuse the MP component entities and provide the additional functions required by the MP RFM Receiver or MP Decapsulator Responder entities. Implementing these DDCFM entities on non-MPs would require all the previously mentioned MP subentities. Figure 29-5 shows an MP-independent RFM Receiver and Figure 29-6 shows an MP-independent DR. On the other hand, implementing these DDCFM entities on MPs would require only the addition of the MP Decapsulator Responder and MP RFM Receiver component entities in the MP architecture with the appropriate changes in the Opcode Demultiplexer as specified in 19.2 and 19.3.

29.2.2 FPT RR

The RR is a CFM protocol shim for filtering frames to be reflected, copying the filtered frames to the Passive SAP if the Continue option is set, and encapsulating each filtered frame with the RFM header (29.4.2). For an interface supporting DDCFM, an RR shim shall be allowed at EISS/ISS SAPs where MPs are allowed on the protocol stack shown in Figure 22-4, Figure 22-8, Figure 26-2, and Figure 26-8. By placing an RR shim on an aggregated port within a Bridge Port, the RR can reflect data frames from an member link of a LAG to test if specific data frames can go through the link.

The Figure 29-4 illustrates the component entities of an RR.

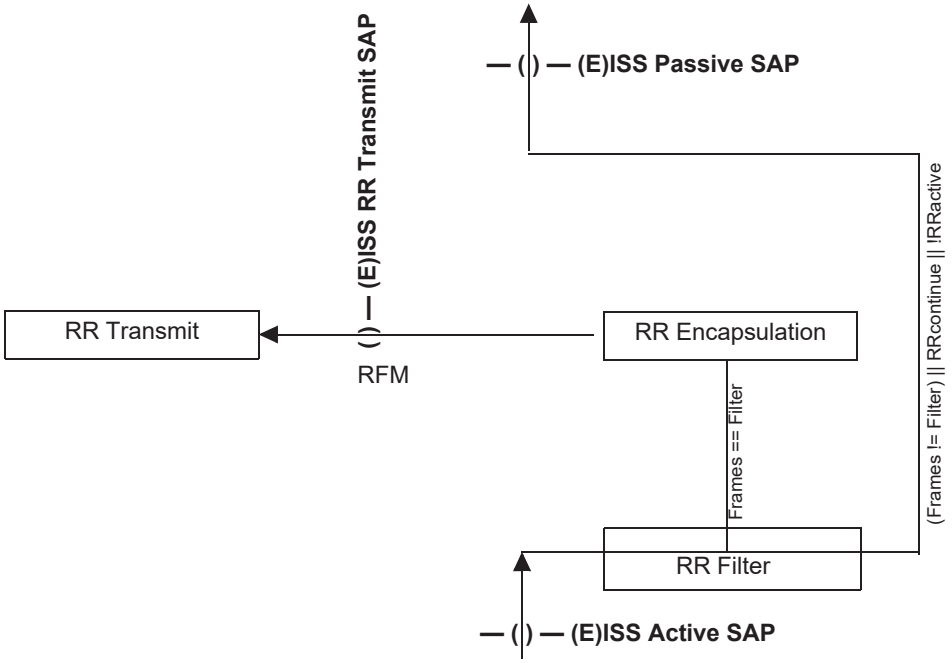


Figure 29-4—Detailed functions of RR

29.2.2.1 RR Filter

The RR Filter function within the RR filters frames from Active SAP that match the Reflection Filtering definition(s) [item b2) in 29.2.3]. When the RR is active and the sampling interval has expired, a frame that matches the Reflection Filter definition(s) is sent to RR Encapsulation to be reflected. A frame is passed to the Passive SAP when RR is not active, the frame does not match the Reflection Filter definition(s), or the Continue option is true.

To prevent data frames from being reflected multiple times within a network, RFM frames cannot be reflected. An RR Filter definition implicitly includes the condition of the OpCode in common CFM header not equal to RFM, in addition to all other conditions specified.

29.2.2.2 RR Encapsulation

The RR Encapsulation function within the RR is for encapsulating the filtered frame with the appropriate RFM header. If a sampling interval is specified, once a frame meeting the Reflection Filtering definitions is identified within one sampling interval, no more frames shall be encapsulated until the next sampling interval starts.

29.2.2.3 RR Transmit

RR Transmit identifies the egress port by querying FDB and forwards the RFM frames to the LOM entity of the identified egress port. The query uses the Reflection Target address [item b3) in 12.17.2.1.2] and the vlan_identifier associated with the RFM [item c) in 29.3.3.3]. If there is no vlan_identifier associated with the RFM, the PVID value of the port where RR is configured is used. If an egress port cannot be identified and the FloodingEnabled flag of the RR is true, then the RFM frame is sent to the LOM entity on every port associated with the VID set of the RFM frame. If the FloodingEnabled flag of the RR is false and an egress port cannot be identified, the RFM frame is dropped.

29.2.3 RR-related parameters

29.2.3.1 RR identification

An RR is identified by the interface upon which the RR is created, a Maintenance Domain that identifies the administrative boundaries, and a value indicating the direction (Up or Down) in which the RR is facing. The interface upon which the RR is created can be a Bridge Port or a member port of a LAG of a Bridge Port.

29.2.3.2 MA for RR

The primary VID associated with RR's MA is in the RFM emitted by the RR. When MA for an RR is set to 0, then the VID of the filtered frame are used in the corresponding RFM.

29.2.3.3 RR Filter definition

The RR Filter is for selecting data frames to be reflected. Multiple filters can be combined together by "&& (and)", "|| (or)", or "! (negation)" operations.

All Bridges supporting DDCFM shall support the following reflection filters (and may support additional Reflection Filters):

a) Reflect All—all frames are selected.
b) VLAN-based selection—all data frames associated with the specified VID are selected.
c) Destination address-based selection—all data frames with the specified destination address are selected.
d) Source address-based selection—all data frames with the specified source address are selected.
e) EtherType.

29.2.3.4 Sampling interval

The sampling interval controls the maximum rate at which frames can be reflected. If no sampling interval is set, then all frames that arrive while the RR is active and match the filter criteria are reflected. If a sampling interval is specified then the first matching frame that arrives during the interval is reflected, other matching frames arriving in that interval are not reflected.

29.2.3.5 Continue option

The Continue option [item b5) in 12.17.2.2.2] allows the selected data frames to be continued to their original destinations by making a copy of the selected frames to be reflected.

The Continue option is set to be true by default, which means that the selected data frames are branched to two directions—one direction to the RR Encapsulation function, and the other direction to the passive SAP. When the Continue option is set to be false, the selected frames shall only be forwarded to the RR Encapsulation function.

29.2.3.6 Duration for RR to remain active

Reflecting data frames back into network can create extra traffic in the network. To prevent this action running forever, a duration [item b7) in 12.17.2.2.2] is used to limit the maximum amount of time for the RR to be running. Operator can also specify the maximum number of frames to be reflected. Once activated, RR shall remain active until either its specified duration expires or the maximum number of frames reflected is reached, whichever comes first. An active RR can also be deactivated by operator command before its duration expires.

29.2.3.7 Truncation flag

If the received data frame causes the RFM encapsulated frame to exceed the Maximum Service Data Unit Size (6.5.8), either the data frame is truncated, or the data frame is split into two smaller frames and those two smaller frames are encapsulated by two separate RFM frames. If the Truncation flag is set to be true, the data frame shall be truncated to be encapsulated in one RFM.

29.2.4 Reflection Target and RFM Receiver

The Reflection Target is where the RFM encapsulated reflected frames are forwarded to. The RFM Receiver is a function running on a Reflection Target to pass the received RFMs to their corresponding analyzers.

The Reflection Target has to be within the same Maintenance Domain as the RR in order to receive the RFM encapsulated data frames.

When an RFM Receiver is defined on a Bridge interface that does not support MP, the RFM Receiver is implemented as a separate CFM entity, as depicted in Figure 29-5 for receiving RFMs from Active SAP. It requires a number of the component entities that are required by an MP. If the RFMs are associated with a VID-based MA, the RFM receiver needs to be placed in a demultiplexer SAP provided by an EISS multiplex entity (6.17).

29.2.5 RPT-related parameters

RPT configuration has two parts: one part is to configure SFM Originator and the other part is to configure DR.

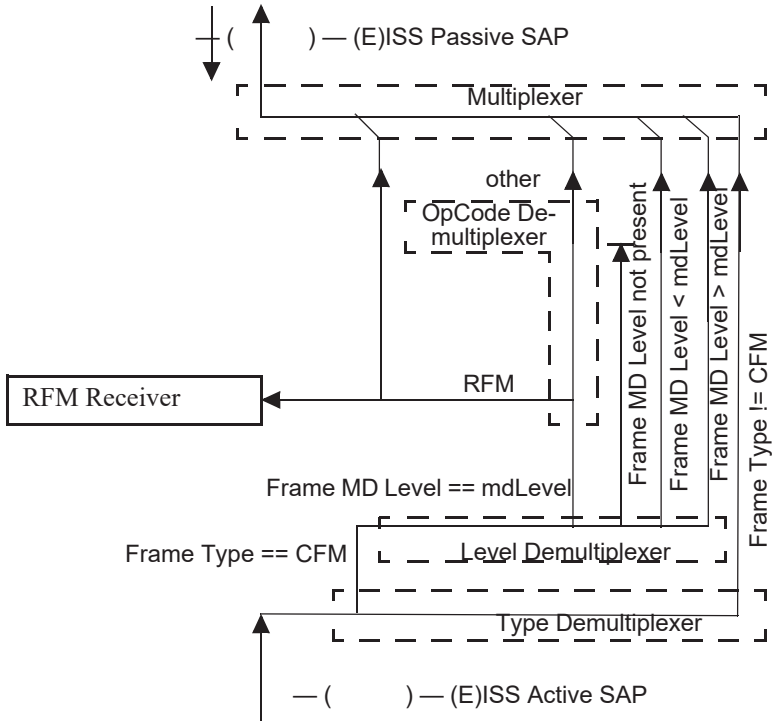


Figure 29-5—RFM Receiver on an non-MP

29.2.6 Decapsulator Responder (DR)

The DR decapsulates SFMs and sends the decapsulated frames toward destinations specified by the destination_address field of the decapsulated data frames. Under normal circumstance, the source_address field of the decapsulated frame is replaced by the DR's own MAC address to avoid confusing other Bridges' learning in the network. However, a network operator can enforce the DR not to modify the source_address field of the decapsulated frame for special purpose fault diagnosis. The DR configuration is specified in 12.17.4.1.

DR shim shall be allowed at EISS/ISS SAPs where MPs are allowed on the protocol stack shown in Figure 22-4, Figure 22-8, Figure 26-2, and Figure 26-8.

Multiple DRs can be created on one Bridge interface to receive SFMs at different MD levels or SFMs originated from different SFM Originators.

When an SFM is received by an active DR, it is examined for validity and discarded if invalid. If valid, the received SFM shall be decapsulated. The source_address field of the decapsulated frame is replaced by DR's own MAC address unless SourceAddressStayFlag is set. The modified frame shall be used to identify the egress port by querying the FDB. The query uses the destination_address and vlan_identifier values of the decapsulated data frame. If the decapsulated frame is untagged, the PVID value of the port where DR is configured is used. The Boolean FloodingEnabled flag of the DR indicates if the frame is to be flooded or discarded if an egress port cannot be identified by FDB. Figure 29-6 illustrates the detailed functions of DR. DR shim can be placed at any places where MPs are allowed on the protocol stack as shown in Figure 22-8.

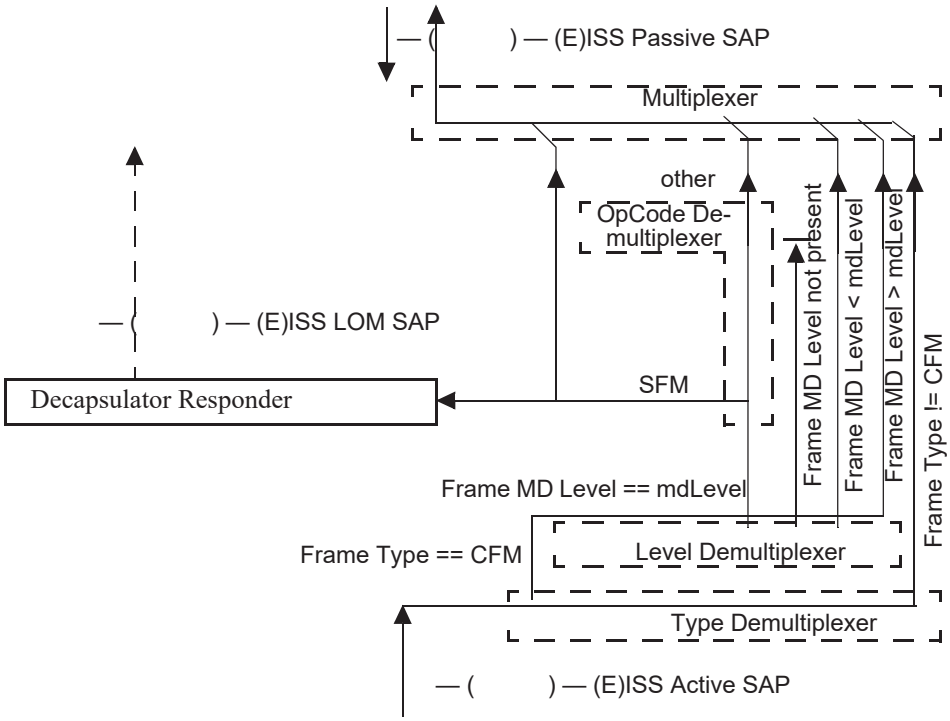


Figure 29-6—Return Path DR

29.2.7 SFM Originator

SFM Originator is for generating SFMs and sending the SFMs to the corresponding DR. Each SFM encapsulates one data frame. The SFM Originator configuration is specified in 12.17.5.1.

The Bridge interface on which SFM Originator is created does not have to support any MP. However, the SFM Originator has to be configured with the same Maintenance Domain level as the DR, so that the SFM can be forwarded to the DR. It is beyond the scope of this standard to address how SFMs are generated.

29.3 DDCFM protocols

This subclause specifies the DDCFM protocols in terms of a number of state machines, the variables and procedures associated with each machine.

29.3.1 RR variables

There is one instance of the following parameters per RR, except the nPendingRFMs variable, that is common to all RRs on the Bridge components (i.e., per Bridge component, but not per RR).

29.3.1.1 RRcontinue

A Boolean variable for the RR's Continue option [item b5) in 12.17.2.2.2] attribute.

29.3.1.2 nPendingRFMs

An integer value used to track the number of RFMs to be transmitted. nPendingRFMs is a variable that can be incremented by every RR's Encapsulation state machine and can be decremented by RR Transmit state machine.

nPendingRFMs is set to 0 when all of the RRs on the Bridge are deactivated.

29.3.1.3 dataReceived

dataReceived is a Boolean variable, which is set to true when there is a data frame received from (E)ISS, and set to false by the RR Filter state machine.

29.3.1.4 dataFrame

This variable is the data frame received from (E)ISS.

29.3.1.5 nFilteredFrameList

This variable keeps track of the number of filtered data frames to be reflected. This variable is incremented by RR Filter and decremented by RR's Encapsulation state machine.

29.3.1.6 filteredFrameList

This is a list of received data frames from RR Filter that have not been processed yet.

29.3.1.7 nextFilteredFrame

This variable copies the first one on the filteredFrameList to be reflected as RFM. Once a frame is copied to this variable, the frame is removed from the filteredFrameList.

29.3.1.8 RRtime

RRtime is the value of RR Duration (29.2.3.6).

29.3.1.9 RRwhile

RRwhile is a timer variable, which is initialized to RR Duration [item b7) in 12.17.2.2.2] when RR is activated and used by the RR Filter state machine to time out the active RR. RRwhile has granularity in seconds.

29.3.1.10 RRsampInt

RRsampInt is the sampling interval (29.2.3.4) during which the RR only reflects a maximum of one frame that meets the filter condition. When the sampling interval is not configured, RRsampInt is set to 0.

29.3.1.11 RRsampWhile

A timer variable used by RR Filter state machine to time out sampling interval.

29.3.1.12 RRmaxFrames

The maximum number of frames for RR to reflect after RR is activated [item b8) in 12.17.2.2.2]. Once activated, RR will stay active until either RRmaxFrames is reached or RRwhile (29.3.1.9) expires, whichever comes first. If RRmaxFrames is set to 0, the RR stays active until RRwhile (29.3.1.9) expires.

29.3.1.13 RRframeCount

A counter used by the RR's Encapsulation state machine to keep track of the number of data frames to be reflected. Once RRframeCount is equal to or greater than RRmaxFrames, RR is deactivated.

29.3.1.14 filterMatched

A Boolean variable that is set to true if the data frame received matches with the RR's filter conditions and false if the data frame received does not match the RR's filter conditions.

29.3.1.15 RRactive

RRactive is true when the corresponding RR is active and false otherwise.

29.3.1.16 nextRFMtransID

The value to place in the RFM Transaction Identifier field of the next RFM to be transmitted. nextRFMtransID is incremented by 1 by the RR's processRRencap() procedure with each transmission.

This variable is readable as a managed object [item b14) in 12.17.2.3.3].

29.3.1.17 maxDataTLVvalueSize

This is the maximum number of bytes allowed to be copied into Reflected Data TLV's value field in order to keep the RFM's SDU size not exceeding its Maximum Service Data Unit Size (MSDUS) (6.5.8).

The length of an RFM PDU is 12 octets (4 bytes for CFM header + 1 byte for End TLV(0) + 4 bytes Transaction Identifier + 3 bytes Reflected Data TLV Length/Type field) + the actual number of bytes of the reflected data frame. If there is no other optional TLV for the RFM data frame[41], then:

a) maxDataTLVvalueSize = MSDUS – (5 (CFM common header length) + 4 (Transaction Identifier) + 3 (Reflected Data Frame TLV Length/Type field)).

29.3.1.18 reflectedDataLength

This variable is to hold the value for the Length field of Reflected Data TLV (29.4.2.4).

29.3.2 RR Filter procedures

The following procedures are defined for the RR Filter state machine:

a) filterFrame()
b) forwardFrame()
c) loadFilteredFrameList()

29.3.2.1 forwardFrame()

This procedure passes the frame received to (E)ISS Passive SAP.

29.3.2.2 filterFrame()

filterFrame() is called when RRactive is true and there is a data frame received from EISS. This procedure performs the following steps:

a) If the received data frame from (E)ISS SAP meets the Reflection Filter definition(s), then returns true.
b) Otherwise, returns false.

29.3.2.3 loadFilteredFrameList()

This procedure adds the received frame to the filteredFrameList.

[41] Even though not required, implementers may choose to include other optional TLVs in RFM. If extra TLVs are included in a RFM, the maxDataTLVvalueSize has to be decremented by the number of bytes taken by the extra TLV.

29.3.3 RR Encapsulation procedures

The following procedures are defined for the RR Encapsulation state machine:

a) processRRencap()
b) splitFilteredFrame()
c) constructRFM()

29.3.3.1 processRRencap()

processRRencap() is called when RR is activated and filteredFrameList is not empty. There are two local variables in this procedure: DataFrame_1 and DataFrame_2, which are used when the filtered frame has to be truncated or split into two frames to be reflected.

processRRencap() processes the incoming data frame from the RR Filter as follows:

a) Set the reflectedDataLength variable to the length of the nextFilteredFrame.
b) If the value of reflectedDataLength is larger than the Bridge's maxDataTLVvalueSize (29.3.1.17), then call splitFilteredFrame (nextFilteredFrame, DataFrame_1, DataFrame_2) and then perform the following two steps:
    1) If Truncation flag is set, call constructRFM(TLV_type, maxDataTLVvalueSize, DataFrame_1), where the TLV_type is set to the "Truncated Data TLV" type value defined by Table 21-5.
    2) If the Truncation flag is not set, perform the following two steps:
        i) Call constructRFM(TLV_type, maxDataTLVvalueSize, DataFrame_1), where the TLV_-type is set to the "Data Part 1 TLV" type value defined by Table 21-5.
        ii) Call constructRFM(TLV_type, reflectedDataLength – maxDataTLVvalueSize, Data-Frame_2), where the TLV_type is set to the "Data Part 2 TLV" type value defined by Table 21-5.
c) Otherwise, call constructRFM(TLV_type, reflectedDataLength, nextFilteredFrame), where TLV_type is set to the "Data TLV" type value defined by Table 21-5.

29.3.3.2 splitFilteredFrame()

This procedure is called when the nextFilteredFrame causes the length of RFM's SDU size to be larger than the Maximum Service Data Unit Size (6.5.8). There are three parameters for this procedure:

a) nextFilteredFrame, which is an input to the procedure.
b) DataFrame_1, which contains the first maxDataTLVvalueSize number of bytes from the nextFilteredFrame.
c) DataFrame_2, which contains the remaining bytes from the nextFilteredFrame.

splitFilteredFrame() performs the following steps:

— Copy the maxDataTLVvalueSize number of bytes from the nextFilteredFrame to DataFrame_1.
— Copy the remaining bytes from the nextFilteredFrame to DataFrame_2.

29.3.3.3 constructRFM()

This procedure is to construct a RFM frame and increment the nPendingRFMs by 1. There are three parameters passed into this procedure:

a) TLV_Type, which could be 3 (i.e., Data TLV) (21.5.6), 9 (Truncated Data TLV) (21.5.1.1), 10 (Data Part 1 TLV), or 11 (Data Part 2 TLV).
b) TLV_Length, which is the length of the reflected data frame.
c) Data frame to be included in the TLV value field.

This procedure constructs the RFM (E)M_UNITDATA.request by the following steps:

d) Set the source_address parameter to the MP's or Bridge interface's own MAC address.
e) If the Reflection Target Address [item b4) in 12.17.2.2.2] is not specified, then source_address of the selected data frame is copied to the RFM's destination_address parameter; otherwise, Reflection Target Address is copied to the RFM's destination_address parameter.
f) Set the priority and drop_eligible parameters to the priority and drop_eligible attributes of the Reflection Responder managed object (12.17.2.2.2).
g) In a VLAN-aware Bridge, the primary VID associated with the RR's MA [item b1) in 12.17.2.1.2] is used as the vlan_identifier. If the RR's MA is set to 0, the vlan_identifier is determined by the following:
    1) If the RR is defined on an S-VLAN component, use the S-VID if the S-VID is present in the selected data frame; otherwise, use the PVID of the port where RR is configured.
    2) If the RR is defined on a C-VLAN component, use the C-VID if the C-VID is present in the selected data frame; otherwise, use the PVID of the port where the RR is configured.
h) Copy RFM OpCode to the RFM's OpCode Field.
i) Copy the RR's Maintenance Domain Level [item a) in 12.17.2.1.2] to the RFM's MDLevel field.
j) Copy the first parameter (TLV_Type) to the Reflected Data TLV Type field.
k) Copy the second parameter (TLV_Length) to the Reflected Data TLV Length field.
l) Copy the third parameter (Data frame) to the Reflected Data TLV value field.
m) Copy the nextRFMtransID to the RFM Transaction Identifier field. Increment nextRFMtransID by 1, wrapping around from $2^{32} - 1$ to 0.
n) Increment nPendingRFMs by 1.
o) Set the frame_check_sequence parameter to the unspecified value; sets the connection_identifier to null.

29.3.4 RR Transmit procedure

The following procedure is defined for the RR Transmit state machine:

a) xmitRFM()

29.3.4.1 xmitRFM()

xmitRFM() is called by the RR Transmit state machine. It queries the FDB in order to identify an egress port. The set of potential transmission ports, normally created by the Active Topology enforcement (8.6.1), is the set of all Bridge interfaces that are both in the active set of the vlan_identifier associated with the RFM, and that are in the Forwarding state for that vlan_identifier.

a) Query FDB using the RFM's destination_address field and vlan_identifier parameter values.
b) If an egress port is identified and the identified Egress port meets the following conditions:
    1) The Egress port does not have a Down MEP with higher MD level than the RFM's MD,
    2) The Egress port does not have an Up MEP with same or higher MD level as the received RFM's MD,
    1) then send an RFM EM_UNITDATA.request to the egress port's LOM SAP. Otherwise, drop the received RFM frame.
c) If an egress port cannot be identified:
    2) When the FloodingEnabled flag of the RR [item b7) in 12.17.2.1.2] is not set, drop the frame.

When the FloodingEnabled flag of the RR is set, send M_UNITDATA.request to the LOM's SAP of every forwarding port that meets the conditions 1) and 2) of item b) above.

29.3.5 RR-related state machines

29.3.5.1 RR Filter state machine

Figure 29-7 depicts the state machine for RR Filter.

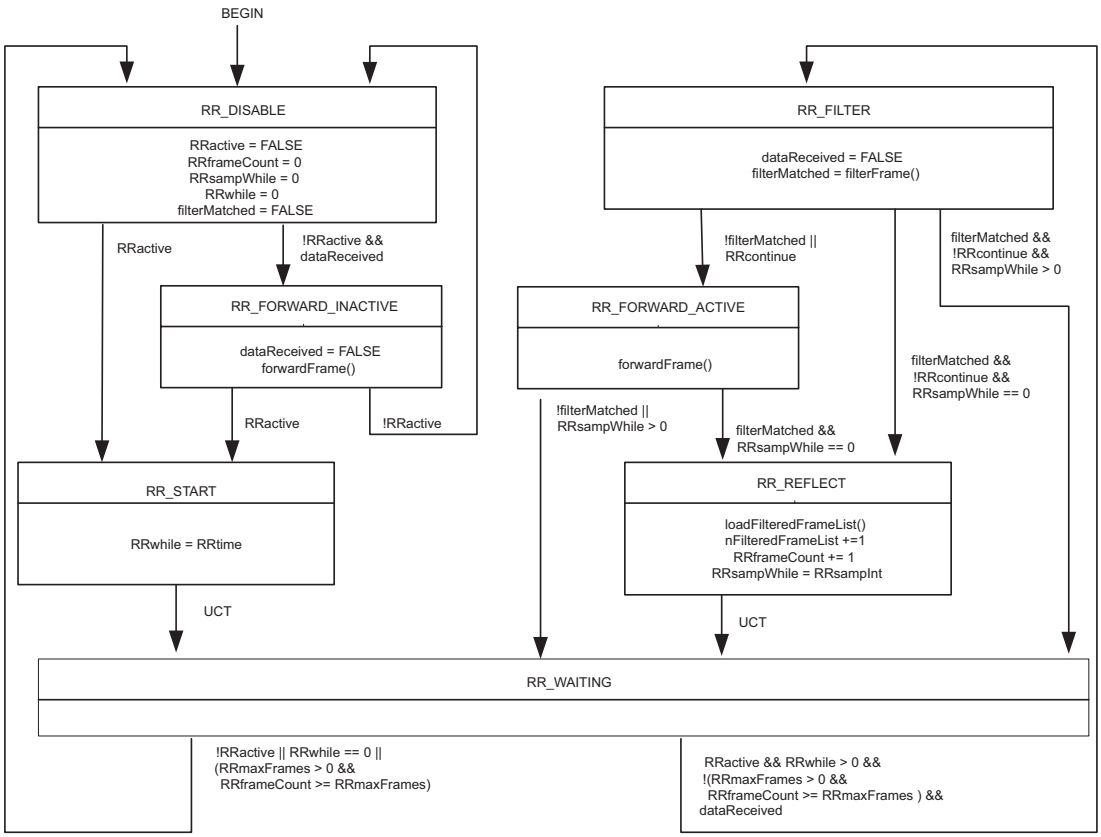


Figure 29-7—RR Filter state machine

Figure 29-8 describes the state machine for RR Encapsulation.

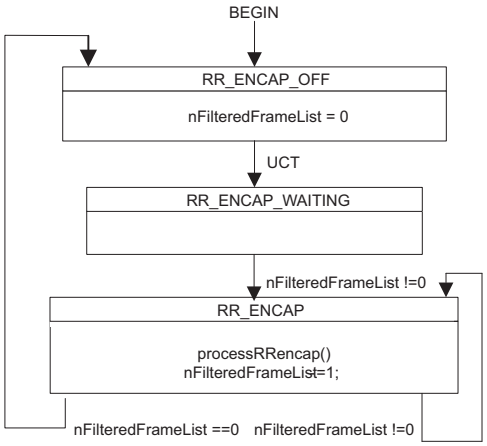


Figure 29-8—RR Encapsulation state machine

29.3.5.2 RR Transmit state machine

RR Transmit state machine (Figure 29-9) can be shared by multiple RRs activated on the Bridge.

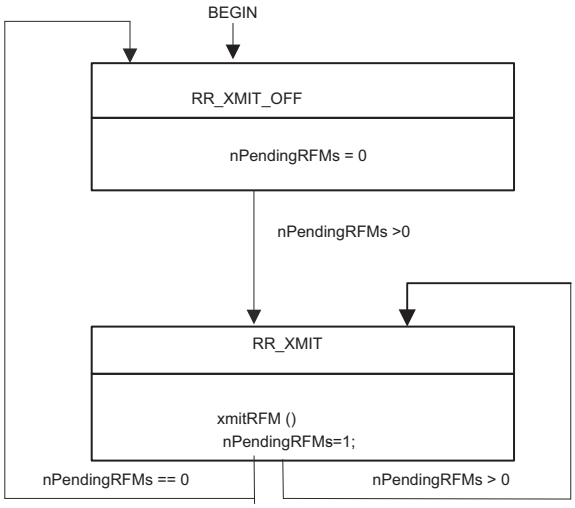


Figure 29-9—RR Transmit state machine

29.3.6 RFM Receiver variables

The following variables are local to the RFM Receiver state machine. There is one instance of these variables per RFM Receiver.

29.3.6.1 RFMreceived

RFMreceived is a Boolean variable, which is set to true by the MP OpCode Demultiplexer when an RFM is received, and cleared by the RFM Receiver state machine.

29.3.6.2 RFMPDU

RFMPDU is a record of the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the last RFM received by the MP OpCode Demultiplexer (19.2.7).

29.3.7 RFM Receiver procedure

The procedure listed in 29.3.7.1 and 29.3.7.2 is defined for the RFM receiver.

29.3.7.1 ReceiveRFM()

ReceiveRFM() procedure performs the following steps:

a) If the destination_address field of the received RFM does not match the RFM Receiver's MAC address, drops the frame.
b) Otherwise, pass the received RFMPDU to RFM Analyzer.[42]

Even though RFM Analyzer is out of the scope of this standard, RFM Analyzer has to be able to recognize the value in Reflected Data TLV (29.3.3.2), which could be:

— A whole data frame being reflected; or
— A truncated data frame being reflected; or
— The first portion of the data frame being reflected; or
— The second portion of the data frame being reflected.

If an RFM Receiver is configured on an MP and the RFM Receiver does not receive any RFMs within the expected time frame, it can send a LBM (21.7) to the MP on which the RR is defined to verify the connectivity to the MP. If there is no LBR received, ReceiveRFM() can report an alarm to the network administrator.

29.3.7.2 RFM Receiver state machine

Figure 29-10 describes the state machine for RFM Receivers.

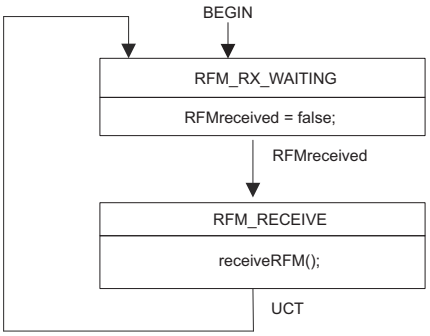


Figure 29-10—RFM Receiver state machine

[42] RFM Analyzer is out of the scope of this standard.

29.3.8 DR variables

There is one instance of the parameters listed in 29.3.8.1 through 29.3.8.7 per DR.

29.3.8.1 DRwhile

A timer variable used by the Decapsulator Responder state machine to time out the active DR. DRwhile has a granularity finer than or equal to 1 s.

29.3.8.2 DRtime

The time that the DR can remain active after its activation.

29.3.8.3 SFMPDU

SFMPDU is a record of the M_UNITDATA.indication or EM_UNITDATA.indication parameters of the SFM received by the MP OpCode Demultiplexer (19.2.7) when an SFM is received.

29.3.8.4 DRactive

DRactive variable represents the activation status of the corresponding DR. DRactive is set to true when the corresponding DR is activated and set to false when the corresponding DR is deactivated or its duration expires. When DRactive is false, all SFMs received by the Bridge interface are dropped.

29.3.8.5 SFMreceived

SFMreceived is set to true by the OpcodeDemultiplexer (19.2.7) when an SFM is received.

29.3.8.6 previousSFMtransId

previousSFMtransId variable keeps the value of SFM Transaction Identifier of the previously received SFM frame. The previousSFMtransId variable is initialized to zero when the DR is activated.

29.3.8.7 SFMsequenceErrors

SFMsequenceErrors variable keeps the total number of out-of-sequence SFMs received. SFMsequenceErrors is initialized to zero when the DR is activated.

29.3.9 DR procedures

The DR has the following procedures:

a) ProcessSFM()
b) DropSFM()

29.3.9.1 processSFM()

Called by the Decapsulator Responder state machine when an SFM is received and the DR is active. processSFM() processes the incoming SFM in SFMPDU as follows:

a) The SFM is examined for validity using the methods used for CFM as described in (20.46) and discarded if invalid.
b) If the destination_address of the SFM does not match the DR's own MAC address or the source_address of the SFM does not match with DR's SFM Originator [item b2) in 12.17.4.3.2], the frame is discarded.

c) If the SFM frame passes these tests, the frame carried in its Original Data TLV (29.4.3.4) is decapsulated to create an (E)M_UNITDATA.request as follows:
   1) The destination_address parameter is set to the destination_address of the frame in the Original Data TLV.
   2) If the SourceAddressStayFlag [item b1) in 12.17.4.3.2] is false, the source_address parameter is set to the DR's MAC address; otherwise, the source_address parameter is set to the source_address of the frame in the Original Data TLV.
   3) The vlan_identifier, priority, drop_eligible, and mac_service_data_unit parameters are set as follows:
      i) If the DR is configured on a port of an S-VLAN component, and the TPID of the frame in the Original Data TLV indicates the S-TAG, the vlan_identifier, priority, and drop_eligible parameters are taken from the corresponding values in the Tag Control Information (TCI) and the mac_service_data_unit is taken from the reminder of the frame following the TCI and excluding the last four octets (FCS).
      ii) If the DR is configured on a port of a C-VLAN component, and the TPID in the Original Data TLV indicates a C-TAG, the vlan_identifier, priority, and drop_eligible parameters are taken from the corresponding values in the TCI, and the mac_service_data_unit is taken from the remainder of the frame in the Original Data TLV following the TCI and excluding the last four octets (FCS).
      iii) Otherwise, the vlan_identifier is set to the PVID for the port on which the DR is configured, the priority is set to the priority of the SFM, the drop_elibible parameter is set to the value of drop_eligible for the SFM, and the mac_service_data_unit is taken from the frame in the Original Data TLV immediately following the source_address and excluding the last four octets (FCS).
   4) Sets the frame_check_sequence parameter to the unspecified value (IEEE Std 802.1AC).
   5) Sets the connection_identifier parameter to null.

d) ProcessSFM() queries the FDB using the destination_address and vlan_identifier parameters of the (E)M_UNITDATA.request. The set of potential transmission ports, normally created by the Active Topology enforcement (8.6.1), is the set of all Bridge Ports that are both in the member set of the vlan_identifier and that are in the Forwarding state for that vlan_identifier.
   1) If an Egress Port is identified, the decapsulated frame is carried to the related LOM SAP for transmission.
   2) If an Egress Port is not identified and the FloodingEnabled flag of the DR is set, the decapsulated frame is flooded to the LOM SAP of all forwarding ports in the VID set; otherwise, the frame is discarded.

e) If the received SFM is not the first frame received by the DR and the value of SFM Transaction Identifier field in the received SFM is not 1 greater than the value saved in the previousSFMtransId, increment SFMsequenceErrors by 1.

f) Set the value of previousSFMtransId to the value of the SFM Transaction Identifier field of the received SFM.

29.3.9.2 DropSFM()

Called by Decapsulator Responder state machine whenever the DR is not active in order to silently discard the received SFM frames.

29.3.10 Decapsulator Responder state machine

Once the DR is configured and activated by network administrator, it remains active until the configured timer expires or being deactivated by the network administrator (see Figure 29-11).

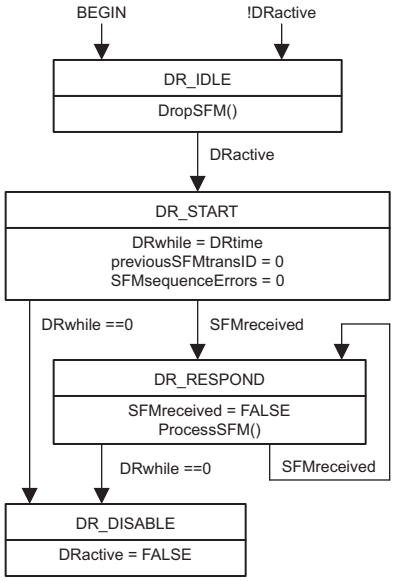


Figure 29-11—Decapsulator Responder state machine

29.4 Encoding of DDCFM PDUs

This subclause specifies the method of encoding DDCFM PDUs. The specifications include the following:

a) The format of RFM
b) The format of SFM

29.4.1 RFM and SFM Header

The RFM Header and SFM Header are same as the Common CFM Header defined by Table 21-2, with extra OpCodes defined for RFM and SFM (Table 21-3).

29.4.2 RFM format

The RFM format is shown in Table 29-1.

29.4.2.1 Flags

(1 octet) in RFM. The Flags field of the Common CFM Header for RFM is reserved for future use.

29.4.2.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in a RFM is transmitted as 4.

Validation Test: The First TLV Offset field of the Common CFM Header in a RFM contains a value greater than or equal to 4.

Table 29-1—RFM format

Field	Octet
Common CFM Header	1–4
RFM Transaction Identifier	5–8
Reserved for definition in future versions of the protocol[a]	
Reflected Data TLV	First TLV Offset + 5
Additional TLV	First TLV Offset + 5 + Length of Reflected Data TLV
End TLV (0)	

[a] This field has 0 length in this version 0 of DDCFM. It is shown in order to stress that additional information can be present in future versions of DDCFM, and that a version 0 receiver ignores its contents, if present.

29.4.2.3 RFM Transaction Identifier

(4 octets) An RR copies the content of nextRFMtransID variable (29.3.1.16) to this field.

29.4.2.4 Reflected Data TLV

Reflected Data TLV in RFM is a Data TLV (21.5.6) to contain the reflected data frame. The Length field is the total octets of the reflected data frame.

The Type field of the Reflected Data TLV could be one of the following four values (Table 21-5):

a) Data TLV Type value, which is 3
b) Truncated Data TLV Type value, which is 9
c) Data-Part-1 TLV Type value, which is 10
d) Data-Part-2 TLV Type value, which is 11

29.4.2.5 Additional RFM TLVs

The following TLVs may be included in a RFM by each MP originating RFM (RR):

a) Send ID TLV (21.5.3)
b) Organization-Specific TLVs (21.5.2)

The Additional RFM TLVs may be placed in any order.

29.4.3 SFM format

The SFM format is shown in Table 29-2.

29.4.3.1 Flags

(1 octet) in SFM. The Flags field of the Common CFM Header for SFM is reserved for future use.

29.4.3.2 First TLV Offset

(1 octet) The First TLV Offset field of the Common CFM Header in an SFM is transmitted as 4.

Validation Test: The First TLV Offset field of the Common CFM Header in an SFM contains a value greater than or equal to 4.

Table 29-2—SFM format

Field	Octet
Common CFM Header	1–4
SFM Transaction Identifier	5–8
Reserved for definition in future versions of the protocol[a]	
Original Data TLV	First TLV Offset + 5
Additional TLVs	First TLV Offset + 5 + Length of Original Data TLV
End TLV (0)	

[a] This field has 0 length in this version 0 of DDCFM.

29.4.3.3 SFM Transaction Identifier

(4 octets) SFM originator may use this field to distinguish the order of SFMs sent. DR may use this identifier to check the order of the received SFMs.

29.4.3.4 SFM Original Data TLV

SFM Original Data TLV is a Data TLV (21.5.6) to contain the original data frame. The Length field is the total octets of the original data frame, including its destination_address, source_address, TPID, TCI, Length/Type, client data, pad, and FCS fields.

29.4.3.5 Additional SFM TLVs

The following TLVs may be included in an SFM by each SFM Originator:

a) Send ID TLV (21.5.3)
b) Organization-Specific TLVs (21.5.2)

The Additional SFM TLVs may be placed in any order.

30. Principles of congestion notification

Congestion notification comprises capabilities for detecting and mitigating queue congestion for selected classes of traffic in Virtual Bridged Networks. These capabilities can be used in networks with a bandwidth-delay product on the order of 5 Mbits or less in order to decrease the likelihood of frame loss for Congestion Controlled Flows (CCFs). As the geographical size, per-hop delay, and/or maximum hop count of a network grow, causing the bandwidth-delay product of the network to increase beyond this value, oscillations in buffer occupancy begin, and their amplitude increases gracefully with bandwidth-delay product. If the parameters controlling the algorithm are not adjusted accordingly and the sizes of the Bridges' buffers are not increased, frames are then likely to be lost due to congestion.

Congestion notification depends on the formation of a cooperating set of systems including VLAN Bridges and end stations to achieve the reduction in frame loss. By partitioning the Bridges' and end stations' resources, frames sourced or sunk by noncooperating end stations or Bridges can be carried with minimal contention with CCFs for those resources. Accordingly, congestion notification entities (Clause 31) are specified as shims that make use of and provide the ISS or EISS (IEEE Std 802.1AC, 6.8) at SAPs within the network. The operation of the congestion notification protocol is described in Clause 32, and the formats of the CNM and Congestion Notification TLV are described in Clause 33.

This clause provides the context necessary to understand the congestion notification protocol: how congestion controlled regions of networks are identified; how CCFs are identified and separated from other frames; and how congestion notification entities in Bridges and end stations operate.

This clause introduces the concepts essential to congestion notification as follows:

a) The problem and requirements on the solution are presented (30.1).
b) The basic principles of the Quantized Congestion Notification protocol (QCN) are presented, including descriptions of a CP that sends a CNM to a RP (30.2).
c) A CCF consists of frames, all with the same priority value, and all assigned to a single Flow queue and RP in the originating end station (30.3).
d) A Congestion Notification Priority Value (CNPV) is one of the eight priority values that has been configured exclusively for the use of CCFs in the congestion-aware systems of a Virtual Bridged Network (30.4).
e) A CN-TAG can be transmitted with every data frame in a CCF, and is returned in every CNM (30.5).
f) A CND is constructed as a subset of Bridges and end stations in a Virtual Bridged Network, all of which are configured to handle a particular CNPV, the resources of which subset are defended by the Bridges whenever the offered load exceeds the network capacity (30.6).
g) The relationship of Multicast data to congestion notification is explained (30.7).
h) The peering relationship of RPs and CPs in PBNs and PBBNs is explained (30.8).

30.1 Congestion notification design requirements

The congestion notification protocol, congestion notification algorithm (QCN), and supporting protocols specified in this standard meet requirements for the following:

— CCF and network performance.
— Limiting the implementation complexity, of both RPs and CPs.
— Not over-constraining the design of Bridged Networks using CCF.
— Facilitating interoperability, coexistence, and deployment into existing networks, and limiting the administrative effort associated with using CCF in a network.

NOTE 1—QCN is designed to operate over a wide range of conditions. This subclause (30.2) necessarily uses qualitative terms such as "low probability," "small," "stable," and "modest" (for brevity). The bibliography (Annex W)

provides references (Alizadeh et al. [B1]) to studies of QCN performance for various network and traffic configurations, using both simulation and a fluid model (see 30.3 for the necessary equations, and for network sizing recommendations).

The following performance requirements are met for s CCFs (30.3):

a) There is a very low probability of frame discard due to buffer overflow at a CP.
b) The average buffer occupancy at each CP that is a Current Congestion Point (CCP) for one or more CCFs is a small fraction of the bandwidth delay product, and largely independent of the number of CCFs, thus ensuring that loss avoidance does not result in large and fluctuating transit delays.
c) The buffer occupancy at a CCP has a low probability of underflow, i.e., of becoming empty and thus failing to use available bandwidth when an RP is rate limiting a CCF as a result of CNMs received from that CCP.
d) When multiple CCFs with a single CCP share that CCP, they obtain very nearly the same share of the bandwidth. When multiple CCFs have one or more CCPs in common they each obtain a share of bandwidth resources proportional to their share of contested resources.
e) The low probability of buffer overflow and underflow at a CCP is maintained for both small and large numbers of CCFs, and when CCFs or the load offered by a given CCF changes.
f) The bandwidth provided to each CP by its attached LAN will be used, at all times, i.e., if the CP's buffer is not empty it will transmit, given the available bandwidth. The fact that the bandwidth available to one CCF passing through a given CP can be constrained by another CCP will not reduce the bandwidth through that CP for other CCFs not sharing the CCP.

NOTE 2—The probability of frame loss in the absence of CCF naturally depends on the response of higher layer protocols to increasing transit delay, and the importance of avoiding loss on their response. Highly loss sensitive protocols typically lack loss avoidance mechanisms, and no such mechanisms are assumed in the analysis of QCN.

NOTE 3—Requirements a) through d) can be summarized by characterizing the performance of QCN as stable, responsive, and (proportionally) fair with respect to buffer occupancy processes. Requirements e) and f) demand that available resources are used, and that stability not depend on having a large number of slowly changing CCFs.

The following requirements limit the complexity and hence the cost of Bridge Port (CP) support for CCF:

g) The CCF state retained by each Bridge Port is fixed, and determined solely by the number of congestion management transmission queues (i.e., by the number of CPs, one per CNPV, up to a maximum of 7) and the per CP requirements of the congestion notification algorithm (QCN).
h) A CP does not retain any per CCF or per RP state, nor is it required to allocate any data frame passing through the CP to a CCF or an RP. All the information necessary for a CP to address a CNM to an end station, and for that end station to identify the CCF and RP from the CNM, is contained in each frame of a CCF.
i) The buffering required, at each CP, to avoid frame loss should be a small fraction of the network's bandwidth delay product.

The following requirements limit the complexity and hence the cost of end station (RP) support for CCF:

j) The CCF state retained by each end station for each congestion managed transmission queue, i.e., for each RP, is fixed.
k) The end station state requirements of QCN are determined solely by the number of RPs, and are independent of the number of CCFs and the number of CPs in the network.
l) The number of CCFs, the identification of each CCF, the allocation of transmitted frames to CCFs, and the allocation of CCFs to RPs is determined by each end station independently.
m) The end station is not required to transmit any additional frames, as a consequence either of transmitting or of receiving a frame for a CCF.
n) The CN-TAG for each CCF is independent of changes in RP state information.
o) The CCF protocol and QCN do not use any higher-layer protocol information carried in frames.
p) QCN calculations are simple and can be performed rapidly: i.e., the number of operations required to process each event is fixed, and all multiplications and divisions can be reduced to the use of

factors of 2 or the use of a fixed and small lookup table. An RP does not attempt to calculate control loop gains and delays and other, potentially rapidly changing CCF-dependent variables.

NOTE 4—A CP or an RP can retain additional state for the purposes of management, but this state is not required by the CCF protocol or QCN.

NOTE 5—An end station can use higher layer protocol information to decide whether a frame is to be allocated to a CCF, and to select a CCF.

The following requirements ensure that CCF does not over-constrain the design of the network, or limit the use of protocols that determine the active topology of the network:

q) RPs and CPs are unaware of the path taken by frames through the network, require no signaling from the network of changes in path, and take no exceptional action when paths change.

r) An RP does not assume that all frames that it transmits, or any identifiable subset of those frames such as those identified by the end station as belonging to a single CCF or transmitted to the same destination, are constrained to follow the same path through the network. An RP can transmit frames to many different destinations, and transmission to a given destination can be multi-path.

The following requirements support interoperability, facilitate deployment, and limit the administrative effort required to use CCF:

s) The boundaries of each CND are determined automatically.

t) The destination of a CCF can lie outside the transmitting end station's CND, and the destination end station can be unaware of the use of CCF within the CND. Incremental deployment of CCF is therefore possible.

u) The feedback provided in each CNM provides the receiving RP with the information needed to act on that CNM, and does not require the RP to know or interpret information about the sending CP.

v) PBBNs can be interposed into a CND, in order to reduce the number of MAC addresses leaned by Bridges in environments with large numbers of (perhaps virtual) end stations.

These requirements have a number of additional consequences for the design of QCN, including the following:

w) Additional mechanisms to determine round trip time are not required, as the algorithm is robust over its targeted range of round trip time.

x) QCN cannot regulate frame transmission by acknowledgments, as does Transmission Control Protocol/Internet Protocol (TCP/IP) [B18] [B19].

30.2 Quantized Congestion Notification protocol (QCN)

This subclause provides an overview of the baseline simulation of the QCN algorithm (Alizadeh et al. [B1]) used to develop this standard. This introduction provides no normative text. It will focus on the key features of the QCN algorithm, omitting the normative details given in the rest of this standard.

The QCN algorithm is composed of the following two parts:

a) **CP algorithm:** the mechanism by which a congested Bridge or end station buffer samples outgoing frames and generates a feedback message (CNM, 33.3, in this standard) addressed to the source of the sampled frame. The feedback message contains information about the extent of congestion at the CP.

b) **RP algorithm:** the mechanism by which a Rate Limiter (RL) associated with a source decreases its sending rate based on feedback received from the CP, and increases its rate *unilaterally* (without further feedback) to recover lost bandwidth and probe for extra available bandwidth.

30.2.1 The CP algorithm

A Bridge containing a CP is modeled as an ideal output-queued Bridge. The CP buffer is shown in Figure 30-1. The goal of the CP is to maintain the buffer occupancy at a desired operating point, Q_{eq}.[43] The CP computes a congestion measure F_b (defined below) and, with a probability depending on the severity of congestion, selects a frame from the incoming stream and sends the value of F_b in a feedback message to the source of the selected frame.

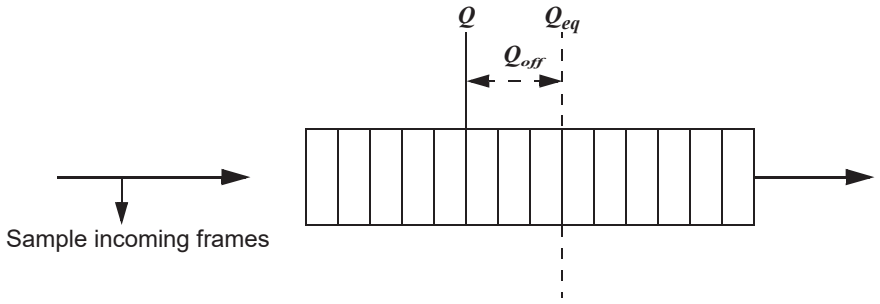


Figure 30-1—Congestion detection in QCN CP

Let Q denote the instantaneous queue size and Q_{old} denote the queue size when the last feedback message was generated. Let $Q_{off} = Q - Q_{eq}$ and $Q_{\delta} = Q - Q_{old}$.

Then F_b is given by Equation (30-1).

$$F_b = -(Q_{off} + wQ_{\delta}) \tag{30-1}$$

where w is a non-negative constant, taken to be 2 for the baseline simulation. The value of F_b is quantized to 6 bits before transmission, based on Q_{eq} and w.

The interpretation is that F_b captures a combination of queue size excess (Q_{off}) and rate excess (Q_{δ}). Indeed, $Q_{\delta} = Q - Q_{old}$ is the *derivative* of the queue size and equals input rate less output rate. Thus, when F_b is negative, the buffer is oversubscribed. When $F_b < 0$, Figure 30-2 shows the probability with which a congestion message is reflected back to the source as a function of $|F_b|$. The feedback message contains the value of F_b, quantized to 6 bits. When $F_b \geq 0$, there is no congestion and no feedback messages are sent.

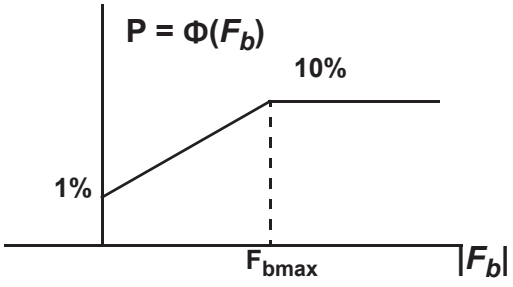


Figure 30-2—Sampling (reflection) probability in QCN CP as a function of $|F_b|$

[43] In simulation, setting Q_{eq} to 20% of the physical buffer size (150 000 octets) produced good results.

30.2.2 Basic RP algorithm

The RP is not given positive rate-increase signals by the network. Also, there are no acks at Layer 2 to trigger rate increases, Therefore, the RP requires a local mechanism to determine when, and by how much, the send rate is increased. Before proceeding to explain the RP algorithm, readers need the following terminology:

— **Current Rate (*CR*):** The transmission rate of the Rate Limiter (RL) at any time.
— **Target Rate (*TR*):** The sending rate of the RL *just before* the arrival of the last feedback message, and the new goal for the Current Rate.
— **Byte Counter:** A counter at the RP for counting the number of bytes transmitted by the RL. It triggers rate increases by the RL. See 30.2.2.2.
— **Timer:** A clock at the RP that is also used for triggering rate increases at the RL. The main purpose of the timer is to allow the RL to rapidly increase the rate when its sending rate is very low and bandwidth becomes available. See 30.2.3.

This clause now explains the RP algorithm assuming that only the byte counter is available. Later, how the timer is integrated into the RP algorithm is briefly explained. Figure 30-3 shows the basic RP behavior.

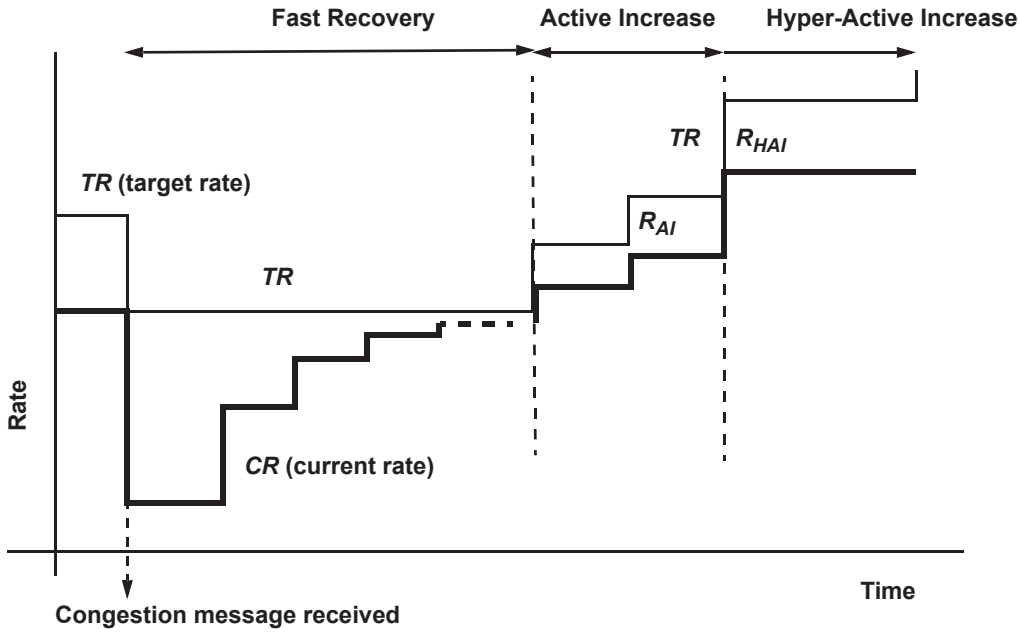


Figure 30-3—QCN RP operation

30.2.2.1 Rate decreases

Rate decreases occur only when a feedback message is received, in which case *CR* and *TR* are updated as follows in Equation (30-2) and Equation (30-3):

$$TR \leftarrow CR \tag{30-2}$$
$$CR \leftarrow CR(1 - G_d|F_b|) \tag{30-3}$$

where the constant G_d is chosen so that $G_d|F_{bmax}| = ½$, i.e., the sending rate can decrease by at most 50%.

30.2.2.2 Rate increases

Rate increases occur in two phases: Fast Recovery and Active Increase.

Fast Recovery (FR). The byte counter is reset every time a rate decrease is applied and the RP enters the FR state. FR consists of 5 cycles, each cycle equal to 150 kB of data transmission by the RL. The RP counts the cycles of the byte counter. At the end of each cycle, *TR* remains unchanged while *CR* is updated as follows in Equation (30-4):

$$CR \leftarrow \tfrac{1}{2}(CR + TR) \tag{30-4}$$

The cycle duration of 150 kB is chosen to correspond to the transmission of 100 frames, each 1500 bytes long. The idea is that when the RL has transmitted 100 frames and, given that the minimum sampling probability at the CP is 1%, if it has not received a feedback message then it may infer that the CP is uncongested. Therefore, it increases its rate as above, recovering some of the bandwidth it lost at the previous rate decrease episode. Thus, the goal of the RP in FR is to *rapidly recover* the rate it lost at the last rate decrease episode.[44]

Active Increase (AI). After 5 cycles of FR have completed, the RP enters the Active Increase (AI) phase where it probes for extra bandwidth on the path. During AI, the byte counter counts out cycles of 50 frames (this can be set to 100 frames for a less frequent probing). At the end of each cycle, the RL updates *TR* and *CR* as follows in Equation (30-5) and Equation (30-6):

$$TR \leftarrow TR + R_{\mathrm{AI}} \tag{30-5}$$
$$CR \leftarrow \tfrac{1}{2}(CR + TR) \tag{30-6}$$

where R_{AI} is a constant chosen to be 5 Mb/s in the baseline simulation.

30.2.3 RP algorithm with timer

Since rate increases using the Byte Counter occur at a frequency proportional to the current sending rate of the RL, when *CR* is very small, the duration of Byte Counter cycles when measured in seconds can become unacceptably large. Since the speed of bandwidth recovery (or responsiveness) is a key performance metric, a Timer was included in QCN.

The Timer functions similarly as the Byte Counter: it is reset when a feedback message arrives, enters FR and counts out 5 cycles of T ms duration (T is 10 ms long in the baseline), and then enter AI where each cycle is T/2 ms long.

The Byte Counter and Timer jointly determine rate increases at the RL as shown in Figure 30-4. After a feedback message is received, they each operate independently and execute their respective cycles of FR and AI. Together, they determine the state of the RL and its rate changes as follows:

a) The RL is in FR if *both* the Byte Counter and the Timer are in FR. In this case, when either the Byte Counter or the Timer completes a cycle, CR is updated according to Equation (30-4).
b) The RL is in AI if *only one of* the Byte Counter and the Timer is in AI. In this case, when either completes a cycle, *TR* and *CR* are updated according Equation (30-5) and Equation (30-6).
c) The RL is in HAI (for Hyper-Active Increase) if *both* the Byte Counter and the timer are in AI. In this case, the *i*th time that a cycle for either the Byte Counter or the Timer is completed, *TR* and *CR* are updated as shown in Equation (30-7) and Equation (30-8):

$$TR \leftarrow TR + i\mathrm{R}_{\mathrm{HAI}} \tag{30-7}$$
$$CR \leftarrow \tfrac{1}{2}(CR + TR) \tag{30-8}$$

where $\mathrm{R}_{\mathrm{HAI}}$ is constant set to 50 Mb/s in the baseline simulation (Figure 30-3). So the increments to *TR* in HAI occur in multiples of 50 Mb/s.

[44] The BIC-TCP algorithm [B65] has a similar Fast Recovery mechanism.

Thus, the Byte Counter and Timer should be viewed as providing the RL opportunities to increase the rate. Their state determines the state of, and hence the amount of rate increase at, the RL.

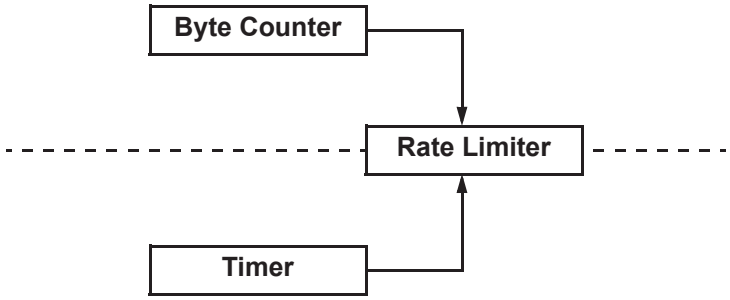


Figure 30-4—Byte Counter and Timer interaction with Rate Limiter

It is very important to note that the RL goes to HAI only after at least 500 frames have been sent and 50 ms have passed since the last congestion feedback message was received. This doubly ensures that aggressive rate increases occur only after the RL provides the network adequate opportunity (in frames sent for possible sampling) for sending rate decrease signals should there be congestion. This is vital to ensure the stability of the algorithm, and while optimizations can be performed to improve its responsiveness, in the interests of stability and simplicity, the baseline simulation (Alizadeh et al. [B1]) took no further optimization steps.

30.3 Congestion Controlled Flow (CCF)

A CCF consists of all of the frames passing through a single Flow queue (31.2.2.1) in an originating end station. Examples of CCFs include, but are not limited to,

a) The frames carrying data for a single User Datagram Protocol (UDP, IETF RFC 768, STD0006 [B17]) connection.
b) All of the frames generated by a particular process running in an end station.
c) All of the frames being transmitted by an end station that produce the same value when a hash computation is performed on the source and destination IP addresses, UDP vs. Transmission Control Protocol (TCP) selection, and source and destination UDP/TCP port numbers of the IP packets carried by those frames.
d) All of the frames passing through an RP that have the same destination_address parameter.
e) All of the frames being transmitted by an end station.
f) All of the frames passing through a Bridge Port sharing identical source_address, destination_address, and priority parameters.
g) All of the frames leaving a router that contain IP packets, and have identical values for their source and destination IP addresses, UDP vs. TCP selection, and source and destination UDP/TCP port numbers.
h) All of the frames with a certain value for the priority parameter.

All of the frames in a given CCF are sent with the same priority value, which is a CNPV (30.4).

Not all frames transmitted by an end station with an RP need be CCFs. Frames not belonging to CCFs bypass the Flow queues and RPs.

30.4 Congestion Notification Priority Value (CNPV)

A CNPV consists of one value of the priority parameter such that all of the Bridges' and end stations' ports in a Congestion Notification Domain (CND) are configured to assign frames at that value to the same CP and/or an RP. Different CNPVs correspond to classes of applications, or even single applications, such as interprocess communications or disk storage data, that have different requirements for such network resources as latency or bandwidth. Since there are eight values for the priority parameter, a single port in a Virtual Bridged Network can support as many as seven CNPV values; at least one value is required for best-effort traffic.

30.5 Congestion Notification tag (CN-TAG)

An end station may add a CN-TAG to every frame it transmits from a CCF. The CN-TAG contains a Flow Identifier field. The destination_address, Flow ID, and a portion of the frame that triggered the transmission of the CNM are the means provided by this standard by which a station can determine to which RP a CNM applies. How the station makes that determination is beyond the scope of this standard. The reasons for adding a CN-TAG include the following:

a) An end station can identify a particular flow within a CCF that triggered the CNM.
b) It can be simpler for the end station to use a Flow ID, rather than to parse the returned mac_service_data_unit of the original triggering frame, in order to identify either the RP or the particular flow.
c) Depending on the application, e.g., if fragmented IP datagrams are transmitted, it can be impossible to determine either the RP or the particular flow based solely on a returned mac_service_data_unit.

An end station that has only a single RP per CNPV, or that is able to identify the RP on the basis of the returned portion of the triggering frame, can omit transmitting the CN-TAG. The CP always returns a CN-TAG in a CNM with the triggering frame's Flow ID, or with a 0 Flow ID, if the triggering frame has no CN-TAG. The fixed format for the CNM minimizes the effort required of the CP to generate the CNM.

30.6 Congestion Notification Domain (CND)

In order for congestion notification to successfully control congestion in a Virtual Bridged Network, the managed objects controlling the congestion notification state machines in the Bridges and end stations in that network have to be configured with values that are appropriate to the characteristics of the CCFs generated by the applications that expect congestion controlled services. For example,

a) If frames that were not originated from an RP can enter a CP experiencing congestion, then the CNMs generated by that CP upon receipt of those frames cannot correct the problem, and congestion notification cannot operate correctly.
b) Congestion notification cannot operate correctly if a CP's configuration is inappropriate for the CCFs passing through it, or if priority values are regenerated in a manner that moves frames in and out of CNPVs.
c) Frames transmitted from an end station with a CN-TAG cannot be understood by an end station that is not congestion aware.

Congestion-aware Bridges therefore construct a CND, within which a particular CNPV is supported. A CND is a connected subset of the Bridges and end stations in a Virtual Bridged Network that are appropriately configured to serve a particular CNPV. This standard does not assume that every Bridge in a Virtual Bridged Network will be capable of congestion control, does not assume that every capable Bridge will be so configured, and does not assume that the subset of Bridges in a Virtual Bridged Network forming a CND that serves one CNPV will be the same subset that form a CND serving another CNPV.

CNDs can be created by configuring the Bridges and end stations in a network, or they can be created automatically, using an additional Type Length Value element, the Congestion Notification TLV (D.2.7), that this standard adds to the IEEE 802.1AB Link Layer Discovery Protocol (LLDP). Either way, every Bridge Port knows, for each CNPV, whether its neighbor(s) are or are not all configured with a matching CNPV.

NOTE—If CND boundaries are configured individually, rather than through LLDP, and there is an error in the configuration, there is a risk that frames not originating from RPs will pass through a CP, or that RP-originated frames will pass through a congested Port that has no CP. Either case can result in congestion that cannot be alleviated, with consequent excessive discarding of RP-originated data frames. In addition, such misconfiguration can result in a congestion-aware end station being unable to communicate with a congestion unaware end station, because the latter is receiving CN-TAGs that it does not understand.

Making each CND/CNPV independent, rather than making a single determination of neighbor capabilities based on whether all CNPVs are configured the same for all Ports attached to the LAN, allows a CND to be added to or removed from a network already using another CND, without disrupting the operation of the first CND.

30.7 Multicast data

Although control of multicast streams is not an object of this standard, and no simulations or experiments involving multicast data were utilized in the writing of this standard, the transmission of multicast data through a CCF is not prohibited. Some applications primarily send unicast data, but send occasional multicast frames for purposes such as discovery. Transmission of multicast data has been allowed in order to allow well-designed applications using a very small percentage of multicast traffic to operate on a CNPV.

Multicast streams are often sent to multiple destinations along multiple paths through the network, and a unicast stream normally travels along a single path. Therefore, a multicast stream is more likely to encounter any congested ports that exist in a network than is a unicast stream. The consequences of sending multicast streams on a CCF include the following:

a) The RP could limit the CCF to the rate of the slowest (most congested) path taken by the multicast.
b) The chances of unintended fate sharing are higher in a CCF that included multicast streams. That is, a multicast stream is more likely to unnecessarily slow down a unicast stream sharing the same CCF than one unicast stream is likely to slow down another.

30.8 Congestion notification and additional tags

The transmission of a CNM from a CP to an RP makes the CP and RP peer entities in the sense discussed in IEEE Std 802.1AC. An example of this peering relationship for a VLAN Bridged Network is illustrated in Figure 30-5, with the CP-RP relationship shown by a heavy dashed line.

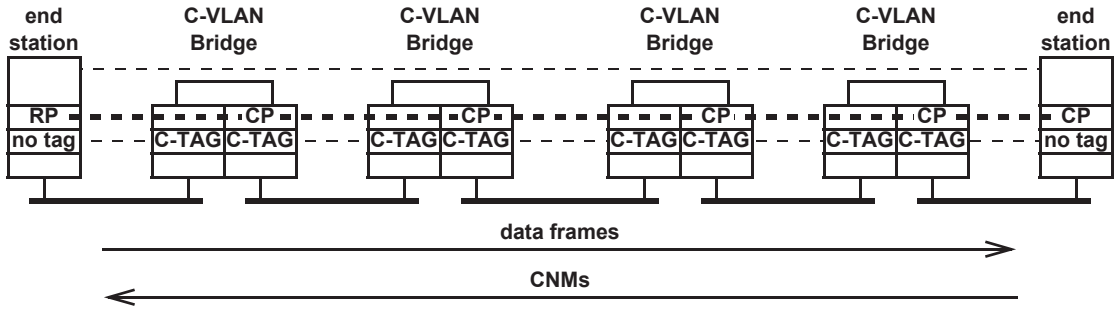


Figure 30-5—CP–RP peering in VLAN Bridged Network

PBBs (Clause 25) could be used in a data center environment, in order to reduce the number of MAC addresses that have to be learned in the core of the network. The I-component (5.7) of a PBB adds and removes I-TAGs (9.7) on data frames. However, as illustrated in Figure 30-6,[45] adding an I-TAG to a data frame by an I-component impairs the ability of a CP in the core of that network to return a CNM that will be meaningful to the originating end station. The following two difficulties follow from the fact that a CP in a BCB is not a peer of the RP in an end station:

a) The BCB CP cannot parse the I-TAG and C-TAG, which is necessary in order to find the RP's MAC address and the data frame's CN-TAG, in order to build an I-TAG-encapsulated, CNM addressed to the RP.
b) There is no MAC address available to the BCB CP that would be a valid source_address in the CNM when received by the RP.

In order to provide the benefits of PBBNs or other hierarchical bridging technologies to the data center environment, an interworking function (32.16) is defined to allow core CPs to peer with end stations.

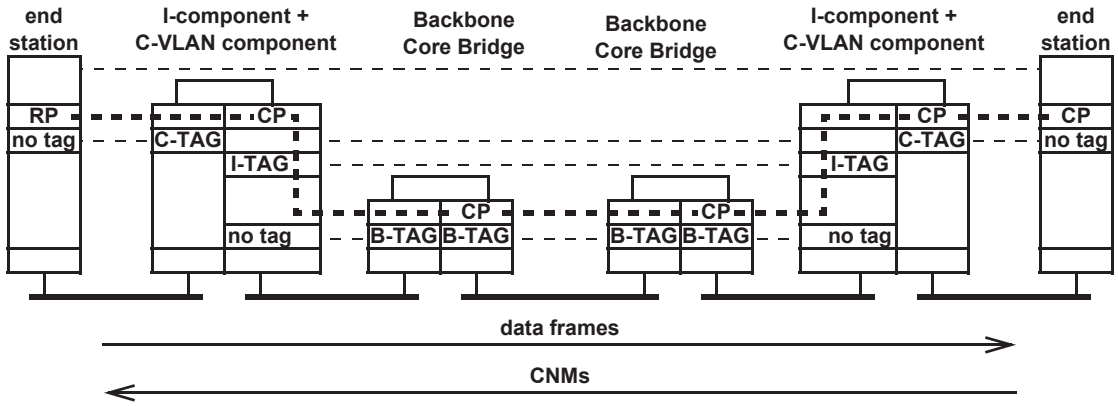


Figure 30-6—CP–RP peering in PBBN

[45] In the configuration chosen for illustration for the data center environment in Figure 30-6, each S-VLAN component of an I-components is, in effect, a Provider Bridge (5.10). That is, each CNP in an I-component is virtualized and multiplied, and connected to a corresponding virtual PEP of a C-VLAN component offering a single CEP facing the end station. This offers a C-TAG interface to the end station, without incurring the burden of an additional layer of S-TAGs.

31. Congestion notification entity operation

This clause specifies the following:

a) The architecture of the CP in the Forwarding Process in a congestion-aware Bridge component or end station (31.1).
b) The architecture of a CP and an RP in a congestion-aware end station (31.2).

NOTE—Clause 30 introduces the principles of congestion notification operation and the network architectural concepts that support it. Clause 32 specifies the protocols operated by entities defined in this clause. Clause 33 specifies the encoding of the PDUs used by congestion notification.

The models of operation in this clause provide a basis for specifying the externally observable behavior of congestion notification, and are not intended to place additional constraints on implementations; these can adopt any internal model of operation compatible with the externally observable behavior specified. Conformance of equipment to this standard is purely in respect of observable protocol.

31.1 Congestion-aware Bridge Forwarding Process

Figure 8-12 illustrates the details of the Bridge Forwarding Process. Figure 22-1 shows a different view of those details, rearranged so that those entities of the Forwarding Process that are concerned only with a single Bridge Port can be put in the proper relationship to entities such as CFM shims. Figure 31-1 shows only the queuing functions of Figure 22-1, as modified for a congestion-aware Bridge. Two new entities are added for the congestion-aware Bridge: the CP (31.1.1) and the CP ingress multiplexer (31.1.2).

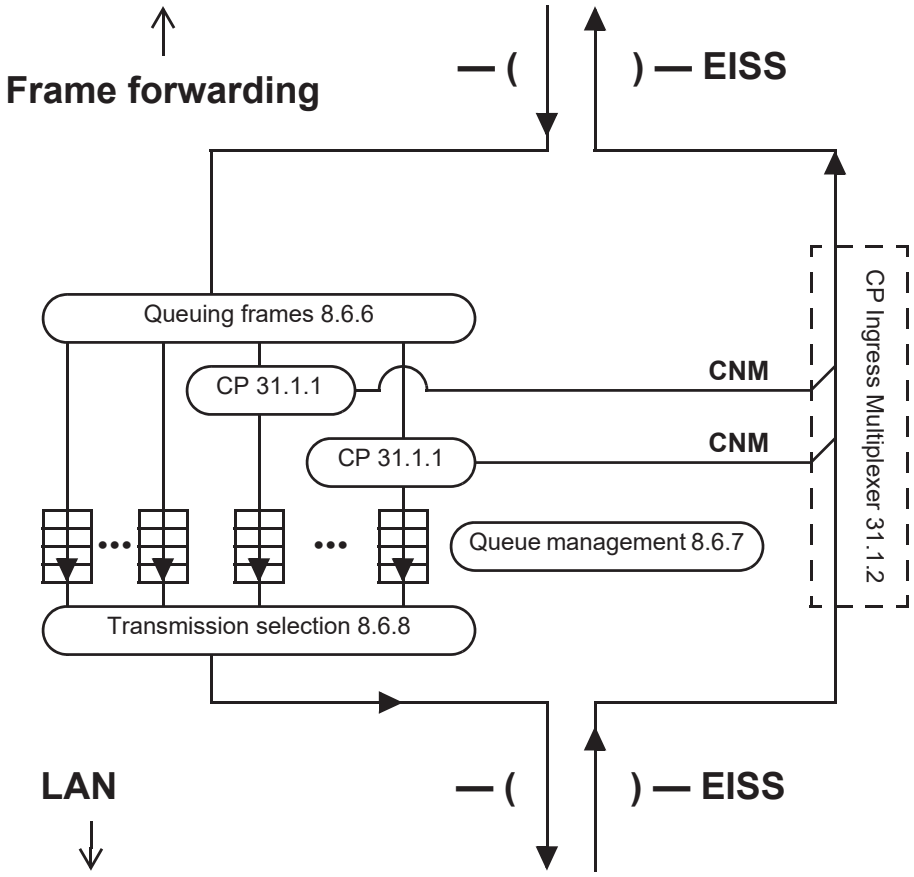


Figure 31-1—CPs and congestion-aware queues in a Bridge

31.1.1 Congestion Point (CP)

As described in 32.8 and 32.9, based on the state of its internal variables, and a frame given the CP by the Queuing frames entity (8.6.6) in an EM_UNITDATA.request (parameters) (32.9.3), a CP either inserts the frame into its attached queue or discards the frame, and can generate a CNM, based on the frame. Discarded frames are counted in the variable cpDiscardedFrames (32.8.12). Frames successfully queued are counted in the variable cpTransmittedFrames (32.8.13). Any CNM generated is passed to the CP ingress multiplexer (31.1.2, Figure 31-1) or Flow multiplexer (31.2.4, Figure 31-2) for transmission back to the RP that sourced the frame.

Congestion notification does not operate correctly if frames not belonging to a CCF are allowed to pass through a CP. The CND operations (32.1) help to ensure that the only frames passing through a CP belong to CCFs.

The CP shall remove the CN-TAG from every frame passing through it with a priority value (a CNPV) for which the port on which the CP resides is acting in cptEdge or cptInterior CND defense mode.

The functions of Figure 22-1 could be implemented in different ways than that illustrated, without altering the externally observed behavior of the conformant equipment. For example, the CP could pass a copy of the output frame triggering a CNM to a function in the higher layer interfaces of a Bridge, which in turn, could generate the CNM. However, in order to provide a management interface that is useful over a wide range of implementations, the following provisions are made:

a) CNMs generated on a Bridge Port are not counted in the Frames Received [item a) in 12.6.1.1.3] or Octets Received [item b) in 12.6.1.1.3] counters.
b) CNMs generated on one Bridge Port are counted, as are ordinary data frames, on the Bridge Ports (if any) on which they are output.

If a Bridge supports the dot1agCfmVlanTable or the ieee8021CfmVlanTable, its CPs transmit each CNM to the Primary VID associated with the vlan_identifier of the frame triggering the CNM's transmission.

31.1.2 CP ingress multiplexer

Inserts the CNMs generated by the CPs (31.1.1) among the frames received from the LAN.

31.2 Congestion-aware end station functions

Figure 31-2 illustrates the architecture of the queue functions of a congestion-aware end station. These functions offer a service to higher layers through a single instance of the ISS or EISS, and utilize an instance of the ISS or EISS to connect to the lower layers. The Output flow segregation function is presumed to exercise control over the higher layers' ability to present frames for transmission through the ISS or the EISS, and the Reception selection function to control the flow of frames to the higher layers, by means of additional parameters local to this instance of the ISS or the EISS and/or locally significant LMI parameters (IEEE Std 802.1AC), neither of which are specified by this standard.

In Figure 31-2, the outbound queue block, in the lower left of Figure 31-2, is exactly the same as the output queues in a Bridge Port that is not congestion aware, as illustrated in Figure 22-1.

The remaining entities illustrated in Figure 31-2 are those that are peculiar to a congestion-aware end station, and are further described in the following subclauses.

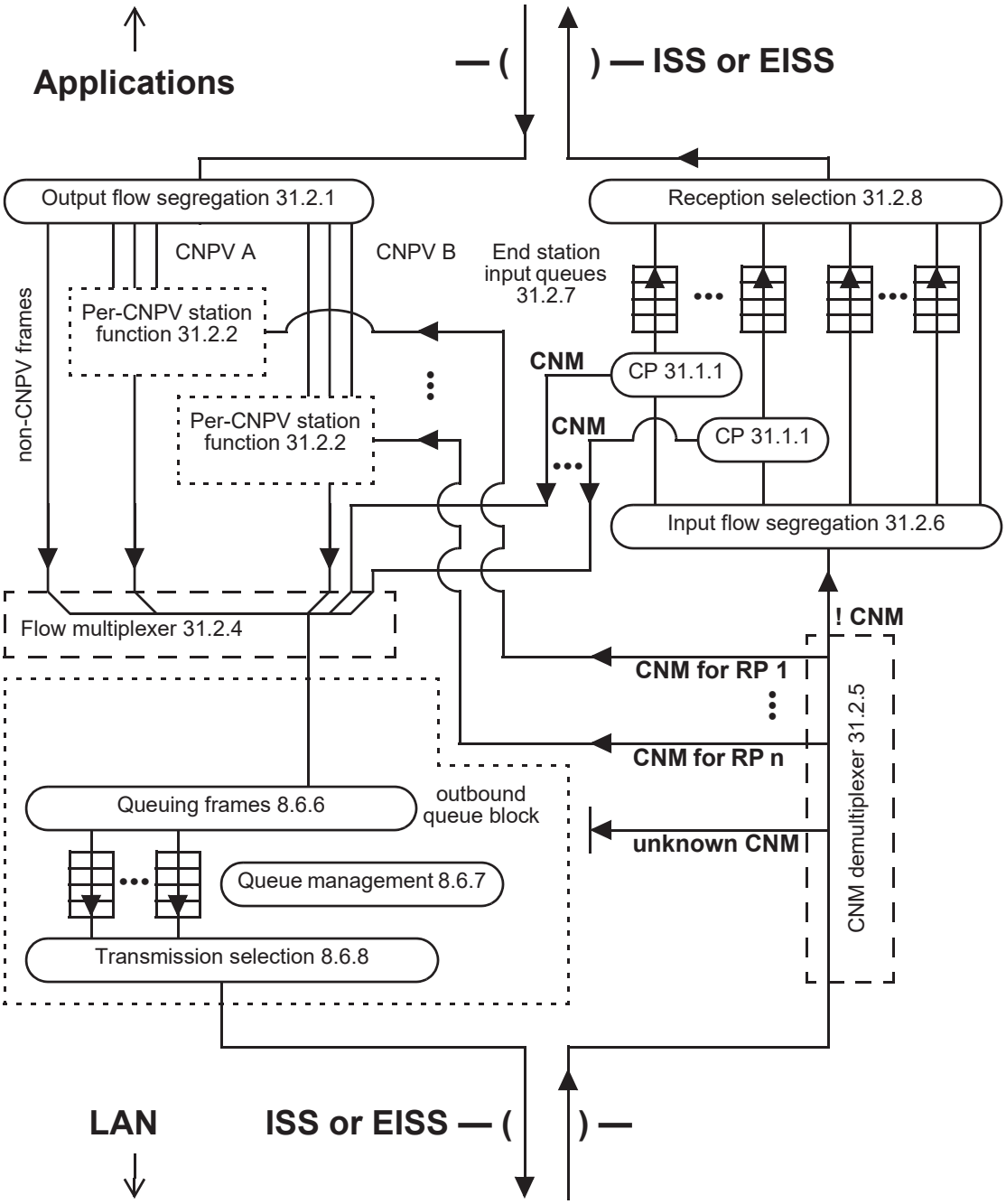


Figure 31-2—Congestion-aware queue functions in an end station

31.2.1 Output flow segregation

For each frame received from the upper layers for transmission, the Output flow segregation entity:

a) Assigns the frame a priority parameter based on the priority presented from the upper layer and/or upon other criteria, unspecified by this standard.
b) Determines, using priority value and the Flow Select Database (31.2.3), to which Flow queue, if any, the frame is to be assigned.
c) If the frame is not assigned to any Flow queue (the frame's priority is not a CNPV), passes the frame directly to the Flow multiplexer entity (31.2.4).
d) If the frame is assigned to a particular Flow queue (the frame's priority is a CNPV), enqueues the frame in the selected Flow queue.
e) For frames that are assigned to a Flow queue, depending on the state of the Flow queue to which the frame is assigned, and through means unspecified by this standard, can influence the higher layers' presentation of further frames to the Output flow segregation entity.

The Output flow segregation entity never discards a frame. Every frame presented to it is either passed to the Flow multiplexer entity (31.2.4) or stored in a Flow queue, as described previously. This standard assumes that the Output flow segregation entity can apply means, unspecified by this standard, to prevent the upper layers from offering a frame that should be stored in a Flow queue, but for which the Flow queue has insufficient resources.

The default configuration for an end station shall have a single Flow queue per CNPV. An end station may support additional Flow queues, or support more than one CNPV with a single Flow queue.

NOTE—Requirements for a default configurations do not imply that explicit action via SNMP is required to change from the default. For example, managed objects in an end station can be adjusted by an application program.

If the Output flow segregation function in an end station can change its method for assigning frames to Flow queues, it shall not do so in a manner that impairs the ability of any compliant CP implementation to throttle the data from the sourcing end station, and shall not materially increase the likelihood of misordered frame transmissions in a manner that adversely impacts the higher layers' functions.

31.2.2 Per-CNPV station function

There is one Per-CNPV station function on each Port of a congestion-aware end station for each priority value that is a CNPV. All of the frames passing through a Per-CNPV station function have the same CNPV priority parameter value.

As illustrated in Figure 31-3, each Per-CNPV station function is composed of the following entities:

a) One or more Flow queues (31.2.2.1).
b) One or more RPs (31.2.2.2), each associated with exactly one Flow queue, each comprising:
    1) A RP state machine (31.2.2.3) for each RP.
    2) A Rate Limiter (31.2.2.4) for each RP.
c) One Flow Selection function (31.2.2.5).

31.2.2.1 Flow queue

A Flow queue is a first-in-first-out queue of frames, all for the same CNPV. An Output flow segregation entity selects the Flow queue into which a given frame is inserted, and an RP determines when a frame is removed from a Flow queue.

NOTE—The Flow queue is a notional convention used to unambiguously describe the behavior of the RP. An end station can implement the Flow queue without explicitly storing frames in a queue, based on its knowledge of the state of the higher-layer applications supplying the frames.

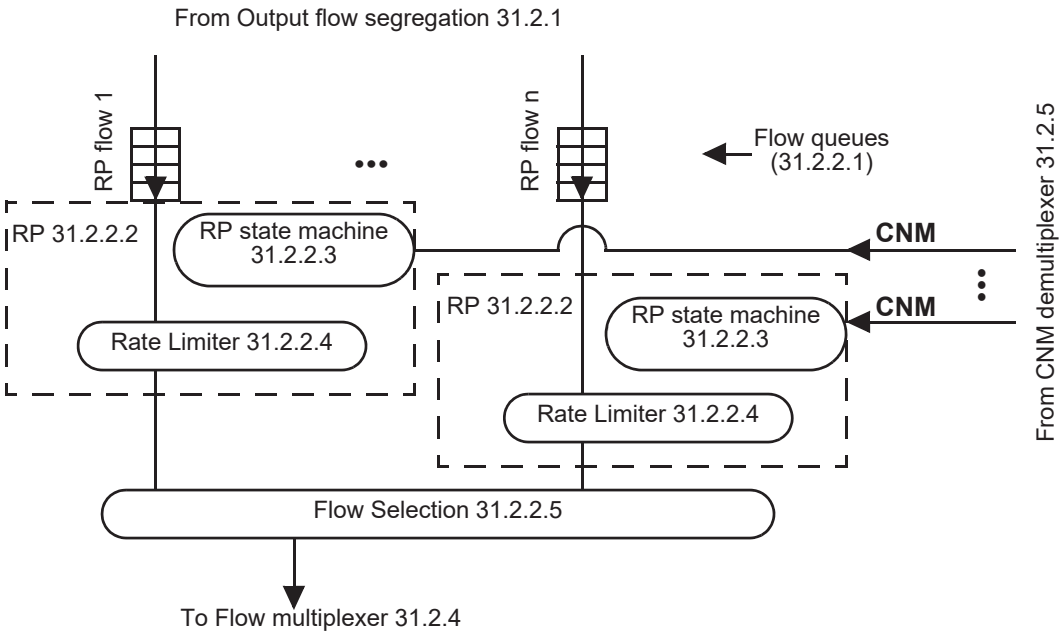


Figure 31-3—Per-CNPV station function

31.2.2.2 Reaction Point (RP)

A single RP is associated with each Flow queue. An RP is composed of a RP state machine (31.2.2.3) and a Rate Limiter (31.2.2.4).

31.2.2.3 RP state machine

A single RP state machine is associated with each Flow queue. As described in detail in Clause 32, the RP state machine consists of a timer (32.12), variables (32.10, 32.11, and 32.13), procedures (32.14), and a state machine (32.15) that determine the value of the rpLimiterRate variable (32.13.8), which, via the Rate Limiter (31.2.2.4), controls the transmission of frames from the Flow queue. The state machine and variables, in turn, are controlled by the frames input, managed objects (12.20.4), the Output flow segregation entity (31.2.1), and the CNMs received from the CNM demultiplexer (31.2.5).

31.2.2.4 Rate Limiter

A single Rate Limiter is associated with each Flow queue. The Rate Limiter enforces the output rate, rpLimiterRate (32.13.8), determined by the RP state machine (31.2.2.3). The octets in the frames passed from the Rate Limiter to the Flow Selection function (31.2.2.5) are counted in rpByteCount (32.13.2). The details of the operation of the Rate Limiter are not specified by this standard, but the measurable output rate is specified.

For a given measurement period T, R_T is defined as the integral of rpLimiterRate over T, and L_T as the number of octets actually output to the LAN, including preambles, inter-frame gaps, etc., stemming from frames that pass through that RP's Rate Limiter. An end station shall ensure that:

$$L_T \leq (1.05 \times R_T) + (16 \text{ maximum-sized frames}) \quad (31\text{-}1)$$

for the two values of T = one second and T = 1 million bits divided by the physical line rate (in bits per second), where any number of simultaneous measurements can start at any time.

NOTE 1—The rate computations and variables [Equation (31-1), 32.13.6, 32.11.6, etc.] include all of the octets associated with a frame on the LAN, including preambles, inter-frame gaps, etc., and thus reflect actual physical data rates. However, the resource actually protected by congestion notification is octets in buffers, not octet times on wires. Per-frame overhead on the LAN is added to serve as a reasonable approximation, made at the RP, to the actual size of the frame in the Bridges' or end stations' buffers. The extra 5% margin in Equation (31-1) is provided because this approximation is inexact.

NOTE 2—Although the simulations have been studied with a burst of one maximum-sized frame, this standard allows the end stations to send data in bursts of 16 maximum-sized frames, primarily to ease implementations. Larger bursts of data have a negative impact on the overall performance of the QCN algorithm, and can lead to lower link utilization.

31.2.2.5 Flow Selection

The Flow Selection function decides from which Flow queue in its Per-CNPV station function, if any, a frame will be offered to the Flow multiplexer. Whenever the output queue that receives frames from the Flow Selection function (via the Flow multiplexer) is full, the Flow Selection function shall not present any frame to the Flow multiplexer; this ensures that no frames in CNPVs will be discarded in the Port due to a lack of room in the output queue.

By means unspecified in this standard, the Flow Selection function selects frames to pass to the Flow multiplexer from the uncontrolled Flow queues (31.2.2.1) and Rate Limiters (31.2.2.4). Whenever a frame is passed from a Rate Limiter through the Flow Selection function to the Flow multiplexer, the Flow Selection function calls TransmitDataFrame (32.14.3) to update the RP variables (32.13). If the port's neighbor is ready to receive frames with CN-TAGs for the frame's CND (defense mode is cptInteriorReady), the Flow Selection function may insert a CN-TAG (30.5) at the beginning of the frame's mac_service_data_unit, and if not (any CND defense mode other than cptInteriorReady), it shall not insert a CN-TAG. (See 33.2 for a further explanation of CN-TAG insertion.)

31.2.3 Flow Select Database

The Flow Select Database is used by the Output flow segregation (31.2.1) entity to determine to which Flow queue (31.2.2.1) a given frame is assigned.

The means by which the Flow Select Database selects a Flow queue is unspecified by this standard.

31.2.4 Flow multiplexer

The Flow multiplexer merges the frames from the Per-CNPV station functions' Flow Selection functions (31.2.2.5), the frames bypassing the Per-CNPV station functions, and the CNM frames from the CPs (31.1.1), and delivers the frames to the Queuing frames (8.6.6) entity in the end station's output path.

31.2.5 CNM demultiplexer

The CNM demultiplexer identifies CNMs received from the LAN, uses the Flow ID (33.2.1) and/or Encapsulated priority (33.4.7) to determine to which RP (31.2.2.2) each CNM is intended, and directs them to the correct RPs. This standard does not specify whether or how the end station can use the Flow ID to further identify one or more individual flows within a Flow queue and its associated RP. If a CNM is received that has no CN-TAG, or a CN-TAG whose Flow ID is unknown to the RP, the CNM is discarded. All non-CNM frames are passed to the Input flow segregation entity (31.2.6).

31.2.6 Input flow segregation

For each frame received from the lower layers for reception, the Input flow segregation entity:

a) If the frame's priority is not a CNPV, decides, in an unspecified manner, whether to pass the frame to an unspecified queue, pass it to the higher layers, or discard it.
b) If the frame's priority is a CNPV, passes the frame to a CP (31.1.1), selected by unspecified means, for processing.

NOTE 1—For example, an end station might support a single CP, or support one CP per CNPV, per VID, per application, or per data flow. Neither these nor any choices for CP selection are required by this standard.

The Input flow segregation entity never discards a CNPV frame. Every CNPV frame presented to it is passed to a CP, as described previously.

NOTE 2—This does not mean that a station cannot drop CNPV frames. See 31.2.7.

31.2.7 End station input queue

The number and operation of end station input queues and the method used to drain these queues (i.e., to select and transfer frames to the receiving higher layer applications) are not specified by this standard. However, the procedures performed by a CP (32.9) require that its associated end station input queue exist, and possess certain operational parameters (32.8).

In the unfortunate event that a misconfiguration or an unfortunate sequence of frame transmissions results in more CNM frames arriving at a station than it can process, an end station input queue can fill up, and discard a frame presented to it by its CP or by the Input flow segregation (31.2.6) entity.

31.2.8 Reception selection

The Reception selection entity selects frames for delivery to the upper layers. It takes the place of the Transmission selection entity (8.6.8) of a congestion-aware Bridge. The selection algorithm depends on interactions between the applications receiving the data, the operating system supporting those applications, and the received frames that are not specified by this standard. The Reception selection entity is shown in Figure 31-2 for completeness, to indicate that frames enqueued by the Queuing frames entity (8.6.6) are, in fact, removed from the queues.

If the first octets of the mac_service_data_unit of a frame selected by the Reception selection entity are a CN-TAG, Reception selection removes the CN-TAG from the mac_service_data_unit before passing the frame to the higher layers. (See 33.2 for a further explanation of CN-TAG removal.)

32. Congestion notification protocol

Congestion-aware systems can participate in the congestion notification protocols specified in this clause:

a) CND operations (32.1).
b) The variables controlling congestion notification at the end station or Bridge component (32.2) and Port and CNPV levels (32.3).
c) The variables (32.4), procedures (32.5), and state machine (32.6) that control the defense of a CND.
d) The congestion notification protocol (32.7).
e) The variables (32.8) and procedures (32.9) that define a CP.
f) The variables associated with all (32.10), or a subset of (32.11), the RPs on a given Port and CNPV.
g) The timer (32.12), variables (32.13), procedures (32.14), and state machine (32.15) that define the operation of a single a RP.
h) The processing of CNMs by a congestion notification and encapsulation interworking function (32.16).

NOTE—Clause 30 introduces the principles of congestion notification operation and the network architectural concepts that support it. Clause 31 breaks down the congestion notification entities into their components. Clause 33 specifies the encoding of the PDUs used by congestion notification.

32.1 CND operations

As described in 30.6, a CND is a connected subset of a Virtual Bridged Network configured to support a particular CNPV. This standard provides a means whereby a VLAN Bridge or end station can recognize the like-configured ports of a CND (32.1.1), and defend its CND against incoming frames from outside the CND.

32.1.1 CND defense

Unless every Bridge along a path between two congestion-aware end stations using a particular CNPV is configured for congestion notification (belongs to a CND), and unless the Bridges ensure that frames not in CNPVs use different queues than the queues used by those two end stations, those end stations will not accrue the advantages that congestion notification offers. Therefore, steps must be taken at the boundaries of a CND to protect both the CND and the network outside the CND.

Every frame received on a Port passes through the ISS Support by specific MAC procedures (IEEE Std 802.1AC), which can change the priority parameter of the received frame, using the Port's Priority regeneration table, Table 6-4. This table can be controlled by a managed object (12.6). In addition, in order to prevent frames not in CNPVs from entering CP-controlled queues, each Port's Priority regeneration table can be modified.

If a Port's neighbor is known to also be configured for a particular CNPV, the entry in the Port's Priority regeneration table for that CNPV is ignored, and the priority is never changed on input. The Bridge component or end station connected to that Port can be trusted to use that CNPV. If the Port's neighbor is known to not be configured for a particular CNPV, the entry in the Port's Priority regeneration table for that CNPV shall be overridden to translate the CNPV to an alternate non-CNPV value. The neighboring system is not trusted, so the priority values of any frames carrying the CNPV's value are changed. Altering the priority values of received frames defends the CND from frames not originating from an RP. Similarly, if a CNPV is configured on any Port, then on that Port, the Port's Priority regeneration table shall be overridden to prevent any other priority value from being remapped into that CNPV.

If a port has multiple neighbors, or if the neighbor on a Port is not congestion aware, then the CN-TAGs shall be removed from any frames transmitted on a CNPV. This ensures that the benefits of congestion notification can be provided as far as possible along a path from a congestion-aware source to a

noncongestion-aware destination. Furthermore, CN-TAGs shall be removed from any frames transmitted from a CNPV toward a system that is congestion aware, but is still remapping the CNPV to a non-CNPV priority.

Thus, for each priority value, the CND defense mode can take one of the following four values, whether derived from LLDP or set by managed variables:

— **cptDisabled:** The congestion notification capability is administratively disabled for this priority value and port. This priority is not a CNPV. The priority regeneration table (6.9.4) controls the remapping of input frames on this port to or from this priority. CN-TAGs are neither added by an end station nor stripped by a Bridge.

— **cptEdge:** On this port and for this CNPV, the priority parameters of input frames are remapped to an alternate (non-CNPV) value, and no priority value is remapped to this CNPV, regardless of the priority regeneration table. CN-TAGs are not added by an end station and are removed from frames before being output by a Bridge.

NOTE—The cptEdge CND defense mode is optional for an end station. See 32.4.9.

— **cptInterior:** On this port and for this CNPV, the priority parameters of input frames are not remapped to another value, and no priority value is remapped to this CNPV, regardless of the priority regeneration table. CN-TAGs are not added by an end station, and are removed from frames before being output by a Bridge.

— **cptInteriorReady:** On this port and for this CNPV, the priority parameters of input frames are not remapped to another value, and no priority value is remapped to this CNPV, regardless of the priority regeneration table. CN-TAGs can be added by an end station and are not removed from frames by a Bridge.

The determination of the operational state of a CNPV on a given port is determined by variables and by LLDP (32.1.1, 32.2.1, 32.3.7, 32.3.4, 32.4.1, 32.4.3).

Taken together, these capabilities ensure that as long as the default values of the managed variables controlling CND defense are not overridden with incorrect values:

a) A data frame received by an end station on a CNPV has been governed by congestion notification along its entire path from the transmitting end station.
b) Uncontrolled data streams sourced by an end station that is congestion unaware cannot pass through a CP, with a resultant excessive loss of congestion-aware frames.
c) A data frame carrying a CN-TAG cannot be delivered to a system that is congestion unaware, and thus be unreadable by that system.

It is therefore recommended that the network administrator allow CND recognition to operate automatically (32.1.2).

CND defense operates on each LAN separately; it does not ensure the existence of an end-to-end congestion-aware path from end station to end station through a VLAN Bridged Network. Misconfiguration, the presence along the path of a congestion unaware Bridge, or the activation of a new Bridge or LAN (temporarily) can cause frames to exit a CND, and hence the following to occur:

d) Data frames can be transmitted by a congestion-aware end station on a CNPV, then be uncontrolled for congestion along some part of their path, and be delivered to an end station on a non-CNPV priority value with no CN-TAG.
e) If a congestion-aware end station transmits data frames with CN-TAGs, and is connected to a congestion unaware end station along a path consisting entirely of congestion unaware or misconfigured Bridges, the receiving end station will be unable to understand the CN-TAG, and thus unable to process the data frames.

f) If a system generates CNMs on a CNPV (not recommended, see 32.2.2), they can be delivered on a non-CNPV priority value with no CN-TAG.

32.1.2 Automatic CND recognition

Congestion notification can use the Link Layer Discovery Protocol (LLDP), defined in IEEE Std 802.1AB, to advertise the CNPVs supported on a Bridge's or end station's port, to determine whether the other Bridges' or end stations' ports connected to the same LAN are configured for those same CNPVs, and to control the operation of the CND defenses (32.1.1).

Multiple instances of LLDP can be run on a single port. Each instance's LLDPDUs use a different destination_address and therefore can reach different distances through a Virtual Bridged Network, depending on the types of the devices in that network and their connectivity. Since any Bridge that is not congestion aware can spoil the ability of the Virtual Bridged Network to minimize frame loss, the selection of which LLDP instance is used for CND defense defaults to the Nearest Bridge Address (01-80-C2-00-00-0E). This instance minimizes the reach of LLDP, and hence the risk that a noncongestion-aware Bridge is present.

As described in D.2.7, a single Congestion Notification TLV can be inserted into the LLDPDUs transmitted from any Bridge or end station port that is configured to support a CNPV. The Congestion Notification TLV carries two fields that together provide for automatic control the of the CND defenses:

a) Eight per-priority CNPV indicators (D.2.7.3), one per priority level, indicating whether each priority is or is not a CNPV on this port; and
b) Eight per-priority Ready indicators (D.2.7.4), one per priority level, indicating whether the priority remap defenses are disabled on this port.

For every CNPV configured on a port, if LLDP finds exactly one remote neighbor, and if that neighbor's database in the port's LLDP table carries a Congestion Notification TLV (D.2.7) with that CNPV's bit set in the per-priority CNPV indicators, then that CNPV is known to be configured on the remote system's port. This condition is summarized by the cnpdRcvdCnpv variable (32.4.11). Similarly, the cnpdRcvdReady variable (32.4.11) indicates whether the remote neighbor has or has not turned off its priority remapping defense. The read-only managed object cnpdAutoDefenseMode (32.4.3) indicates the results of the LLDP.

32.1.3 Variables controlling CND defense

In order to control CND defense, CN component managed objects (12.21.1), CN component priority managed objects (12.21.2), CN Port priority managed objects (12.21.3), and Congestion Point managed objects (12.21.4) override and are overridden by each other as follows:

a) Altering the CN component managed object (12.21.1) or CN component priority managed object (12.21.2) does not alter the values of any of the other managed objects (12.21.3, 12.21.4, 12.21.6).
b) If cngMasterEnable (32.2.1) is FALSE, all congestion notification activity is suppressed; the Priority Regeneration Table (6.9.4) operates normally, and CNMs, CN-TAGs, and LLDP Congestion Notification TLVs are never generated and are always ignored on receipt. If TRUE, the other managed objects control the operation of congestion notification.
c) The Port/priority and component objects override each other as shown in Table 32-1 and Table 32-2. In each case, if the Port/priority object contains the specified value, the component or component/priority object controls the specified function.

Table 32-1—LLDP instance selection managed object overrides

(Per-port per-priority) cnpdLldpInstanceChoice 32.4.4	(Component per-priority) cncpLldpInstanceChoice 32.3.6	Congestion Notification TLV is sent/received	LLDP instance is selected by
cnlNone	any	No	None selected
cnlAdmin	any	Yes	(Per-port per-priority) cnpdLldpInstanceSelector 32.4.5
cnlComponent	cnlNone	No	None selected
cnlComponent	cnlAdmin	Yes	(Component per-priority) cncpLldpInstanceSelector 32.3.7

Table 32-2—CND defense mode selection managed object overrides

(Per-port per-priority) cnpdDefModeChoice 32.4.1	(Component per-priority) cncpDefModeChoice 32.3.1	CND defense mode is selected by	Alternate priority is selected by
cpcAdmin	any	(Per-port per-priority) cnpdAdminDefenseMode 32.4.2	(Per-port per-priority) cnpdAlternatePriority 32.4.6
cpcAuto	any	(Per-port per-priority) cnpdAutoDefenseMode 32.4.3	(Component per-priority) cncpAutoAltPri 32.3.3
cpcComp	cpcAdmin	(Component per-priority) cncpAdminDefenseMode 32.3.4	(Component per-priority) cncpAlternatePriority 32.3.2
cpcComp	cpcAuto	(Per-port per-priority) cnpdAutoDefenseMode 32.4.3	(Component per-priority) cncpAutoAltPri 32.3.3

32.2 CN component variables

Every congestion-aware end station or Bridge component has a set of CN component variables to control the overall operation of congestion notification. All of these variables are included in the CN component managed object (12.21.1). Variables marked, “CP only” are not required for an end station that does not support CPs. The CN component variables include the following:

a) cngMasterEnable (32.2.1)
b) cngCnmTransmitPriority (32.2.2)
c) cngDiscardedFrames (32.2.3)
d) cngErroredPortList (32.2.4)

32.2.1 cngMasterEnable

A Boolean value specifying whether congestion notification is enabled in this Bridge component or end station.

32.2.2 cngCnmTransmitPriority

(CP only) The priority value to be used when transmitting CNMs from this Bridge component or end station (default 6) [item h) in 32.9.4].

NOTE—If cngCnmTransmitPriority is itself a CNPV, then it is possible that another CP could generate a CNM in response to a CNM sent by this Port. Although this is not desirable, the fact that CNMs are sent in response to only a sampling of frames means that the network will not fail due to an excessive number of CNMs.

32.2.3 cngDiscardedFrames

(CP only) The total number of frames discarded from full CP queues. This is the total of the values of all cpDiscardedFrames (32.8.12) variables for this end station or Bridge component.

32.2.4 cngErroredPortList

(CP only) A list of Ports whose alternate priority values (cnpdAlternatePriority, 32.4.6) specify a CNPV, where 0 indicates that the Bridge's alternate priority value (cncpAlternatePriority, 32.3.2) specifies a CNPV.

NOTE—The alternate priority (cncpAlternatePriority, 32.3.2, or cnpdAlternatePriority, 32.4.6) for a given CNPV cannot itself be a CNPV. But, because alternate priority values can be set using different managed objects for different CNPVs, invalid configurations can be specified. cngErroredPortList provides the network administrator with a list of Ports that could have invalid configurations.

32.3 Congestion notification per-CNPV variables

An instance of the congestion notification per-CNPV variables exists for each CNPV in a congestion-aware end station or Bridge component to control CN for all Ports in the end station or Bridge component. Variables marked "CP only" are not required for an end station that does not support CPs. The congestion notification per-CNPV variables include the following:

a) cncpDefModeChoice (32.3.1)
b) cncpAlternatePriority (32.3.2)
c) cncpAutoAltPri (32.3.3)
d) cncpAdminDefenseMode (32.3.4)
e) cncpCreation (32.3.5)
f) cncpLldpInstanceChoice (32.3.6)
g) cncpLldpInstanceSelector (32.3.7)

32.3.1 cncpDefModeChoice

An enumerated value specifying how the CND defense mode and alternate priority for all Ports for this CNPV are to be selected, unless overridden (32.1.3) by the variables in the CND defense per-Port per-CNPV variables (32.4), either one of the following:

1) **cpcAdmin:** The Port's default CND defense mode for this priority is controlled by cncpAdminDefenseMode (32.3.4) and the alternate priority by cncpAlternatePriority (32.3.2); or
2) **cpcAuto:** The Port's default CND defense mode for this priority is controlled by LLDP and the Congestion Notification TLV (cnpdAutoDefenseMode, 32.4.3) and the alternate priority by cncpAutoAltPri (32.3.3).

32.3.2 cncpAlternatePriority

(CP only) An alternate priority value to which this priority value is to be remapped when the Port's CND defense mode is cptEdge for this priority (default value 0). This can be overridden by cnpdAlternatePriority (32.1.3, 32.4.6).

32.3.3 cncpAutoAltPri

An integer indicating the next lower priority value than this CNPV that is not a CNPV in an end station or Bridge component, or the next higher non-CNPV, if all lower values are CNPVs (32.1.1).

32.3.4 cncpAdminDefenseMode

An enumerated value controlling the CND defense mode (30.6) for all Ports for this CNPV in this Bridge component or end station: cptDisabled (1), cptInterior (2, the default value), cptInteriorReady (3), or cptEdge (4) (32.1.1). This can be overridden by cnpdAdminDefenseMode (32.1.3, 32.4.2).

32.3.5 cncpCreation

An enumerated value controlling the applicability of this CN component priority managed object to the Ports in that Bridge component or end station, either one of the following:

1) **cncpAutoEnable:** The cnpdDefModeChoice variable (32.4.1) in any CN Port priority managed object created as a result of the creation of this CN component priority managed object or the creation of a Port is given the value cpcComp (3); or
2) **cncpAutoDisable:** The cnpdDefModeChoice variable (32.4.1) in any CN Port priority managed object created as a result of the creation of this CN component priority managed object or the creation of a Port is given the value cpcAdmin (1).

32.3.6 cncpLldpInstanceChoice

Determines the method by which the component LLDP instance selector, specifying on which LLDP instance the Congestion Notification TLV is to carry information for this priority, is determined (32.1.1), either one of the following:

1) **cnlNone:** if LLDP is not to carry Congestion Notification TLVs on any Port or priority; or
2) **cnlAdmin:** If cncpLldpInstanceSelector (32.3.7) governs LLDP instance selection for all Ports and priorities (this is the default value).

This choice can be overridden (32.1.3) on a per-Port per-priority basis by cnpdLldpInstanceChoice (32.4.4).

32.3.7 cncpLldpInstanceSelector

A reference to the LLDP destination address table entry whose LLDPDUs are to carry Congestion Notification TLVs for this Bridge component or end station (32.1.1). The use of this variable is controlled by cncpLldpInstanceChoice (32.3.6).

32.4 CND defense per-Port per-CNPV variables

For each Port in a congestion-aware end station or Bridge component, and for each priority value for which a set of congestion notification per-CNPV variables exists, there is an instance of the CND defense per-Port per-CNPV variables. These variables control congestion notification on the port for a CNPV, including CND defense. Variables marked, “CP only” are not required for an end station that does not support CPs. The CND defense per-Port per-CNPV variables include the following:

a) cnpdDefModeChoice (32.4.1)
b) cnpdAdminDefenseMode (32.4.2)
c) cnpdAdminDefenseMode (32.4.2)
d) cnpdAutoDefenseMode (32.4.3)
e) cnpdLldpInstanceChoice (32.4.4)
f) cnpdLldpInstanceSelector (32.4.5)
g) cnpdAlternatePriority (32.4.6)
h) cnpdXmitCnpvCapable (32.4.7)
i) cnpdXmitReady (32.4.8)
j) cncpDoesEdge (32.4.9)
k) cnpdAcceptsCnTag (32.4.10)
l) cnpdRcvdCnpv (32.4.11)
m) cnpdRcvdReady (32.4.12)
n) cnpdIsAdminDefMode (32.4.13)
o) cnpdDefenseMode (32.4.14)

32.4.1 cnpdDefModeChoice

An enumerated value specifying how the CND defense mode and the alternate priority of the Port for this priority is to be determined, (30.6, 32.1.1, 32.1.1):

1) **cpcAdmin:** The Port’s CND defense mode for this priority is controlled by cnpdAdminDefenseMode (32.4.2), and the alternate priority by cnpdAlternatePriority (32.4.6);
2) **cpcAuto:** The Port’s CND defense mode for this priority is controlled by LLDP and the Congestion Notification TLV (cnpdAutoDefenseMode, 32.4.3) and the alternate priority by cncpAutoAltPri (32.3.3); or
3) **cpcComp:** The Port’s CND defense mode for this priority is controlled by cncpDefModeChoice (32.3.1) and the alternate priority by cncpAutoAltPri (32.3.3) (this is the default value).

32.4.2 cnpdAdminDefenseMode

An enumerated value specifying the CND defense mode of the Port for this priority, if and only if cnpdDefModeChoice (32.4.1) has the value cpcAdmin (1) (30.6, 32.1.1, 32.1.1):

1) **cptDisabled:** The CP is disabled on this port for this CNPV. Priority regeneration on input is controlled by the priority regeneration table. This is the same behavior as when cngMasterEnable (32.2.1) has the value FALSE. (This is the default value.);
2) **cptInterior:** The priority parameter of frames input are not remapped to or from this priority, and CN-TAGs are not output;
3) **cptInteriorReady:** The priority parameter of frames input are not remapped to or from this priority, and CN-TAGs can be output; or
4) **cptEdge:** The priority parameter of frames input at this priority are remapped to an alternate value, frames at other priorities are not remapped to this priority, and CN-TAGs are not output.

32.4.3 cnpdAutoDefenseMode

An enumerated value indicating the operating mode: cptInterior (2), cptInteriorReady (3), or cptEdge (4), in which the Port would operate for this CNPV if cnpdDefModeChoice (32.4.1) had the value cpcAuto (2).

NOTE—cncpAdminDefenseMode (32.3.4) is controlled by the network administrator. The object cnpdAutoDefenseMode (32.4.3) indicates what the CND defense mode would be, if it were controlled by the LLDP Congestion Notification TLV.

32.4.4 cnpdLldpInstanceChoice

Port and priority LLDP instance selector, specifying on which LLDP instance the Congestion Notification TLV is to carry information for this priority on this Port (32.1.1):

1) **cnlNone:** No LLDP Congestion Notification TLV is to carry Per-priority CNPV indicators or Per-priority Ready indicators on this Port for this priority;
2) **cnlAdmin:** cnpdLldpInstanceSelector (32.4.5) governs which LLDP instance is to carry Per-priority CNPV indicators and Per-priority Ready indicators for this priority in its Congestion Notification TLV on this Port; or
3) **cnlComponent:** cncpLldpInstanceSelector (32.3.7) governs LLDP instance selection for this Port and priority (this is the default value).

32.4.5 cnpdLldpInstanceSelector

A reference to the LLDP destination address table entry for an LLDP instance selector, specifying on which LLDP instance the Congestion Notification TLV is to carry information for this priority on this Port, if and only if cnpdLldpInstanceChoice (32.4.4) is set to cnlAdmin (2). Default value is 1. (32.1.1);

32.4.6 cnpdAlternatePriority

(CP only) An alternate priority value to which this priority value is to be remapped when the Port's CND defense mode is cptEdge for this priority, if and only if cnpdDefModeChoice (32.4.1) is set to cpcAdmin (1) (default value 0).

32.4.7 cnpdXmitCnpvCapable

Per-port per-priority Boolean variable indicating whether a given priority on this Port is (TRUE) or is not (FALSE) currently operating as a CNPV. cnpdXmitCnpvCapable is transmitted in the per-priority CNPV indicators in the Congestion Notification TLV (D.2.7.3). The variable is TRUE if and only if all of the following conditions are met:

a) cngMasterEnable (32.2.1) is TRUE; and
b) The CND defense mode, as selected by cncpDefModeChoice, cncpAdminDefenseMode, cnpdDefModeChoice, and cnpdAdminDefenseMode, according to Table 32-2, is not cptDisabled.

32.4.8 cnpdXmitReady

Per-port per-priority Boolean variable indicating whether the priority remap defenses for this port and CNPV have been disabled. cnpdXmitReady is transmitted in the per-priority Ready indicators in the Congestion Notification TLV (D.2.7.4). This variable is set and reset by the CND defense state machine (32.6).

32.4.9 cncpDoesEdge

Boolean variable indicating whether the cptEdge CND defense mode (32.1.1) is (TRUE) or is not (FALSE) implemented on this port for this priority. This variable is TRUE in a Bridge. In an end station, it may be either TRUE or FALSE. This variable is not a managed object.

NOTE—This variable, when FALSE, causes the state machine in Figure 32-1 to pass through the CNDD_EDGE state directly to the CNDD_INTERIOR state. Since the state machine takes, in theory, no time to execute, it is impossible to tell from any measurement taken outside the system whether the actions specified in the CNDD_EDGE state are actually executed.

32.4.10 cnpdAcceptsCnTag

Boolean variable indicating whether the CN-TAG is (TRUE) or is not (FALSE) acceptable on data frames received on this port for this CNPV. This variable is TRUE in a Bridge. In an end station, it may be either TRUE or FALSE. This variable is not a managed object.

NOTE—This variable can be used by an end station that finds it convenient for the adjacent Bridge to remove CN-TAGs from frames on a CNPV. By preventing this Port and CNPV's cnpdXmitReady variable from being set TRUE, (see Figure 32-1) cnpdAcceptsCnTag prevents the adjacent device's CND defense state machine (32.6) from advancing from the CNDD_INTERIOR state to the CNDD_INTERIOR_READY state, and thus prevents it from transmitting a CN-TAG on this CNPV.

32.4.11 cnpdRcvdCnpv

Per-port per-priority Boolean variable indicating the presence of an LLDP neighbor's Congestion Notification TLV (D.2.7). cnpdRcvdCnpv is TRUE only if all of the following are true:

a) An LLDP instance is selected by cncpLldpInstanceSelector (32.3.7) and cnpdLldpInstanceSelector (32.4.5);
b) The selected LLDP instance indicates that the Port has a single neighbor;
c) The selected LLDP instance's neighbor information includes a Congestion Notification TLV; and
d) That Congestion Notification TLV's Per-priority CNPV indicators field has a value of 1 in the position corresponding to this CNPV.

32.4.12 cnpdRcvdReady

Per-port per-priority Boolean variable indicating that the neighboring system has turned off its CND defenses. cnpdRcvdReady is TRUE only if all of the following are true:

a) cnpdRcvdCnpv is TRUE; and
b) The bit in the same Congestion Notification TLV's (D.2.7) Per-priority Ready indicators field (D.2.7.4) has a value of 1 in the position corresponding to this CNPV.

32.4.13 cnpdIsAdminDefMode

Boolean variable derived from the managed objects, indicating to the CND defense state machine (32.6) whether the CND defense mode is being forced to a particular state by the managed objects, as shown in Table 32-3.

NOTE—The purpose of this variable is to simplify the Boolean expressions in Figure 32-1.

32.4.14 cnpdDefenseMode

Enumerated value, indicating the management choice for the CND defense mode, if any, as shown in Table 32-3. The value of this variable is not defined if the managed variables indicate no choice for the CND defense mode.

Table 32-3—Determining cnpdIsAdminDefMode and cnpdDefenseMode

(Per-port per-priority) cnpdDefModeChoice (32.4.1)	(Component per-priority) cncpDefModeChoice (Clause 32)	cnpdIsAdminDefMode (32.4.13) is	cnpdDefenseMode (32.4.14) is obtained from
cpcAdmin	Any	TRUE	(Per-port per-priority) cnpdAdminDefenseMode 32.4.2
cpcAuto	Any	FALSE	Not defined
cpcComp	cpcAdmin	TRUE	(Component per-priority) cncpAdminDefenseMode 32.3.4
cpcComp	cpcAuto	FALSE	Not defined

NOTE—The purpose of this variable is to simplify the exit condition expressions in Figure 32-1.

32.5 CND defense procedures

There are three procedures associated with the CND defense state machine. They are as follows:

a) DisableCnpvRemapping() (32.5.1)
b) TurnOnCnDefenses() (32.5.2)
c) TurnOffCnDefenses() (32.5.3)

32.5.1 DisableCnpvRemapping()

Removes any overrides by congestion notification of the Priority Regeneration Table (6.9.4).

32.5.2 TurnOnCnDefenses()

Overrides the Priority Regeneration Table (6.9.4) to use the alternate priority specified by cncpAlternatePriority (32.3.2), cncpAutoAltPri (32.3.3), and cnpdAlternatePriority (32.4.6) for frames with this CNPV, instead of the value in the Priority Regeneration Table.

32.5.3 TurnOffCnDefenses()

Overrides the Priority Regeneration Table (6.9.4) to not alter the priority of incoming frames with this CNPV, instead of using the value in the Priority Regeneration Table.

32.6 CND defense state machine

The CND defense state machine is illustrated in Figure 32-1. A congestion-aware Bridge component or end station shall implement one CND defense state machine per port per priority level.

NOTE—In Figure 32-1, global transitions are associated with each value of cnpdDefenseMode when the CND defense mode is chosen by the managed variables; the nonglobal transitions from state to state can take place only when the CND defense mode is chosen by LLDP.

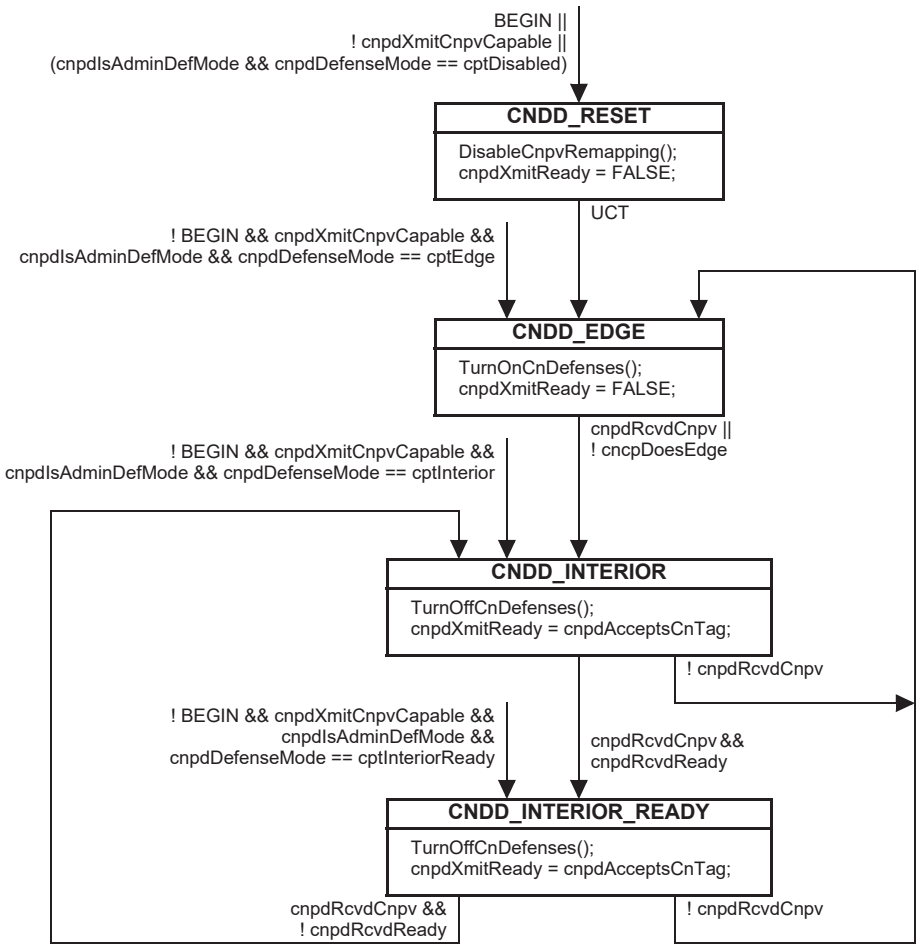


Figure 32-1—CND defense state machine

32.7 Congestion notification protocol

Clause 32 is a detailed specification of the state machines required to implement the QCN algorithm introduced in 30.2. Table 32-4 shows the correlation between the description of QCN in 30.2, the state machine variables in this clause, and the CNM PDU fields in 33.4.

There are two stateful participants in the congestion notification protocol:

a) The CP (31.1.1) shall behave in a manner that is indistinguishable, from an observer external to a system, from a strict implementation of the variables in 32.8 and the procedures in 32.9.
b) The RP (31.2.2.2) shall behave in a manner that is indistinguishable, from an observer external to a system, from a strict implementation of the timer in 32.12, variables in 32.13, the procedures in 32.14, and the state machine in 32.15.

Table 32-4—Correspondence of QCN and CCF message fields

Quantized Congestion Notification protocol, 30.2	Congestion notification protocol, 32.7	Congestion Notification Message, 33.3
Quantized Feedback calculation (32.8.9, item e) in 32.9.4)		
F_b (30.2.1)	—	cpFb (33.4.3)
Q_{off} (30.2.1)	– cpQOffset (32.8.7)	cnmQOffset (33.4.5)
Q (30.2.1)	cpQLen (32.8.4)	—
Q_{eq} (30.2.1)	cpQSp (32.8.3)	—
Q_{δ} (30.2.1)	cpQDelta (32.8.8)	cnmQDelta (33.4.6)
Q_{old} (30.2.1)	cpQLenOld (32.8.5)	—
w (30.2.1)	cpW (32.8.6)	—
RP rate calculations (32.14.5, 32.14.6, Figure 32-2)		
CR (30.2.2)	rpCurrentRate (32.13.6)	—
TR (30.2.2)	rpTargetRate (32.13.5)	—
Byte Counter (30.2.3)	rpByteCount (32.13.2)	—
Timer (30.2.3)	RpWhile (32.12.1)	—
G_d (30.2.2.1)	rpgGd (32.11.8)	—
R_{AI} (30.2.2.1)	rpgAiRate (32.11.6)	—
R_{HAI} (30.2.3)	rpgHaiRate (32.11.7)	—
i (30.2.3)	min(rpByteStage, rpTimeStage) (RPR_HYPER_INCREASE)	—

32.8 CP variables

The following variables control the operation of a CP:

a) cpMacAddress (32.8.1)
b) cpId (32.8.2)
c) cpQSp (32.8.3)
d) cpQLen (32.8.4)
e) cpQLenOld (32.8.5)
f) cpW (32.8.6)
g) cpQOffset (32.8.7)
h) cpQDelta (32.8.8)
i) cpFb (32.8.9)
j) cpEnqued (32.8.10)
k) cpSampleBase (32.8.11)
l) cpDiscardedFrames (32.8.12)
m) cpTransmittedFrames (32.8.13)
n) cpTransmittedCnms (32.8.14)
o) cpMinHeaderOctets (32.8.15)

32.8.1 cpMacAddress

The MAC address, belonging to the system transmitting the CNM PDU, used as the source_address of CNMs sent from this CP [item b) in 32.9.4].

32.8.2 cpId

Unsigned integer. A number that uniquely identifies a CP in a Virtual Bridged Network [item p) in 32.9.4].

NOTE—This standard does not specify whether the Congestion Point Identifier (CPID) reported in a CNM by a CP that serves multiple CNPVs does or does not have the same value for its different CNPVs.

32.8.3 cpQSp

Unsigned integer. The set-point for the queue. This is the target number of octets in the CP's queue [item e) in 32.9.4]. Default value 26000.

32.8.4 cpQLen

Unsigned integer. The current number of octets in the CP's queue [item c) in 32.9.4].

32.8.5 cpQLenOld

Unsigned integer. The previous value of cpQLen. cpQLenOld is updated from cpQLen each time GenerateCnmPdu() is called [item c) in 32.9.4].

32.8.6 cpW

Real number. cpW is the weight to be given to the change in queue length in the calculation of cpFb (32.8.9). Default value 2. Although cpW is specified as a real number, it is constrained to be a power of 2, e.g., 1/2, 1, 2, 4. In practice, therefore, it can be represented as a shift distance (plus an addition) in item e) in 32.9.4.

32.8.7 cpQOffset

The signed integer value of the transmitting CP's cpQSp (32.8.3) – cpQLen (32.8.4) used to calculate cpFb (32.8.9), and thus the Quantized Feedback field (33.4.3).

32.8.8 cpQDelta

The signed integer value of the transmitting CP's cpQLen (32.8.4) – cpQLenOld (32.8.5) used to calculate cpFb (32.8.9), and thus the Quantized Feedback field (33.4.3).

32.8.9 cpFb

Signed integer. Calculated just before the CP attempts to enqueue a frame:

$$cpFb = cpQOffset - cpW \times cpQDelta,$$

where

$$cpQDelta = cpQLen - cpQLenOld \quad cpQOffset = cpQSp - cpQLen$$

cpFb has two terms. The first term is the difference between the current and the desired queue lengths (cpQOffset, 32.8.7). The second is a weight factor cpW times the difference cpQDelta (32.8.8) between the current and the previous queue lengths. Thus, a multiple of the first derivative of the queue size is subtracted from the current nonoptimality of the queue, so that if the queue length is moving toward the set point cpQSp, cpFb will be closer to 0 than if the queue length is moving away from cpQSp.

32.8.10 cpEnqued

Signed integer. The number of octets remaining to be enqueued by the CP before a CNM PDU is to be generated (32.9.3).

32.8.11 cpSampleBase

Unsigned integer. The minimum number of octets to enqueue in the CP's queue between CNM PDU transmissions (32.9.3). Default value 150 000.

32.8.12 cpDiscardedFrames

The number of frames offered to this CP that were discarded because of a full output queue (31.1.1).

32.8.13 cpTransmittedFrames

The number of data frames enqueued for transmission on this CP's output queue (31.1.1).

32.8.14 cpTransmittedCnms

The number of CNMs transmitted by this CP [item s) in 32.9.4].

32.8.15 cpMinHeaderOctets

The minimum number of octets that the CP is to return in the Encapsulated MSDU field (33.4.10) of each CNM it generates [item k) in 32.9.4]. Default value 0.

32.9 CP procedures

The procedures used in a CP include the following:

a) Random() (32.9.1)
b) NewCpSampleBase() (32.9.2)
c) EM_UNITDATA.request (parameters) (32.9.3)
d) GenerateCnmPdu() (32.9.4)

A CP needs no state machine; the procedure EM_UNITDATA.request (parameters), called each time a frame is presented for queuing, triggers all of the CP's functions.

32.9.1 Random

The Random function takes two parameters, min and max, and returns a pseudo-random number in the range min ≤ number < max. This function shall be initialized so that it generates a different value each time the system is reset.

32.9.2 NewCpSampleBase()

Called by EM_UNITDATA.request (parameters) (32.9.3) when generating a new value for cpSampleBase (32.8.11) from the CNM PDU Quantized Feedback field (33.4.3) last generated by GenerateCnmPdu(). NewCpSampleBase() returns a real number according to Table 32-5.

NOTE—The values in Table 32-5 are chosen so that the value returned by NewCpSampleBase() can be an integer to be used in a division, rather than a real number to be used in a multiplication.

Table 32-5—NewCpSampleBase() return value as a function of cpFb

Quantized Feedback / 8	Value returned by NewCpSampleBase()
0	1
1	1/2
2	1/3
3	1/4
4	1/5
5	1/6
6	1/7
7	1/8

32.9.3 EM_UNITDATA.request (parameters)

A CP offers an instance of the EISS (6.8) to the Queuing frames function (8.6.6). When called upon to enqueue a frame, the CP:

a) Determines the number of octets of buffer space required to enqueue the frame, and subtracts that number from cpEnqued (32.8.10).
b) If cpEnqued ≤ 0, then:
   1) Calculates a new value for cpFb according to 32.8.9.
   2) Calls GenerateCnmPdu() to conditionally transmit a CNM PDU.
   3) Replaces cpEnqued with cpSampleBase × NewCpSampleBase() × Random(0.85, 1.15), and if the result is less than zero, resets cpEnqued to 0.

The accuracy of the sample jitter introduced by the function Random(0.85, 1.15) is not critical to the success of congestion notification. The amount of jitter introduced by this function should be no more than 0.75 ≤ jitter < 1.25 and no less than 0.875 ≤ jitter < 1.125.

32.9.4 GenerateCnmPdu()

Called by the CP to conditionally generate a CN-TAGged CNM PDU for output. GenerateCnmPdu()

a) Uses the source_address of the frame triggering the CNM PDU as the destination_address of the generated CNM PDU.
b) Uses cpMacAddress (32.8.1) as the source_address of the CNM PDU.
c) Replaces the value of cpQLenOld (32.8.5) with cpQLen (32.8.4).
d) If cpFb is greater than or equal to 0, or if the destination_address parameter of the CNM PDU is a Group, and not an Individual, address, does nothing; no further processing takes place, and no CNM PDU is transmitted.
e) Fills the Quantized Feedback field (33.4.3) of the CNM PDU as follows:

   if (cpFb < – cpQSp × (2 × cpW + 1))

   Quantized Feedback = 63

   else

   Quantized Feedback = – cpFb × 63 / (cpQSp × (2 × cpW + 1))
f) If the Quantized Feedback field equal to 0 does nothing; no further processing takes place, and no CNM PDU is transmitted.

g) If the first octets of the mac_service_data_unit of the frame triggering the CNM PDU are a CN-TAG, copies the Flow Identifier field (33.2.1) from that CN-TAG to the CN-TAG of the CNM, else fills the Flow Identifier field of the CNM's CN-TAG with 0.

h) Sets the priority parameter of the CNM PDU from cngCnmTransmitPriority (32.2.2).

NOTE 1—The default value for the priority of a CNM PDU is 6. CNM PDUs are not expected to be sent in high volumes, but undelivered CNM PDUs reduce the ability of congestion notification to prevent lost data frames. Priority 7 is typically reserved for control traffic that, if not delivered, can result in the loss of connectivity in the Bridged Network.

i) Sets the vlan_identifier of the CNM PDU from the vlan_identifier of the frame triggering the CNM PDU, if the dot1agCfmVlanTable is not implemented, else the Primary VID of that vlan_identifier.

j) Fills the Encapsulated destination MAC address field (33.4.8) of the CNM PDU with the destination_address parameter of the frame triggering the CNM PDU.

k) Fills the Encapsulated MSDU field (33.4.10) of the CNM PDU with the first octets of the remainder of the mac_service_data_unit following the CN-TAG, if present, of the frame triggering the CNM PDU. The minimum number of octets is the value of cpMinHeaderOctets (32.8.15), or the whole of the mac_service_data_unit following the CN-TAG, if it is shorter, and the maximum is 64.

l) Fills the Encapsulated MSDU length field (33.4.9) of the CNM PDU with the number of octets inserted into the Encapsulated MSDU field (33.4.10).

m) Inserts the encapsulation appropriate to the CP's port, as specified in 33.3, at the beginning of the mac_service_data_unit.

NOTE 2—This encapsulation is changed by the Bridge, if required, before the CNM PDU is output on a port that uses a different encapsulation from the CP's port.

n) Fills the Version field (33.4.1) of the CNM PDU with 0.

o) Fills the ReservedV field (33.4.2) of the CNM PDU with 0.

p) Fills the Congestion Point Identifier field (33.4.4) of the CNM PDU from the variable cpId (32.8.2).

q) Computes and fills the cnmQOffset and cnmQDelta fields (33.4.5, 33.4.6) from the variables cpQOffset and cpQDelta.

r) Fills the Encapsulated priority field (33.4.7) from the priority parameter of the frame triggering the CNM PDU.

s) Increments cpTransmittedCnms (32.8.14).

t) Passes the CN-TAG and CNM PDU as an EM_UNITDATA.indication to the higher layers (Figure 31-1), if the CP is in a Bridge, or to the Flow multiplexer (31.2.4), if the CP is in an end station (Figure 31-2).

32.10 RP per-Port per-CNPV variables

There is one set of these variables per Port per CNPV in a congestion-aware end station. A set of RP per-Port per-CNPV variables is created or deleted whenever a CN Port priority managed object is created or deleted. All of the RPs (if more than one) associated with a given Port and CNPV share a single set of the RP per-Port per-CNPV variables.

32.10.1 rpppMaxRps

An unsigned integer controlling the maximum number of RPs allowed for this CNPV on this Port (default 1). An end station shall not create more than rpppMaxRps on a given Port, but it can create fewer.

32.10.2 rpppCreatedRps

The number of times an RP's rpEnabled variable has been set TRUE at this priority level on this Port [item e) in 32.4.14].

32.10.3 rpppRpCentiseconds

An integer containing the number of RP-centiseconds accumulated by RPs at this priority level on this Port. This variable is incremented once per centisecond (10 ms) for each RP on this Port whose rpEnabled variable (32.13.1) is TRUE.

NOTE—Reading rpppRpCentiseconds and SysUpTime[46] at two different times allows a management entity to compute the average number of RPs present for a priority and Port by dividing the change in rpppRpCentiseconds by the change in SysUpTime (which is measured in centiseconds).

32.11 RP group variables

There is one set of RP group variables for each group of RPs belonging to a particular CNPV on a Port in a congestion-aware end station. It is an implementation choice whether each RP rate control state machine (32.15) has its own set of RP group variables or shares them with another RP rate control state machine on the same Port and the same CNPV. This standard does not specify how RPs are grouped together for management purposes, except that all of the RPs controlled by a single set of RP group variables shall serve a single CNPV. At the extremes, a single set of RP group variables could control all of the RPs serving the same CNPV, or each RP could be controlled by its own set of RP group variables. The RP group variables include the following:

a) rpgEnable (32.11.1)
b) rpgTimeReset (32.11.2)
c) rpgByteReset (32.11.3)
d) rpgThreshold (32.11.4)
e) rpgMaxRate (32.11.5)
f) rpgAiRate (32.11.6)
g) rpgHaiRate (32.11.7)
h) rpgGd (32.11.8)
i) rpgMinDecFac (32.11.9)
j) rpgMinRate (32.11.10)

32.11.1 rpgEnable

A Boolean value controlling the rpEnabled variables for all of the RP rate control state machines controlled by this Reaction Point group managed object. If rpgEnable is TRUE, the controlled rpEnabled variables are not held in the FALSE state, thus enabling the RPs to pay attention to received CNMs. If rpgEnable is FALSE, the controlled rpEnabled variables are held in the FALSE state, thus disabling the RPs.

32.11.2 rpgTimeReset

Unsigned integer. RpWhile (32.12.1) is reset to either rpgTimeReset or rpgTimeReset / 2 (with random jitter—see Figure 32-2 in 32.15, RPR_ACTIVE_TIME) each time it reaches 0, according to the state of the RP rate control state machine. Default value 15 ms.

32.11.3 rpgByteReset

Unsigned integer. rpByteCount (32.13.2) is reset to either rpgByteReset or rpgByteReset / 2 (with random jitter—see Figure 32-2 in 32.15, RPR_ACTIVE_BYTE) each time it reaches 0, according to the state of the RP rate control state machine. Default value 150 000 octets.

[46] From IETF RFC 3418.

32.11.4 rpgThreshold

Unsigned integer. Specifies the number of times rpByteStage or rpTimeStage can count before the RP rate control state machine advances states. Default value is 5.

32.11.5 rpgMaxRate

Unsigned integer. The maximum rate, in bits per second, at which an RP can transmit. Default value is the speed of the Port. A system shall support a nonzero minimum value for rpgMaxRate no larger than 5 Mb/s. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc. rpgMaxRate is configurable in multiples of 1 Mb/s.

32.11.6 rpgAiRate

Unsigned integer. The rate, in bits per second, used to increase rpTargetRate in the RPR_ACTIVE_INCREASE state in Figure 32-2 in 32.15. Default value 5 Mb/s. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc. rpgAiRate is configurable in multiples of 1 Mb/s.

32.11.7 rpgHaiRate

Unsigned integer. The rate, in bits per second, used to increase rpTargetRate in the RPR_HYPER_INCREASE state in Figure 32-2 in 32.15. Default value 50 Mb/s. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc. rpgHaiRate is configurable in multiples of 1 Mb/s.

32.11.8 rpgGd

Real number. Multiplied times the Quantized Feedback field (33.4.3) received in a CNM PDU to decrease rpTargetRate. Default value 1/128. rpgGd is configurable as a power of 2, e.g., 1/256, 1/128, 1/64.

32.11.9 rpgMinDecFac

Real number. The minimum factor by which the current RP transmit rate rpCurrentRate can be changed by reception of a CNM. Default value is 0.5.

32.11.10 rpgMinRate

Unsigned integer. The minimum value, in bits per second, for rpCurrentRate (32.13.6) Default value is 10 Mb/s. A system shall support a minimum value for rpgMinRate no larger than 10 Mb/s. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc. rpgMinDecFac is configurable in multiples of 1 Mb/s.

32.12 RP timer

An RP implements one timer as follows:

a) RpWhile (32.12.1).

32.12.1 RpWhile

Timer counter for controlling the RP rate control state machine (32.15). RpWhile operates normally when rpFreeze (32.13.7) is FALSE, and shall not be decremented when rpFreeze is TRUE.

32.13 RP variables

Each RP rate control state machine (32.15) has its own set of RP variables. The RP variables include the following:

a) rpEnabled (32.13.1)
b) rpByteCount (32.13.2)
c) rpByteStage (32.13.3)
d) rpTimeStage (32.13.4)
e) rpTargetRate (32.13.5)
f) rpCurrentRate (32.13.6)
g) rpFreeze (32.13.7)
h) rpLimiterRate (32.13.8)
i) rpFb (32.13.9)

32.13.1 rpEnabled

Boolean. Controls RP rate control state machine. If TRUE, state machine is running. If FALSE, state machine is held in the RPR_RESET state. Initialized to FALSE when an RP rate control state machine is created. Held in the FALSE state if rpgEnable (32.11.1) has the value FALSE.

32.13.2 rpByteCount

Unsigned integer. Counts octets passed from the Rate Limiter (31.2.2.4) to the Flow Selection function (31.2.2.5). The counting down of rpByteCount to or past 0 triggers a reevaluation of rpCurrentRate (32.13.6).

32.13.3 rpByteStage

Unsigned integer. Counts the number of times rpByteCount has counted down to or past 0 since the last CNM was received.

32.13.4 rpTimeStage

Unsigned integer. Counts the number of times RpWhile has counted down to 0 since the last CNM was received.

32.13.5 rpTargetRate

Unsigned integer. The target rate, in bits per second, toward which rpCurrentRate is heading. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc.

32.13.6 rpCurrentRate

Unsigned integer. The rate, in bits per second, at which the Rate Limiter (31.2.2.4) transmits data from its Flow queue when rpFreeze (32.13.7) is FALSE. (The actual output of the Rate Limiter is controlled by rpLimiterRate, 32.13.8.) This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc.

32.13.7 rpFreeze

Boolean. When FALSE, the RP and Rate Limiter operate normally. When TRUE, rpLimiterRate is held to the value 0, to suppress the transmission of frames. rpFreeze is FALSE when there is room for frames from this RP in the output queue, and TRUE when not.

32.13.8 rpLimiterRate

Unsigned integer. The rate, in bits per second, at which the Rate Limiter (31.2.2.4) transmits data from its Flow queue. rpLimiterRate is equal to rpCurrentRate (32.13.6) as long as rpFreeze (32.13.7) is FALSE, and 0, when rpFreeze is TRUE. This rate includes all bits consequent to transmitting the frame on the LAN, including preamble, inter-frame gap, etc.

32.13.9 rpFb

Unsigned integer. The value last received in the Quantized Feedback field (33.4.3) of a CNM PDU or 0.

32.14 RP procedures

The following procedures are used by the RP rate control state machine and the Output flow segregation function (31.2.1):

a) ResetCnm (32.14.1)
b) TestRpTerminate (32.14.2)
c) TransmitDataFrame (32.14.3)
d) ReceiveCnm (32.14.4)
e) ProcessCnm (32.14.5)
f) AdjustRates (32.14.6)

32.14.1 ResetCnm

Called whenever the RP rate control state machine enters the RPR_RESET state (Figure 32-2 in 32.15) to set the following variables:

— rpCurrentRate = rpgMaxRate
— rpTargetRate = rpgMaxRate
— rpByteCount = rpgByteReset
— rpFb = 0

32.14.2 TestRpTerminate

Called by the Flow Selection function (31.2.2.5) each time a frame is passed from the Per-CNPV station function's Rate Limiter (31.2.2.4) to the Flow multiplexer (31.2.4). If:

a) rpCurrentRate equals rpgMaxRate
b) The Flow queue is empty
c) rpEnabled is TRUE

Then TestRpTerminate sets rpEnabled (32.13.1) to FALSE, which disables the RP until another CNM is received.

NOTE—Condition b) can be met when all frames limited by a given Rate Limiter have been processed. See 31.2.2.1.

32.14.3 TransmitDataFrame

TransmitDataFrame() is called each time a frame is passed from a Rate Limiter (31.2.2.4) to the Port's Flow multiplexer (31.2.4). TransmitDataFrame() subtracts the length of the transmitted frame from rpByteCount (32.13.2) and may insert a CN-TAG containing the Flow ID of the Flow queue at the beginning of the frame's mac_service_data_unit.

If an end station is VLAN-aware or priority-aware, and if a CN-TAG is added to a frame, the CN-TAG shall follow the VLAN or priority tag in the frame.

32.14.4 ReceiveCnm

Called whenever a CNM is received. ReceiveCnm() performs the following actions:

a) The CNM is validated according to 33.4.11 and is discarded if invalid.
b) If the CNM frame carries a CN-TAG (33.2), the Flow ID from that CN-TAG (33.2.1) is used to identify the particular RP rate control state machine to which this CNM applies.
c) If the receiving end station is unable to identify the particular RP rate control state machine to which this CNM applies, it discards the CNM, and no further processing takes place.
d) Sets the rpFb variable from the CNM's Quantized Feedback field (33.4.3).
e) If the selected RP rate control state machine's rpEnabled variable is FALSE and is not held FALSE because rpgEnable (32.11.1) has the value FALSE, and the CNM's cnmQOffset field (33.4.5) is positive, then rpEnabled is reset to TRUE, and the variable rpppCreatedRps (32.10.2) is incremented.

These actions activate the selected RP rate control state machine, if it was not active (rpEnabled == FALSE), and also cause the RP rate control state machine to process the received CNM.

32.14.5 ProcessCnm

Called whenever the RP rate control state machine enters the RPR_CNM_RECEIVED state (Figure 32-2 in 32.15) to perform the following actions:

```
if (rpByteStage ! = 0) {
      rpTargetRate = rpCurrentRate;
      rpByteCount = rpgByteReset;
}
rpByteStage = 0;
rpTimeStage = 0;
dec_factor = (1 – (rpgGd * rpFb));
if (dec_factor < rpgMinDecFac)
      dec_factor = rpgMinDecFac;
rpCurrentRate = rpCurrentRate * dec_factor;
if (rpCurrentRate < rpgMinRate)
      rpCurrentRate = rpgMinRate;
RpWhile = rpgTimeReset;
```

32.14.6 AdjustRates

AdjustRates is called whenever the RPR_ADJUST_RATES, RPR_ACTIVE_INCREASE, or RPR_HYPER_INCREASE states are entered. It takes one parameter, *increase*, that specifies how much to increase rpTargetRate, and performs the following actions:

```
if ((rpByteStage == 1) || (rpTimeStage == 1))   &&   (rpTargetRate > 10 * rpCurrentRate))
      rpTargetRate = rpTargetRate / 8;
else
      rpTargetRate = rpTargetRate + increase;
rpCurrentRate = (rpTargetRate + rpCurrentRate)/2;
if (rpCurrentRate > rpgMaxRate)
      rpCurrentRate = rpgMaxRate;
```

32.15 RP rate control state machine

The RP rate control state machine is illustrated in Figure 32-2. In this figure, the RPR_RESET state has no exit. The state machine is held in the RPR_RESET state as long as either the general system initialization variable “BEGIN” is TRUE or the rpEnabled variable, local to the particular instance of the RP rate control state machine, is FALSE. When “BEGIN” becomes FALSE and rpEnabled TRUE, the state machine remains in the RPR_RESET state until a CNM is received by ReceiveCnm (32.14.4) with a Quantized Feedback field (33.4.3) that is less than 0. ReceiveCnm places that field into rpFb (32.13.9), which condition forces the state machine into the RPR_CNM_RECEIVED state. When that state resets rpFb to 0, progress through the state machine continues either until another CNM is received and rpFb is set to a nonzero value, or until the state machine is deactivated by TestRpTerminate (32.14.2) setting rpEnabled to FALSE.

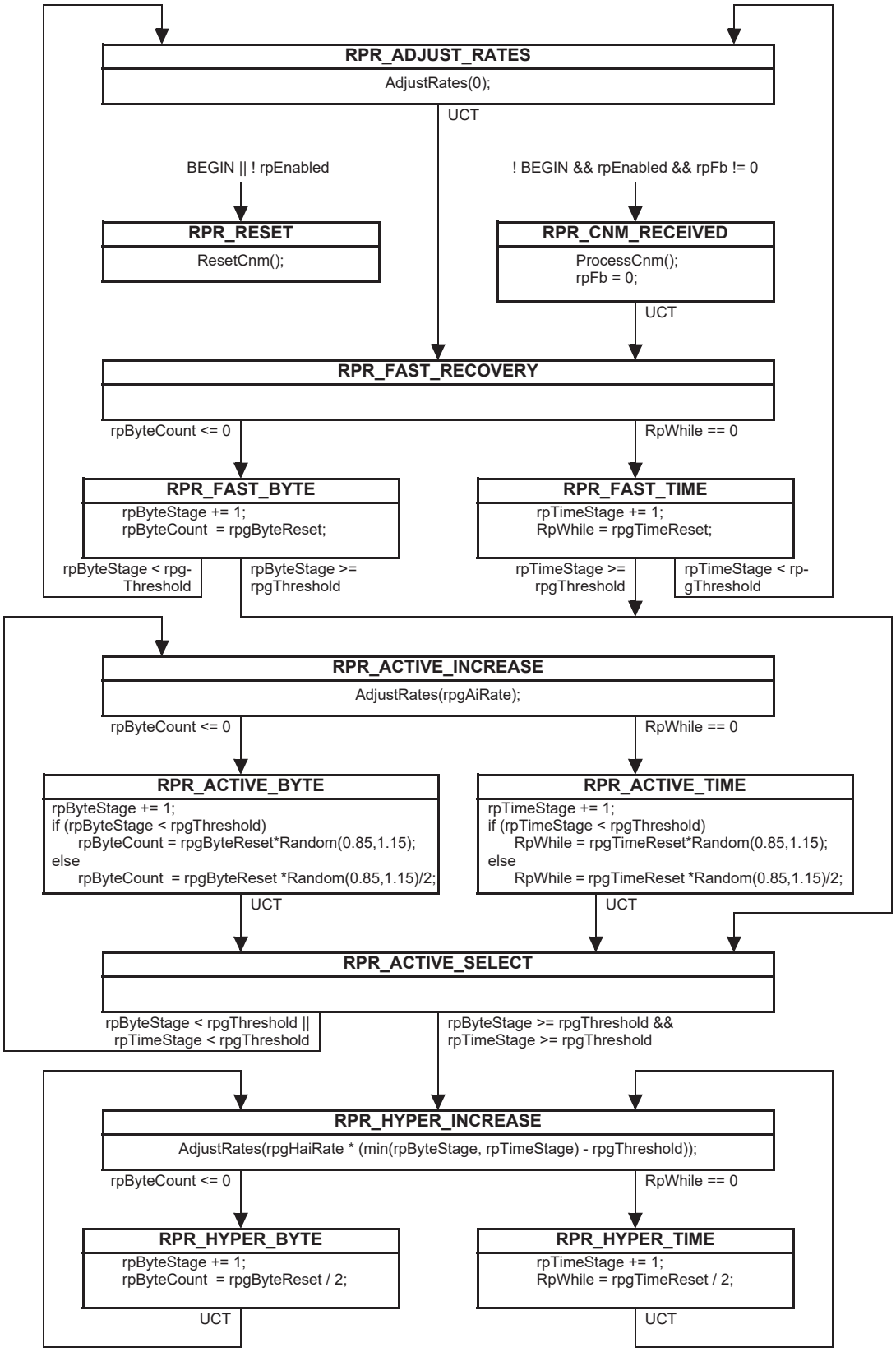


Figure 32-2—RP rate control state machine

32.16 Congestion notification and encapsulation interworking function

As mentioned in 30.8, a hierarchical Bridged Network, e.g., a PBBN, can require a congestion notification and encapsulation interworking function for a CP in the core of the network to generate a CNM that can reach the RP, which is presumably outside the core. This general case is illustrated in Figure 32-3. In the network illustrated, encapsulation and decapsulation functions peer with each other to encapsulate the data frames inside some kind of wrapper, e.g., an S-TAG and/or an I-TAG.

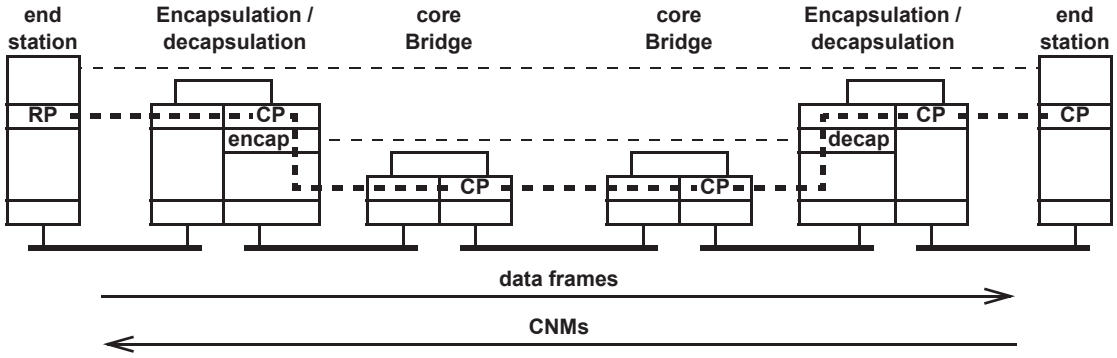


Figure 32-3—CP–RP peering in any hierarchical Bridged Network

Not all encapsulation schemes are equivalent. It is useful to divide hierarchical Bridged Networks into two categories for the purpose of defining congestion notification and encapsulation interworking functions, based on the mac_service_data_unit of a data frame carrying (optionally) a CN-TAG as seen by a CP residing in a core Bridge, with one of these cases further subdivided as follows:

a) In a network where the original end station's mac_service_data_unit, including the optional CN-TAG, comprises the first octets of the mac_service_data_unit at the core Bridge's CP, there is no need for a congestion notification and encapsulation interworking function. For example, a PBN in which the C-TAGs are not carried across the core needs no interworking function.

b) In a network where an encapsulation comprises the first octets of the mac_service_data_unit at the core Bridge's CP, a congestion notification and encapsulation interworking function is required. It is useful to make a further distinction, in this case:

   1) The MAC addresses of Ports in the Bridges where the encapsulation and decapsulation functions are performed are the destination and source addresses of frames crossing the core Bridges. For example, in a PBBN, the I-TAG, and perhaps an S-TAG and/or a C-TAG as well, can be present as the first octets of the mac_service_data_unit, and the source_address and destination_address parameters visible to the core Bridge's CP are the addresses of PIPs in BEBs.

   2) In other networks, although an encapsulation is in the first octets of the mac_service_data_unit at the core Bridge's CP, the source and destination MAC addresses are not altered by the encapsulation and decapsulation operations. For example, in a PBN in which both a C-TAG and an S-TAG are carried across the core, the C-TAG occupies the first octets of the mac_service_data_unit as seen by a core Bridge's CP.

In either type of network covered by case b), the core Bridge's CP is configured by the network administrator to return, in the Encapsulated MSDU field of the CNM PDU (33.4.10), the leading octets of the mac_service_data_unit of the data frame triggering transmission of the CNM. Since the CN-TAG of the data frame, if present, is buried behind encapsulations unknown to the CP, when the CN-TAG and CNM are built according to 32.9.4, the Flow ID returned in the CN-TAG of the CNM is filled with 0. The network administrator configures the CP to return at least enough octets of the data frame's mac_service_data_unit to include the CN-TAG of the original data frame transmitted by the RP.

The difference between case 1) and case 2), preceding, lies in the means used by the Port containing the congestion notification and encapsulation interworking function to recognize the CNM in order to translate it. In case 1), the CNM is addressed to that Port, and has a CN-TAG and the CNM encapsulation, instead of a data frame tag and encapsulation. In case 2), the only reliable indicator of a CNM that needs to be transformed, as opposed for example, to a CNM returned by the destination end station's CP, can be the presence of an encapsulation known to the interworking function in the Encapsulated MSDU field (33.4.10) of the CNM PDU.

When the CNM generated by the core Bridge's CP reaches a congestion notification and encapsulation interworking function, that interworking function uses the information in the CNM PDU, including the encapsulated data frame information, to construct a CN-TAG and CNM PDU to send to the RP. The steps taken are as follows:

c) In case 1), where the CNM is returned to the MAC address of the interworking function's Port, the destination_address parameter is obtained from the appropriate source address found in the Encapsulated MSDU field, and the source_address parameter is a MAC address belonging to the Bridge containing the interworking function, and valid in the context of the newly generated CNM, for example, a management port address.

d) In case 2), where the CNM is recognized by the presence of the encapsulation in the Encapsulated MSDU field, the source_address, and destination_address parameters are unchanged.

e) The vlan_identifier is obtained from the Encapsulated MSDU field.

f) The drop_eligible parameter is False.

g) The priority parameter used is the value configured for a CP on a Port in the Bridge in which the interworking function resides, and through which the CNM passes.

h) The Encapsulated priority field (33.4.7) is obtained from the Encapsulated MSDU field, or if not present there, the Encapsulated priority is left unchanged.

NOTE—In spite of the provisions for CND defense in this clause, it is possible for a network administrator to configure a network so that the priority of a CCF data frame is not preserved. For example, in a PBN, two CNPVs could be mapped to the same S-TAG priority, and the C-TAG not configured to be carried across the network. In that case, an end station with an RP on each of those CNPVs, and that does not distinguish between those RPs using CN-TAGs, would be unable to assign returned CNMs to the right RP. At least some of its CCFs would not be constrained, and uncontrolled congestion would likely result. It is therefore recommended that the CN-TAG be included across a PBN, or that each CNPV be mapped to a separate priority in the backbone.

i) If a CN-TAG is found in the Encapsulated MSDU, its Flow ID is copied to the CN-TAG of the newly generated CNM, else 0 is used for that CN-TAG's Flow ID.

j) The encapsulation in the Encapsulated MSDU field of the CNM PDU, up to and including the CN-TAG (which is not necessarily present), is elided, the remainder (if any) of the Encapsulated MSDU field moved up to the first octets of the field, and the Encapsulated MSDU length field reduced accordingly.

33. Encoding of congestion notification PDUs

This clause specifies the method of encoding congestion notification PDUs. The specifications include the following:

a) The general structure and encoding of congestion notification PDUs (33.1)
b) The format used for the CN-TAG (33.2)
c) The encapsulation used for a CNM (33.3)
d) The format used for the CNM (33.4)

The format of the IEEE 802.1AB Type Length Value (TLV) used to signal that a VLAN Bridge or end station is congestion aware, and the state of its CND defense mode, is specified in D.2.7.

NOTE—Clause 30 introduces the principles of congestion notification operation and the network architectural concepts that support it. Clause 31 breaks down the congestion notification entities into their components. Clause 32 specifies the protocols operated by these components.

33.1 Structure, representation, and encoding

All congestion notification PDUs contain an integral number of octets.

The octets in a congestion notification PDU are numbered starting from 1 and increasing in the order they are put into the MSDU that accompanies a request to or indication from the instance of the MAC Internal Sublayer Service (ISS or EISS) used by a congestion notification entity.

The bits in an octet are numbered from 1 to 8 in order of increasing bit significance, where 1 is the LSB in the octet.

Where octets and bits within a congestion notification PDU are represented using a diagram, octets shown higher on the page than subsequent octets and octets shown to the left of subsequent octets at the same height on the page are lower numbered; bits shown to the left of other bits within the same octet are higher numbered.

Where two or more consecutive octets are represented as hexadecimal values, lower numbered octet(s) are shown to the left and each octet following the first is preceded by a hyphen, e.g., 01-80-C2-00-00-00.

When consecutive octets are used to encode a binary number, the lower octet number has the more significant value. When consecutive bits within an octet are used to encode a binary number, the higher bit number has the most significant value. When bits within consecutive octets are used to encode a binary number, the lower octet number composes the more significant bits of the number. A flag is encoded as a single bit, and is set (TRUE) if the bit takes the value 1, and clear (FALSE) otherwise. The remaining bits within the octet can be used to encode other protocol fields.

33.2 CN-TAG format

The means for identifying CN-TAG PDUs consist of two octets containing the EtherType value shown (in hexadecimal notation) in Table 33-1.

In a VLAN Bridge, the shim that supports the EISS (IEEE Std 802.1AC, 6.8, Figure 22-4) is below the Queuing shim (8.6.6, 8.6.7, 8.6.8, 31.1.1). The CN-TAG is examined by the CP, which is part of the Queuing shim. Therefore, the CN-TAG will be further from the source_address and destination_address fields, and closer to the end of the frame, than a VLAN tag added by 6.8, if any. In order for a Bridge to be able to recognize the CN-TAG in a data frame, an end station shall insert the CN-TAG and VLAN tag in the relative order required by a Bridge: addresses, VLAN tag, CN-TAG, data.[47]

Table 33-1—CN-TAG Encapsulation

	Octet	Length
Tag EtherType (22-E9)	1	2
Flow Identifier	3	2

33.2.1 Flow Identifier

The meaning and encoding of the Flow Identifier field are not specified by this standard. A CP shall not interpret the value in a Flow Identifier field. The Flow ID returned in the CN-TAG of a CNM is used by an end station's CNM demultiplexer (31.2.5) to identify the RP, the Flow queue, or a group of one or more individual flows, from which was transmitted the data frame that triggered the CNM.

33.3 Congestion Notification Message (CNM)

The means for identifying CNM PDUs consist of two octets containing the EtherType value shown (in hexadecimal notation) in Table 33-2.

Table 33-2—CNM Encapsulation

	Octet	Length
PDU EtherType (22-E7)	1	2
CNM PDU	3	24 to 88

33.4 Congestion Notification Message PDU format

The format of a Congestion Notification Message (CNM) PDU is illustrated in Table 33-3. If the frame that triggered the transmission of the CNM carried a CN-TAG, then that CN-TAG is retained in the frame carrying the CNM PDU; otherwise, a CN-TAG with a FlowID of 0 is used in the frame carrying the CNM PDU.

33.4.1 Version

This field, 4 bits in length, shall be transmitted with the value 0, and shall be ignored on receipt. The Version field occupies the most significant bits of the first octet of the CNM PDU.

33.4.2 ReservedV

This field, 6 bits in length, shall be transmitted with the value 0, and shall be ignored on receipt. The ReservedV field occupies the least significant 4 bits of the first octet, and the most significant 2 bits of the second octet, of the CNM PDU.

[47] There are other tags, e.g., the IEEE 802.1AE MAC Security tag, not included in this abbreviated list.

Table 33-3—Congestion Notification Message PDU

	Octet	Length
Version	1	4 bits
ReservedV	1, 2	6 bits
Quantized Feedback	2	6 bits
Congestion Point Identifier	3	8
cnmQOffset	11	2
cnmQDelta	13	2
Encapsulated priority	15	2
Encapsulated destination MAC address	17	6
Encapsulated MSDU length	23	2
Encapsulated MSDU	25	0–64

33.4.3 Quantized Feedback

This field, 6 bits in length, contains the Quantized Feedback value calculated by the CP's EM_UNITDATA.request (parameters) procedure (32.9.3). The Quantized Feedback field occupies the least significant bits of the first two octets of the CNM PDU.

33.4.4 Congestion Point Identifier

This field, 8 octets in length, uniquely identifies the CP that triggered the transmission of this Congestion Notification Message PDU format within the CND. Because the transmitting system can format the Congestion Point Identifier (CPID) in any manner, a receiving RP shall not assign any meaning to subfields within a CPID.

NOTE—Making the CPID 8 octets long removes the connection between CP identity and the source MAC address of the CNM PDU. One way to achieve the requirements for uniqueness of the CPID would be to use a Port's MAC address as the high-order 6 octets of the CPID, and use the low-order two octets of the CPID to hold the priority of the CP's queue and/or an indication of the physical port.

33.4.5 cnmQOffset

The twos-complement signed integer value of (–1 × cpQOffset) (32.8.7) of the transmitting CP in units of 64 octets. This standard does not specify whether cpQOffset is rounded or truncated to obtain cnmQOffset. If the value of cpQOffset is less than –32 768, a value of –32 768 is used in cpQOffset, and if greater than 32 767, then 32 767 is used.

33.4.6 cnmQDelta

The twos-complement signed integer value of the transmitting CP's cpQDelta (32.8.8) in units of 64 octets. This standard does not specify whether cpQDelta is rounded or truncated to obtain cnmQDelta. If the value of cpQDelta is less than –32 768, a value of –32 768 is used in cnmQDelta, and if greater than 32 767, then 32 767 is used.

NOTE—Although cnmQDelta is not used by the RP, it is included in the CNM PDU to aid the network administrator when adjusting configuration parameters.

33.4.7 Encapsulated priority

This field, 2 octets in length, contains the priority parameter of the frame that triggered the transmission of this CNM in the most significant 3 bits of the field. The remaining bits of the field are transmitted as 0, and ignored on receipt.

33.4.8 Encapsulated destination MAC address

This field, 6 octets in length, contains the destination_mac_address parameter of the frame that triggered the transmission of this CNM.

33.4.9 Encapsulated MSDU length

This field, 2 octets in length, contains the number of octets returned in the Encapsulated MSDU field (33.4.10).

33.4.10 Encapsulated MSDU

This field, a maximum of 64 octets in length, contains the initial octets of the mac_service_data_unit of the frame that triggered the transmission of this CNM.

33.4.11 CNM Validation

A CNM PDU received by a CNM demultiplexer (31.2.5) shall be considered invalid and be discarded if the following condition is TRUE:

a) There are fewer than 24 octets in the mac_service_data_unit.

A CNM PDU received by a CNM demultiplexer (31.2.5) may be considered invalid and be discarded if the following condition is TRUE:

b) The CNM PDU has no CN-TAG.

NOTE 1—The variable cnpdAcceptsCnTag (32.4.10), when set FALSE in an end station, indicates to the neighboring Bridge that the CN-TAG is to be removed from all frames, including CNMs, transmitted to the end station. It is not recommended that an end station set cnpdAcceptsCnTag to FALSE if this would result in the end station discarding CNMs for lack of a CN-TAG.

The following condition shall not cause a received CNM PDU to be considered invalid:

c) There are nonzero bits in the Version (33.4.1) or ReservedV (33.4.2).

NOTE 2—These rules permit information to be added to the CNM PDU following the Encapsulated MSDU field (33.4.10) in later revisions of this standard.

34. Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)

34.1 Overview

This clause describes a set of tools that can be used to support the forwarding and queuing requirements of time-sensitive streams. In this context, a "time-sensitive stream" is taken to be a stream (flow) of traffic, transmitted from a single source station (Talker), destined for one or more destination stations (Listeners), where the traffic is sensitive to timely delivery, and in particular, requires transmission latency to be bounded. Such streams include video or audio data streams, where there is a desire to limit the amount of buffering required in the receiving station (Listener). The description in this clause (Clause 34) applies when the transmission gates for scheduled traffic (8.6.8.4) are continuously open, as closing those gates affects the availability of bandwidth.

NOTE 1—An example of the need to support time-sensitive stream requirements would be a live performance where a video image of the performance is simultaneously projected on a screen in the auditorium, and it is desirable for the sound and image to be "in sync" with the performance.

The term "stream reservation class" (SR class) refers to a traffic class whose bandwidth can be reserved for time-sensitive streams using the Stream Reservation Protocol (SRP). FQTSS specifies the relationship between an SR class and the underlying tools of this standard, such as traffic class, priority, and transmission selection.

NOTE 2—The FQTSS functions described in this clause are intended for use with SRP, with the exception of adminIdleSlope [item c) in 34.3]. The adminIdleSlope parameter is intended for TSN configuration models that do not use SRP. In the fully centralized model of TSN configuration (46.1.3.3), the CNC entity can use adminIdleSlope to reserve bandwidth for a traffic class.

In order to address the needs of such traffic in Bridges, the following are provided:

a) A means of detecting the boundary between a set of Bridges that support SRP (an SRP domain) and surrounding Bridges that do not support SRP. This mechanism is described in 34.2.
b) A set of bandwidth availability parameters for each port that are used to record the maximum bandwidth available to a given outbound queue, and the actual bandwidth reserved, for that queue. These parameters are described in 34.3.
c) A discussion of the relationship between the size of the layer 2 "payload" (the MSDU) carried in a frame and how that relates to the actual bandwidth that will be consumed when that MSDU is transmitted on a particular Port (34.4).
d) Specifications for the default configuration of SR classes, including the mapping of the priorities associated with received frames onto the traffic classes available on the transmission Ports of a Bridge (34.5).
e) Specifications for use of transmission selection algorithms for SR classes (34.6).

34.2 Detection of SRP domains

The concepts of time-sensitive streams, the Stream Reservation Protocol (SRP), and the traffic forwarding and shaping functions that support stream transmission (e.g., 8.6.8.1), rely on the ability of each Bridge to detect whether each of its Ports is at the edge of a region of connected Bridges that support SRP on a particular priority, so that the Priority Code Point values associated with traffic entering an *SRP domain* (3.260) can be properly regenerated at the boundary of the domain, as described in 6.9.4.

Bridges detect the edge of an SRP domain by observing SRP behavior. If a Bridge receives SRP registrations using a particular priority, then it is reasonable to believe that they are being received from an SRP-capable device; the SRP engine can therefore signal which Ports of a Bridge are at the boundary of an SRP domain. The per-Port, per-SR class, *SRPdomainBoundaryPort* parameter determines whether a Port is

considered to be at the edge of an SRP domain or within the core of the domain, as defined in 35.1.4. This parameter is controlled by the operation of SRP.

NOTE—SRP domain detection is based on the assumption that a device connected to a Port either is SRP capable for a given SR class, or is not SRP capable for that SR class. SRP provides a boundary detection mechanism through the exchange of MSRPDUs; the boundary of a domain therefore expands to include Ports as SRP attributes are declared. The position of the domain boundary has no effect on the transmission of SRP frames; rather, it reflects where SRP activity is occurring. Ports are removed from the SRP domain when they are removed from the active topology.

34.3 The bandwidth availability parameters

The following bandwidth availability parameters exist for each Port, and for each traffic class, N, that is configured as an SR class (34.5):

a) ***portTransmitRate*** as defined in 8.6.8.2;
b) ***deltaBandwidth(N)***: The bandwidth, represented as a percentage of *portTransmitRate,* that can be reserved by SRP for use by the queue associated with traffic class N. The interpretation of *deltaBandwidth(N)* is determined by the value of the associated *lockClassBandwidth(N)* as specified in 34.3.1 and 34.3.3.
c) ***adminIdleSlope(N)***: The bandwidth, in bits per second, that has been requested by management to be reserved for use by the queue associated with traffic class N. If SRP is in operation for traffic class N, this parameter has no effect. If SRP is not in operation for traffic class N, then the value of *operIdleSlope(N)* is always equal to the value of *adminIdleSlope(N)*.
d) ***operIdleSlope(N)***: The actual bandwidth, in bits per second, that is currently reserved for use by the queue associated with traffic class N (see 34.6.1 and 34.6.2).
e) ***classMeasurementInterval(N)***: The interval of time, in seconds, over which SRP's TSpec (34.4, 35.2.2.8.4) is measured for traffic class N at the Talker.
f) ***lockClassBandwidth(N)***: The Boolean parameter that determines the interpretation of *deltaBandwidth(N)*. For the value false (default), *deltaBandwidth(N)* is specified in 34.3.1. For the value true, *deltaBandwidth(N)* is specified in 34.3.3.

In all cases, bandwidth is defined in terms of the actual bandwidth consumed when frames are transmitted through the Port, not the size of the MSDU "payload" carried within those frames. Subclause 34.4 discusses the relationship between MSDU size and actual bandwidth consumed. The bandwidth availability parameters and their use as described in this clause (Clause 34) do not take into account any interruption to bandwidth availability resulting from the operation of stream gates (8.6.5.2).

34.3.1 deltaBandwidth when lockClassBandwidth is false

When ***lockClassBandwidth(N)*** is false, ***deltaBandwidth(N)*** is the additional bandwidth, represented as a percentage of ***portTransmitRate***, that can be reserved by SRP for use by the queue associated with traffic class N, in addition to the ***deltaBandwidth(N)*** values associated with higher priority queues with ***lockClassBandwidth(N)*** false. For a given traffic class N, the total bandwidth that can be reserved is the sum of the ***deltaBandwidth*** values for traffic class N and all higher traffic classes with ***lockClassBandwidth(N)*** false, minus any bandwidth reserved by higher traffic classes (i.e., configured as SR classes).

The default value of ***lockClassBandwidth(N)*** is false. This default can be changed using the managed objects of the Bandwidth Availability Parameter Table (12.20.1).

The default value of *deltaBandwidth(N)* for the highest numbered traffic class supported is 75%, and for any lower numbered traffic classes, the default value is 0%. The *deltaBandwidth(N)* for a given *N*, plus the *deltaBandwidth(N)* values for any higher priority queues (larger values of *N*) defines the total percentage of the Port's bandwidth that can be reserved for that queue and all higher priority queues. For the highest priority queue, this means that the maximum value of *operIdleSlope(N)* is *deltaBandwidth(N)*% of

portTransmitRate. However, if *operIdleSlope(N)* is actually less than this maximum value, any lower priority queue with *lockClassBandwidth(N)* false can make use of the reservable bandwidth that is unused by the higher priority queue. So, for queue $N-1$, the maximum value of (*operIdleSlope(N)* + *operIdleSlope(N – 1)*) is (*deltaBandwidth(N)* + *deltaBandwidth(N – 1)*)% of *portTransmitRate*.

NOTE 1—For example, suppose two queues, 3 and 2, are configured as SR classes A and B, respectively. Suppose *deltaBandwidth(3)* for SR class A is currently 20%, and *deltaBandwidth(2)* for SR class B is currently 30%, and *lockClassBandwith* is false for both. If *operIdleSlope(3)* is currently 10% of *portTransmitRate*, then half of queue 3's maximum allocation is unused, and the maximum value of *operIdleSlope(2)* is therefore currently 40% of *portTransmitRate*. However, if *operIdleSlope(3)* increases to the full 20% that it is entitled to use, the maximum value of *operIdleSlope(2)* reduces to 30% of *portTransmitRate*.

NOTE 2—The sum of the *deltaBandwidth(N)* values for all values of N should be chosen such that there is sufficient bandwidth available for any nonreserved (best-effort, strict-priority) traffic; the default values are chosen such that the sum of the *deltaBandwidth(N)* values is 75%, so no more than 75% of the Port's available bandwidth is permitted to be reserved. This ensures that when using default settings, there is at least 25% of the Port's bandwidth available for nonreserved traffic. However, as these default settings may be inappropriate for some situations (e.g., links that offer very high bandwidth, or networks with very low levels of nonreserved traffic), they can be modified by management.

34.3.2 deltaBandwidth when lockClassBandwidth is true

When *lockClassBandwidth(N)* is true, *deltaBandwidth(N)* is the maximum bandwidth, represented as a percentage of *portTransmitRate*, that can be reserved by SRP for use by the queue associated with traffic class *N*. The bandwidth limit of *deltaBandwidth(N)* is not related to higher or lower priority traffic classes (i.e., it is not truly a delta).

NOTE—For example, suppose two queues, 3 and 2, are configured as SR classes A and B, respectively. Suppose *deltaBandwidth(3)* for SR class A is currently 20%, *deltaBandwidth(2)* for SR class B is currently 30%, and *lockClassBandwidth* is true for both. If *operIdleSlope(3)* is currently 10% of *portTransmitRate*, then half of queue 3's maximum allocation is unused. Nevertheless, the maximum value of *operIdleSlope(2)* remains 30% of *portTransmitRate*. The value of *operIdleSlope(2)* cannot increase to 40%, because 20% is locked to use by *operIdleSlope(3)*.

34.3.3 Bandwidth availability parameter management

The values of *deltaBandwidth(N)* and *adminIdleSlope(N)* can be changed by management, using the management operations defined in 12.20. If the stream reservation mechanisms defined in SRP are supported, then the values of *operIdleSlope(N)* are determined solely by the operation of SRP. If the stream reservation mechanisms defined in SRP are not supported, then the values of *operIdleSlope(N)* are equal to the values requested by management in the corresponding *adminIdleSlope(N)* parameters.

It is possible for the value of *portTransmitRate* for a Port to change as a result of the normal operation of the underlying MAC Service (e.g., as a result of the operation of IEEE 802.1AX Link Aggregation, or as a result of dynamic changes in bandwidth of the physical layer technology itself, as can occur in wireless LAN technologies); it is also possible for management action to change the values of *deltaBandwidth(N)* for a Port. In either case, the consequence could be one of the following:

a) The sum of the *operIdleSlope(N)* values for the Port could now exceed the total reservable bandwidth allowed for the Port, or the *operIdleSlope(N)* value for a given queue could now exceed the reservable bandwidth allowed for the queue, as defined in 34.3.1 and 34.3.2. Consequently, there could be streams currently active on the Port that can no longer be supported.
b) The bandwidth now available to a given queue could mean that there are streams that are currently inactive that could be supported on the Port.
c) Active streams that continue to be supported after the change could see their latency guarantee change.

In either case, corrective action, either by management or by the stream reservation mechanisms defined in SRP, is required in order to restore the parameters to a consistent set of values. In order to indicate that there have been changes in the bandwidth availability database, a signal, *bandwidthAvailabilityChanged*, is

generated for each Port whenever the bandwidth availability parameters *portTransmitRate* or *deltaBandwidth(N)* are changed; this signal is used by SRP to trigger recalculation of the set of streams that can be reserved on the Port.

NOTE—During recalculation of stream reservations, the Bridge might be temporarily unable to honor bandwidth reservation commitments or forward best-effort traffic.

34.4 Deriving actual bandwidth requirements from the size of the MSDU

The forwarding and queuing mechanisms defined in this clause use bandwidth parameters that are defined in terms of the actual bandwidth used when frames are transmitted on the medium that supports the MAC Service available through the Port. In contrast, the SRP makes use of a traffic specification (TSpec) for each stream that defines the maximum number of bits per frame (*MaxFrameSize*), of the mac_service_data_unit parameter that is relayed by the relay function of the Bridge, and a maximum frame rate (*MaxIntervalFrames*), in frames per class measurement interval, for that stream; i.e., the TSpec takes no account of the per-frame overhead associated with transmitting the MSDU over a given medium. However, when SRP determines the value to be used for the ***operIdleSlope(N)*** parameter associated with a given queue, it is necessary for this value to include the per-frame overhead that will be incurred when frames are transmitted on that Port.

NOTE 1—The frame rate in a TSpec is measured over the classMeasurementInterval (34.3) that depends upon the SR class associated with the stream. Default values for classMeasurementInterval are specified in 34.5.

For the purposes of calculating the bandwidth consumption of a stream, it is assumed that the stream data is essentially of constant size and transmission rate, so these maxima can be used to directly define an assumed maximum payload size and the maximum frame rate in frames per second; i.e.,

$$\textbf{\textit{assumedPayloadSize}} = MaxFrameSize \tag{34-1}$$

$$maxFrameRate = MaxIntervalFrames \times (1/classMeasurementInterval) \tag{34-2}$$

where *classMeasurementInterval* is measured in seconds.

NOTE 2—As stated, the calculation of bandwidth from TSpec parameters assumes that the stream data is essentially of constant frame size, and hence, the approximations shown in this section are valid. If the data varies significantly in frame size, then the calculation of per-frame overhead using these assumptions could be significantly in error.

From this, and also from local knowledge of the protocol stack that supports the Bridge Port, it is possible to determine the overhead that is added to the per-frame MSDU payload when a frame is transmitted. There are at least the following sources of per-frame overhead:

a) Any VLAN tags and security tags (see IEEE Std 802.1AE) that are added to the layer 2 payload as it passes through the various service interfaces in the Port's protocol stack.
b) The MAC framing (header and trailer octets, plus any padding octets that are required to meet minimum frame size limitations) that is added by the underlying MAC Service.
c) Any physical layer overhead, such as preamble characters and inter-frame gaps.

The precise per-frame overhead will therefore depend upon the protocol stack and the underlying MAC technology.

The actual bandwidth needed to support a given stream is therefore defined as follows [using *assumedPayloadSize* from Equation (34-1)]:

$$actualBandwidth = (perFrameOverhead + assumedPayloadSize) \times maxFrameRate \tag{34-3}$$

34.5 Default SR class configuration

This subclause (34.5) makes traffic class, priority, transmission selection algorithm, and classMeasurementInterval recommendations for use with FQTSS.

The recommended mappings of priorities to traffic classes meet the following constraints:

a) Priority values that correspond to SR classes are mapped onto traffic classes that support the credit-based shaper algorithm as the transmission selection algorithm.
b) Traffic classes that support the credit-based shaper algorithm have a higher priority than traffic classes that support the strict priority (or any other) transmission selection algorithm.
c) At least one traffic class supports the credit-based shaper algorithm, and at least one traffic class supports the strict priority transmission selection algorithm.

NOTE 1—The constraint that there is at least one traffic class that supports the strict priority transmission selection ensures that there is at least one traffic class that can support traffic that is not subject to bandwidth reservation, such as "best effort" traffic.

The recommended priority to traffic class mappings for a network that supports SR class A (using priority 3) and SR class B (using priority 2) are shown in Table 34-1. The recommended priority to traffic class mappings for a system that supports only SR class B (using priority 2) are shown in Table 34-2. These mappings can be changed using the managed objects of the Traffic Class Table for each Port (12.6.3).

The corresponding configuration for the Transmission Selection Algorithm Table (see 8.6.8) is that the traffic classes that are shaded in the tables are configured to use the credit-based shaper algorithm, and the remaining traffic classes are configured to use the strict priority algorithm. Traffic classes that are shaded correspond to default SR classes. These defaults can be changed using the managed objects of the Transmission Selection Algorithm Table (12.20.2).

Table 34-1—Default priority to traffic class mappings for SR classes A and B

		Number of available traffic classes						
		2	**3**	**4**	**5**	**6**	**7**	**8**
Priority	0 (Default)	0	0	0	0	0	0	1
	1	0	0	0	0	0	0	0
	2	1	1	2	3	4	5	6
	3	1	2	3	4	5	6	7
	4	0	0	1	1	1	1	2
	5	0	0	1	1	1	2	3
	6	0	0	1	2	2	3	4
	7	0	0	1	2	3	4	5

NOTE 2—The mapping shown in Table 34-1 for the case of only two available traffic classes maps two SR classes to a single traffic class. While this is a permissible configuration, in general it is desirable, and in some applications, can be a requirement, to assign SR classes to distinct traffic classes, as is done in this table for the cases where three or more traffic classes are available. The mappings shown deal only with one or two supported SR classes; a similar mapping strategy can be adopted if more than two SR classes are supported.

Table 34-2—Default priority to traffic class mappings for SR class B only

		Number of available traffic classes						
		2	**3**	**4**	**5**	**6**	**7**	**8**
Priority	0 (Default)	0	0	0	0	0	1	1
	1	0	0	0	0	0	0	0
	2	1	2	3	4	5	6	7
	3	0	0	0	1	1	2	2
	4	0	1	1	2	2	3	3
	5	0	1	1	2	2	3	4
	6	0	1	2	3	3	4	5
	7	0	1	2	3	4	5	6

Table 34-1 and Table 34-2 specify a default configuration of SR class A as priority 3, and SR class B as priority 2. These defaults can be changed using the managed objects of the SR Class to Priority Mapping Table (12.20.4).

The default classMeasurementInterval (34.3) of SR class A is 125 µs. The default classMeasurementInterval of SR class B is 250 µs. These defaults can be changed using the managed objects of the Bandwidth Availability Parameter Table (12.20.1).

34.6 Transmission selection

Transmission selection (8.6.8) is used to shape the transmission of a Stream's frames in accordance with the bandwidth that has been reserved on a given outbound queue for a traffic class.

The following transmission selection algorithm shall be supported for FQTSS, configured as the default for SR class A and/or B:

a) Credit-based shaper algorithm, specified in 8.6.8.2

The following transmission selection algorithm may be supported for FQTSS, configured using the managed objects of the Transmission Selection Algorithm Table (12.20.2):

a) Strict priority algorithm, specified in 8.6.8.1

The following transmission technique may be supported for FQTSS, configured using the managed objects for scheduled traffic (12.29):

a) Scheduled traffic, specified in 8.6.8.4

34.6.1 Credit-based shaper

The ***operIdleSlope(N)*** parameter (34.3) is used by the credit-based shaper algorithm (8.6.8.2) as its idleSlope for the corresponding queue, to shape outbound traffic.

The ***operIdleSlope(N)*** parameter is also used to reserve space in the queue of the traffic class that is assigned to the SR class.

In order for an end station to successfully participate in the transmission and reception of time-sensitive streams, it is necessary for their behavior to be compatible with the operation of the forwarding and queuing mechanisms employed in Bridges. The requirements for end stations that participate as "Talkers"—i.e., sources of time-sensitive streams—are different from the requirements that apply to "Listeners"—i.e., the destination station(s) for the streams.

34.6.1.1 Talker behavior

In order for Talker-originated data streams to make use of the credit-based shaper behavior in Bridges, it is a requirement for a Talker to use the priorities that the Bridges in the network recognize as being associated with SR classes exclusively for transmitting stream data. It is also necessary for the Talker, and the Bridges in the path to the Listener(s), to have a common view of the bandwidth required in order to transmit the Talker's streams, and for that bandwidth to be reserved along the path to the Listener(s). This latter requirement can be met by means of stream reservation mechanisms, such as defined in SRP, or by other management means.

End stations that are Talkers shall exhibit transmission behavior for frames that are part of time-sensitive streams that is consistent with the operation of the credit-based shaper algorithm, both in terms of the way they transmit frames that are part of an individual data stream, and in terms of the way they transmit stream data frames from a Port. In effect, the queuing model for a Talker Port, and for a given priority, can be considered to look like Figure 34-1.

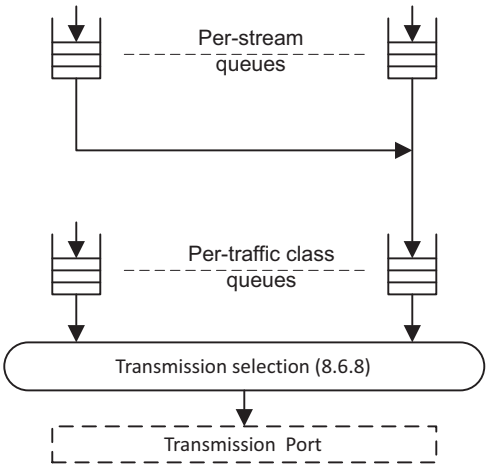


Figure 34-1—Queuing model for a Talker station

The Talker places frames into the queue associated with an individual stream based on the Tspec for that stream; i.e., during each *classMeasurementInterval,* it can place up to *MaxIntervalFrames* data frames, each no longer than *MaxFrameSize* into that stream's queue.

The queue associated with each individual stream uses the credit-based shaper algorithm, with the *idleSlope* set to the bandwidth requirement of the stream on that transmission Port, as the means of determining the rate at which data frames for that stream are placed in the outbound queue for the priority that the stream is using. The outbound queue for that priority, in turn, makes use of the credit-based shaper algorithm, with the *idleSlope* set to the sum of the *idleSlope* values for all streams using that priority on that transmission Port, as the means of determining the rate at which data frames for that stream are selected for transmission.

Transmission selection in a Talker operates in the same way as in a Bridge; from this point of view, a Talker can be thought of as if it is a single-port Bridge.

For streams that make use of SR class A or SR class B, it is a requirement that the rate at which frames for any given stream are selected for placement in its per-stream queue does not exceed the bandwidth reserved for the stream, measured over the *classMeasurementInterval* (34.3) for the SR class. For some combinations of stream bandwidth requirement and transmission Port data rate, this can place a limit on the frame size that can be used when transmitting stream data.

NOTE—The sole implication of the *classMeasurementInterval* is its effect on frame size, because the shaper behavior itself is independent of the *classMeasurementInterval*. The intent in limiting the *classMeasurementInterval* is to limit frame size, as this is a major contribution to the latency experienced by a frame in transit through a time-sensitive network (see discussion in Annex L).

34.6.1.2 Listener behavior

The primary requirement for a Listener end station using the credit-based shaper is that it is capable of buffering the amount of data that could be transmitted for a stream during a time period equivalent to the accumulated maximum jitter that could be experienced by stream data frames in transmission between Talker and Listener. From the point of view of the specification of the forwarding and queuing requirements for time-sensitive streams, it is assumed that the Listener will assess the buffering required for a stream as part of the stream bandwidth reservation mechanisms employed by the implementation.

34.6.2 Strict priority

The ***operIdleSlope(N)*** parameter (34.3) represents the total outbound bandwidth for the queue of traffic class N, and ***operIdleSlope(N)*** shall be used to reserve space in the queue of the associated traffic class N.

NOTE 1—The *operIdleSlope(N)* parameter is not used by the algorithm for transmission selection (8.6.8.1).

When SRP is used for reservation of a stream, the egress Port that uses strict priority will place frames into its outbound queue based on the Tspec for that Stream. The TSpecs of all Streams that egress the Port are used to compute the ***operIdleSlope(N)***.

When SRP is not used, the worst-case bandwidth for traffic class N is computed by a management client (e.g., CNC of 46.1.3.3, using TSpecs from the CUC) for the queue of the associated traffic class N. The management client uses ***adminIdleSlope(N)*** to configure this bandwidth in the station (12.20.1). Since ***operIdleSlope(N)*** is equal to ***adminIdleSlope(N), operIdleSlope(N)*** is used to reserve space in the queue of the associated traffic class N. Since the priority associated with traffic class N is not using SRP, that priority does not need to be configured as an SR class (i.e., assigned an SRclassID using 12.20.4).

NOTE 2—As an example of a traffic class configured using *adminIdleSlope(N)*, consider a traffic class that is protected using scheduled traffic (8.6.8.4). This protected traffic class can use the strict priority algorithm. Traffic in the protected window requires queue reservation in order to ensure that adequate storage exists in its queue. The CNC entity of 46.1.3.3 can use *adminIdleSlope(N)* to ensure that the queue for the protected traffic class is of sufficient size.

NOTE 3—Although *adminIdleSlope(N)* is specified as bits per second, with regard to reserving queue space for a shorter interval of time, it is best to assume that *adminIdleSlope(N)* is uniform over the entire second. For example, for a traffic class that is protected using scheduled traffic (8.6.8.4), if AdminCycleTime is 1 ms, *adminIdleSlope(N)* is divided by 1000 to determine the worst-case traffic for that AdminCycleTime.

34.6.3 Scheduled traffic

When SRP uses Centralized Network Configuration (CNC), scheduled traffic (8.6.8.4) can be used in a Talker as well as the Bridges to each Listener. For information, refer to the specifications for externalControl TRUE in 35.2.2.10.

When SRP is fully distributed (externalControl FALSE in 35.2.2.10), use of scheduled traffic in Bridges is not specified for SRP's Streams. If scheduled traffic is used in a Talker, that Talker appends the TSpecTimeAware TLV to its Talker Advertise. If the nearest Bridge supports the optional capability of translating scheduled traffic in the Talker to the transmission selection used in Bridges (i.e., 34.6.1 or 34.6.2), the nearest Bridge propagates Talker Advertise. As specified in 35.2.2.10.6, if the nearest Bridge does not support the TSpecTimeAware TLV, the nearest Bridge fails the Stream (propagates Talker Failed).

NOTE—For an example using scheduled traffic in a Talker, refer to U.1.1.

35. Stream Reservation Protocol (SRP)

SRP utilizes three signaling protocols [MMRP (10.9), MVRP (Clause 11), and MSRP (35.1)] to establish stream reservations across a bridged network.

Within SRP the Multiple MAC Registration Protocol (MMRP) may be used to control the propagation of Talker registrations throughout the bridged network (35.2.4.3.2).

The Multiple VLAN Registration Protocol (MVRP) is used by end stations and Bridges to declare membership in a VLAN where a Stream is being sourced. This allows the Data Frame Priority [35.2.2.8.5(a)] to be propagated along the path from Talker to Listener(s) in tagged frames. MSRP will not allow Streams to be established across Bridge Ports that are members of the untagged set (8.8.10) for the related VID.

The Multiple Stream Registration Protocol (MSRP) is a signaling protocol that provides end stations with the ability to reserve network resources that will guarantee the transmission and reception of data streams across a network with the requested QoS. These end stations are referred to as Talkers (devices that produce data streams) and Listeners (devices that consume data streams).

Talkers declare attributes that define the stream characteristics so Bridges have the necessary information available when they need to allocate resources for a Stream. Listeners declare attributes that request reception of those same streams. Bridges along the path from Talker to Listener process, possibly adjust, and then forward these MSRP attribute declarations. Bridges associate Talker and Listener attributes via the StreamID present in each of those attributes, which result in changes to the extended filtering services and allocation of internal resources when streams are “brought up.”

In order to establish the SRP domain boundaries, Bridges exchange SR class characteristics with each other and with end stations via MSRP. Neighboring devices that have identical SR class characteristics are considered to be in the same SRP domain and streams may be established between those devices.

MSRP provides a limited error reporting capability that is utilized when a Listener’s request to receive a stream cannot be honored because of some resource constraint within the network.

MSRP also supports the concept of data stream importance. For example, an emergency announcement would be flagged with a more important “rank” than a stream providing background music. This ranking ability allows the Bridges to replace less important streams with more important streams without requiring intervention from the end stations.

There is a considerable body of experience in supplying data streams with guarantees for QoS parameters such as latency, latency variation, or bandwidth. In particular, routers and hosts use the Internet Protocol (IP) and the Resource Reservation Protocol (RSVP, IETF RFC 2205, and IETF RFC 2750) to achieve such guarantees. Supplying guarantees to a data stream requires the following two components:

a) A definition of the resources to be allocated and configured, by end stations and network nodes, for the support of a data stream; and
b) A protocol for end stations to signal to the network nodes their data streams’ requirements, for network nodes to distribute those requirements among each other, and for the network nodes to signal the success or failure of the attempt to reserve resources to support the guarantees.

RSVP supplies the signaling protocol for routers to support data streams in routed networks. This and the following clauses define a protocol to support data streams in bridged networks.

The preceding description of SRP as a signaling protocol corresponds to the Fully distributed model (46.1.3.1) for TSN configuration. SRP also supports the Centralized network/distributed user model (46.1.3.2) for TSN configuration, which can be used to enable enhanced features (see 35.2.2.10). In order to

use the Centralized network/distributed user model, the MRP External Control (12.32.4) feature is enabled in the Nearest Bridge (8.6.3) to each Talker and Listener. Instead of propagating (signaling) through Bridges, SRP messages are exchanged with a Centralized Network Configuration (CNC) entity. The CNC uses remote management protocols (e.g., SNMP, NETCONF) in order to configure Bridges to meet the Stream requirements of each Talker and Listener.

35.1 Multiple Stream Registration Protocol (MSRP)

MSRP supports the reservation of resources for streams, each destined for one or more Listeners, and each from a single source, across a bridged network. Transmitted data that conforms to a successful stream reservation will not be discarded by any Bridge due to congestion on a LAN. In order to propagate requests for reservations, MSRP defines an *MRP application* that provides the Stream resource registration service defined in 35.2.3. MSRP makes use of the MRP Attribute Declaration (MAD) function, which provides the common state machine descriptions defined for use in MRP-based applications. The MRP architecture, and MAD are defined in Clause 10. MSRP defines a new MRP Attribute Propagation (MAP) function, to provide an attribute propagation mechanism.

MSRP propagates registrations for stream reservations in a manner similar to the operation of MMRP (10.9) and MVRP (11.2), which are used for registering Group membership and individual MAC address information, and VLAN membership, respectively. Unlike MMRP and MVRP, however, the registered attributes can be combined, discarded, or otherwise altered, as they are propagated by the participating Bridges.

In order to make and keep QoS guarantees all devices in a bridged network must participate in the signaling and queuing operations required of Bridges. For example, this would include IEEE 802.11 wireless media access points and stations. Thus, MSRP provides a means for Bridges or end stations running MSRP to cooperate both with higher network layers, such as routers or hosts running RSVP, and with lower network layers, such as wireless media.

MSRP is also responsible for establishing the SRP domain boundary for a particular SR class. All systems that support a particular SR class are in the same SRP domain if they use the same priority. An SRP domain boundary exists for an SR class when neighboring devices use different priorities for the SR class.

Figure 35-1 illustrates the architecture of MSRP in the case of a two-Port Bridge and an end station.

The version of MSRP is distinguished by the ProtocolVersion of MRP. ProtocolVersion 0x00 (MSRPv0) is the original version. ProtocolVersion 0x01 (MSRPv1) or higher specifies new AttributeTypes (35.2.2.4) that provide enhanced capabilities. This standard specifies MSRPv1 (35.2.2.1). In order to meet interoperability goals, implementations of this version shall support the original AttributeTypes specified in MSRPv0 as well as the enhanced AttributeTypes. The interoperability goals require a network of mixed MSRPv0 and MSRPv1 end stations and Bridges to provide a quality of service that is as good as or better than a complete MSRPv0 network.

For both MSRPv0 and MSRPv1, each MSRP Participant declares the Domain attribute prior to other MSRP attributes in order to determine SR class boundaries. The MSRPv1 end station or Bridge also uses this Domain exchange to determine the ProtocolVersion of its neighboring MSRP Participant. If the neighbor is MSRPv0, then only the original AttributeTypes are exchanged with that neighbor, although the ProtocolVersion will be set to the value defined in 35.2.2.1 [see item b) in 10.8.3.5]. If the neighbor is MSRPv1, then both original and enhanced AttributeTypes can be exchanged with that neighbor. For a Bridge, this means that it is possible to register an enhanced AttributeType from one Port and propagate and declare that same attribute to another Port as an original AttributeType. To enable this mixture of AtributeTypes, the MSRP Attribute Propagation (35.2.4) specifies the translation from each enhanced AttributeType to its corresponding original AttributeType.

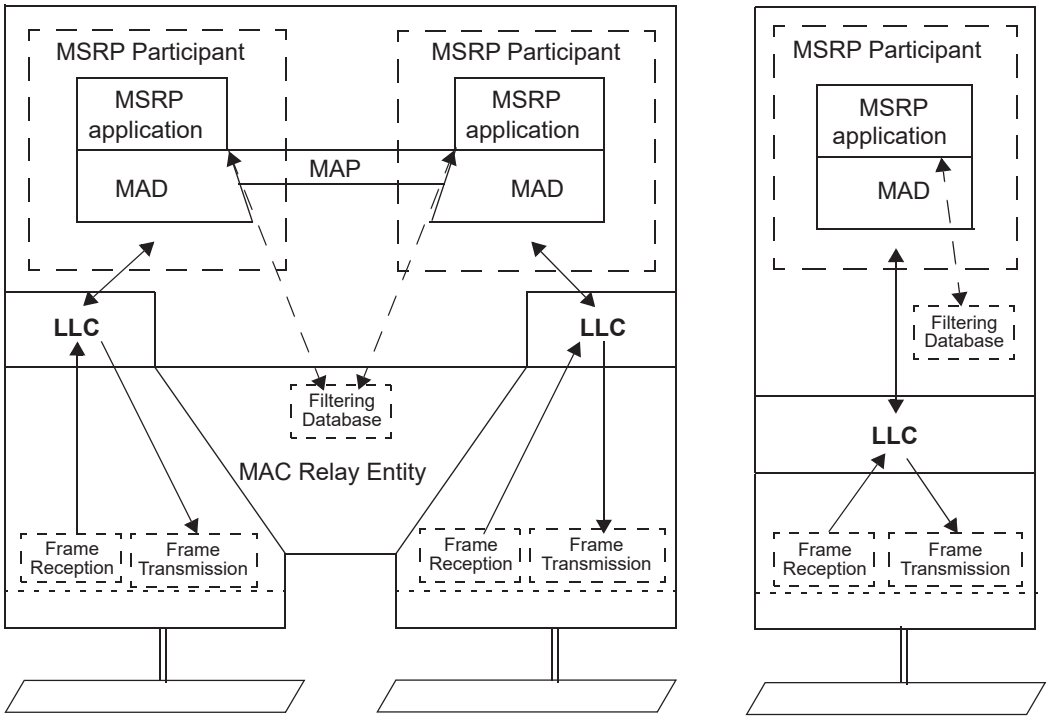


Figure 35-1—Operation of MSRP

For propagation of an MSRP attribute from one Port using MSRPv1 to another Port using MSRPv1, the AttributeType is not changed. This allows original AttributeTypes to propagate through a Bridged Network as is, without translation to enhanced AttributeTypes.

NOTE—MRP (Clause 10) has limitations on the total amount of attribute data that can be exchanged between participants. Therefore, the larger each MSRP attribute's value, the fewer total Streams can be reserved in the network. Due to the enhanced features, the enhanced AttributeType is larger than the original AttributeType. If the Talker and Listeners of a Stream do not need the enhanced features, use of the original AttributeTypes can allow for a larger number of total Streams. If all Talkers and Listeners in the network use original AttributeTypes, the maximum number of Streams in an all-MSRPv1 network is the same as an all-MSRPv0 network.

35.1.1 MSRP and Shared Media

Classic shared media, such as IEEE 802.3 half-duplex Carrier Sense Multiple Access with Collision Detect (CSMA/CD), cannot provide latency or bandwidth guarantees, because their operation depends on random timers. Such media are therefore not supported by MSRP.

There are other shared media where one node on the medium exercises control over access to the medium by the other nodes. For example, an IEEE 802.11 infrastructure wireless medium has a single Access Point (AP) that controls access by the AP and the stations attached to the wireless medium so that some guarantee of latency and bandwidth can be made, subject to frame loss caused by data corruption errors. Similarly, an IEEE 802.3 Ethernet Passive Optical Network has a single Optical Line Terminal (OLT) that controls access to the optical medium by itself and some number of Optical Network Units (ONUs).

Different kinds of shared media use different techniques to allocate opportunities to transmit, and these techniques can have various dependencies on frame sizes, station-to-station vs. station-to-head data paths, or other factors. Rather than introducing the complexities of every such medium into MSRP, this standard takes advantage of the presence of a controlling entity to map medium-specific characteristics to the capabilities of MSRP.

MSRP defines and requires the existence of a Designated MSRP Node (DMN) on any shared medium. This DMN provides the MSRP services for the shared medium and determines each station's ability to receive the MSRPDUs transmitted by other stations on the medium. A Non-DMN Port shall be configured to only process the MSRPDUs transmitted by DMN Ports, and ignore the MSRPDUs transmitted by other Non-DMN Ports. Furthermore, the DMN has the absolute control of the resource allocation on the shared medium. Given these two facts, a DMN can effectively control which reservations are and are not successful on the medium it controls.

Annex C provides examples on various shared media.

35.1.2 Behavior of end stations

35.1.2.1 Talkers

To announce the Streams that can be supplied and their characteristics, Talkers use the MAD_Join.request primitive (10.2) to make the Talker Declarations (35.2.1.3). To indicate the Streams that are no longer supplied, Talkers use the MAD_Leave.request primitive (10.2) to withdraw their Talker Declarations.

The Talker shall issue an MVRP VLAN membership declaration prior to issuing the Talker Declaration. The MVRP VLAN membership shall contain the vlan_identifier of the DataFrameParameters [item b) in 35.2.2.8.3], so that the neighboring Bridge adds the associated Bridge Port to the member set for the VLAN.

NOTE—VLAN membership is needed for the Talker when the neighboring Bridge has the Enable Ingress Filtering parameter set (8.6.2).

Talker Declarations are propagated by MSRP such that the Listeners and Bridges are aware of the presence of Talkers and the Streams that are offered. Talker Declarations are also used to gather QoS information along their paths. Based on the gathered QoS information, Talker Declarations are classified as follows:

a) **Talker Advertise:** An advertisement for a Stream that has not encountered any bandwidth or other network constraints along the network path from the Talker. Listeners that request attachment to this Stream are likely to create a reservation with the described QoS. A Talker Advertise will continue to be declared as long as the resources continue to be available.
b) **Talker Failed:** An advertisement for a Stream that is not available to the Listener because of bandwidth constraints or other limitations somewhere along the path from the Talker.

A Talker Advertise shall not be declared if there are not sufficient bandwidth and resources available. If a Talker Advertise is being declared and the required bandwidth or resources become unavailable the Talker Advertise shall be withdrawn and a Talker Failed may be declared. A Talker is allowed to transition directly from a Talker Advertise to a Talker Failed without waiting for the Talker Advertise to be deregistered from the network (see 35.2.6).

Talkers respond to the registration and deregistration events of Listener Declarations (35.2.1.3), signaled by MAD as follows:

On receipt of a MAD_Join.indication for a Listener Declaration, the Talker first merges (35.2.4.4.3) the Listener Declarations that it has registered for the same Stream. Then the Talker examines the StreamID (35.2.2.8.2) and Declaration Type (35.2.1.3) of the merged Listener Declaration. If the merged Listener Declaration is associated with a Stream that the Talker can supply, and the DeclarationType is either Ready or Ready Failed (i.e., one or more Listeners can receive the Stream), the Talker can start the transmission for this Stream immediately. If the merged Listener Declaration is an Asking Failed, the Talker shall stop the transmission for the Stream, if it is transmitting.

On receipt of a MAD_Leave.indication for a Listener Declaration, if the StreamID of the Declaration matches a Stream that the Talker is transmitting, then the Talker shall stop the transmission for this Stream, if it is transmitting.

35.1.2.2 Listeners

To indicate what Streams they want to receive, Listeners use the MAD_Join.request primitive (10.2) to make the Listener Declarations (35.2.1.3). To indicate the Streams that are no longer wanted, Listeners use the MAD_Leave.request primitive (10.2) to withdraw their Listener Declarations.

The Listener Declaration also conveys the results of the bandwidth and resource allocation along its path back to the Talker. Based on those results, Listener declarations are classified as follows:

a) **Listener Ready:** One or more Listeners are requesting attachment to the Stream. There is sufficient bandwidth and resources available along the path(s) back to the Talker for all Listeners to receive the Stream.
b) **Listener Ready Failed:** Two or more Listeners are requesting attachment to the Stream. At least one of those Listeners has sufficient bandwidth and resources along the path to receive the Stream, but one or more other Listeners are unable to receive the stream because of network bandwidth or resource allocation problems.
c) **Listener Asking Failed:** One or more Listeners are requesting attachment to the Stream. None of those Listeners are able to receive the Stream because of network bandwidth or resource allocation problems.

NOTE 1—The reader will notice that the Talker response to Ready and Ready Failed declarations is the same: the Talker can begin transmitting the Stream. Talkers might choose to pass the Ready Failed response to a higher layer protocol that could notify the user that the Stream is flowing, but not all Listeners are receiving it. It would be the responsibility of that higher layer to respond to this information as appropriate.

If the Listener receives a Talker Advertise declaration, and the Listener is ready to receive the Stream, the Listener shall issue an MSRP Listener Ready declaration for the Stream.

The Listener shall issue an MVRP VLAN membership declaration prior to issuing the MSRP Listener Ready declaration. The MVRP VLAN membership shall contain the vlan_identifier of the Talker Advertise DataFrameParameters [item b) in 35.2.2.8.3], so that the neighboring Bridge adds the associated Bridge Port to the member set for the VLAN.

If the *talkerVlanPruning* parameter (35.2.4.3.4) is not enabled in the Bridges in the path from Talker to the Listener, the Listener receives Talker Advertise prior to declaring MVRP VLAN membership. The Listener can then use the registered Talker Advertise to obtain the vlan_identifier for declaration of MVRP VLAN membership. This is the default behavior for the *talkerVlanPruning* parameter.

If one or more Bridges in the path from Talker to the Listener have enabled the *talkerVlanPruning* parameter, the Listener declares VLAN membership prior to receiving the Talker Advertise declaration. The *talkerVlanPruning* parameter instructs the Bridge to filter Talker declarations for the VLAN (in addition to the VLAN-tagged data frames of the stream). If the *talkerVlanPruning* parameter is enabled and the VLAN is not Registration Fixed (8.8.10), the Listener obtains knowledge of the Talker's vlan_identifier from a higher layer protocol above IEEE Std 802.1Q and uses that knowledge to declare the membership for the vlan_identifier with MVRP.

If *talkerPruning* or *talkerPruningPerPort* is enabled, the Listener must issue an MMRP registration for the Stream's destination MAC address as described in 35.2.4.2 before the Talker Advertise will be received.

If the Listener receives a Talker Failed declaration, and the Listener is ready to receive the Stream, the Listener shall issue either an MSRP Listener Asking Failed declaration or an MSRP Listener Ready declaration for the Stream.

There is no requirement for the order in which the Talker and Listener declarations are communicated. The Listener Declaration can be made before the Listener receives an associated Talker Declaration, in which case the Listener shall issue a Listener Asking Failed declaration.

NOTE 2—One reason for the Listener to issue Listener Ready in response to Talker Failed is that the Listener wants to inform the network that it is ready to proceed in case the Talker's state changes from failed to ready in the future.

35.1.3 Behavior of Bridges

MSRP-aware Bridges register and deregister Talker and Listener declarations on the Bridge Ports according to the procedures defined in MRP (Clause 10), and automatically generate deregistration of stale registrations. Any changes in the state of registration are processed by the MSRP Attribute Propagation (35.2.4) function, and disseminated in the network by making or withdrawing Talker and Listener declarations as defined in the Talker attribute propagation (35.2.4.3) and Listener attribute propagation (35.2.4.4).

In general, Talker declarations are propagated to all other Bridge Ports. There are *talkerPruning* [item b) in 35.2.1.4], *talkerPruningPerPort* [item k) in 35.2.1.4], and *talkerVlanPruning* [item l) in 35.2.1.4] parameters that limit the scope of Talker declaration propagation. Listener declarations are only propagated to the Bridge Port with the associated Talker declaration (i.e., matching StreamID). If there is no associated Talker declaration registered on any Bridge Port then Listener declaration will not be propagated.

35.1.3.1 Blocked Declarations

For the purposes of MSRP Attribute Propagation (35.2.4), a Declaration is said to be "blocked" on a Bridge Port if the state of the spanning tree instance identified by the vlan_identifier in the DataFrameParameters (35.2.2.8.3) of the Declaration, on that Bridge Port, has any value other than Forwarding. In an end station's MSRP Participant, no Declaration is ever blocked.

35.1.4 SRP domains and status parameters

An SRP domain is a set of stations (end stations and/or Bridges), their Ports, and the attached individual LANs, that satisfy all of the following conditions for a given SR class:

a) Those stations that transmit streams all support the credit-based shaper algorithm, defined in 8.6.8, as the transmission selection method for the SR class.
b) The stations all support SRP as the means of creating bandwidth reservations for the SR class.
c) Those stations that transmit streams all associate the same priority value with the SR class.
d) Each Port in the set is either an SRP domain core port or an SRP domain boundary port.
e) Each SRP domain core Port in the set is connected, via an individual LAN that is part of the active topology, to an SRP domain core Port of another station in the set.

In Bridges that support the SRP, and for each SR class supported by the Bridge, an **SRPdomainBoundaryPort** parameter is associated with each Port of the Bridge.

Each SRPdomainBoundaryPort parameter has a Boolean value. The value of the SRPdomainBoundaryPort parameter for a given SR class is TRUE if the operation of SRP has determined that the Port is an SRP domain boundary port (3.260) for that SR class; otherwise, the Port either is an SRP domain core port (3.261) for that SR class or is not part of that SRP domain, and the SRPdomainBoundaryPort parameter value is FALSE.

35.2 Definition of the MSRP application

MSRP maintains two categories of variables. The first category is used internally by the application state machines. These are defined in detail in the subclauses that follow.

MSRP also defines another category of variables identified as MRP elements that are communicated in MSRPDUs between stations on a network. These protocol elements include the MRP frame addressing and other fields defined in the MRPDUs. The MSRP FirstValue fields, which are used to exchange the MSRP attributes, are also defined here.

35.2.1 Definition of internal state variables

The following variables and parameters are utilized by various state machines within MSRP:

a) Port Media Type (35.2.1.1);
b) Direction (35.2.1.2);
c) Declaration Type (35.2.1.3);
d) SRP parameters (35.2.1.4);

35.2.1.1 Port Media Type

MSRPDU processing on a port is handled differently depending on the type of medium the port is attached to. For example, the DMN on a shared medium port that receives MSRPDUs from one station shall update and retransmit those attributes so that all stations on that medium are updated appropriately. The possible values are as follows:

a) **Access Control Port:** Transmitter controls access to the medium on which it is sending, so either it is the DMN for a shared medium, or it is a port on a full-duplex point-to-point medium.
b) **Non-DMN shared medium Port:** Transmitter is attached to a shared medium, but does not control access to the medium.

35.2.1.2 Direction

The Direction field is derived from the MSRP AttributeType definitions (35.2.2.4). The Direction indicates whether this is a Talker: MSRP AttributeType definitions of type Talker Advertise Vector Attribute Type [item a) in 35.2.2.4], Talker Failed Vector Attribute Type [item b) in 35.2.2.4], or Talker Enhanced Vector Attribute Type [item e) in 35.2.2.4]. Set Direction to zero for Talker attributes. or a Listener MSRP Declaration, and takes one of the following two values:

a) **Talker:** MSRP AttributeType definitions of type Talker Advertise Vector Attribute Type [item a) in 35.2.2.4], Talker Failed Vector Attribute Type [item b) in 35.2.2.4], or Talker Enhanced Vector Attribute Type [item e) in 35.2.2.4]. Set Direction to zero for Talker attributes.
b) **Listener:** MSRP AttributeType definitions of type Listener Vector Attribute Type [item c) in 35.2.2.4] or Listener Enhanced Vector Attribute Type [item f) in 35.2.2.4]. Set Direction to one for Listener attributes.

35.2.1.3 Declaration Type

The Declaration Type field is derived from the MSRP AttributeType definitions (35.2.2.4) and the MSRP FourPackedEvents (35.2.2.7.2). The Declaration Type indicates the specific type of the Talker or Listener MSRP Declaration.

For a Talker, the value of the Declaration Type component is either:

a) **Advertise:** MSRP AttributeType definitions of Talker Advertise Vector Attribute Type [item a) in 35.2.2.4] or Talker Enhanced Vector Attribute Type [item e) in 35.2.2.4] with Status.StatusInfo.TalkerStatus equal to Ready (35.2.2.10.9). Set Declaration Type to zero for Talker Advertise.

b) **Failed:** MSRP AttributeType definitions of Talker Failed Vector Attribute Type [item b) in 35.2.2.4] or Talker Enhanced Vector Attribute Type [item e) in 35.2.2.4] with Status.StatusInfo.TalkerStatus equal to Failed (35.2.2.10.9). Set Declaration Type to one for Talker Failed.

For a Listener, the value of the Declaration Type component is one of the following:

c) **Asking Failed:** MSRP AttributeType definitions of Listener Vector Attribute Type [item c) in 35.2.2.4] with MSRP FourPackedType equal to Asking Failed [item b) in 35.2.2.7.2] or Listener Enhanced Vector Attribute Type [item f) in 35.2.2.4] with Status.StatusInfo.ListenerStatus equal to Failed (35.2.2.10.9). Set Declaration Type to two for Listener Asking Failed.

d) **Ready:** MSRP AttributeType definitions of Listener Vector Attribute Type with MSRP FourPackedType equal to Ready [item c) in (35.2.2.7.2] or Listener Enhanced Vector Attribute Type [item f) in 35.2.2.4] with Status.StatusInfo.ListenerStatus equal to Ready (35.2.2.10.9). Set Declaration Type to three for Listener Ready.

e) **Ready Failed:** MSRP AttributeType definitions of Listener Vector Attribute Type with MSRP FourPackedType equal to Ready Failed [item d) in 35.2.2.7.2] or Listener Enhanced Vector Attribute Type [item f) in 35.2.2.4]) with Status.StatusInfo.ListenerStatus equal to PartialFailed (35.2.2.10.9). Set Declaration Type to four for Listener Ready Failed.

35.2.1.4 SRP parameters

The following parameters are used by SRP:

a) **portTcMaxLatency**: The maximum per-port per-traffic class latency, expressed in nanoseconds, a frame may experience through the underlying MAC Service. There may be different latency numbers for different traffic classes on the same port.

b) ***talkerPruning***: Enabling this parameter on the Bridge will limit the Talker declarations to Ports that have the Streams destination_address [item a) in 35.2.2.8.3] in the MAC Address Registration Entries (8.8.4), such as by using MMRP.

c) ***streamAge***: A per-port per-stream 32-bit unsigned value used to represent the time, in seconds, since the control element for the associated port most recently became forwarding in the Dynamic Reservations Entries (8.8.7) corresponding to the stream's destination_address. This value is used when determining which streams have been configured the longest. Streams with a numerically larger streamAge are considered to be configured earlier than other streams and therefore carry a higher implicit importance.

NOTE 1—A 32-bit unsigned value allows for expressing a streamAge of up to 136 years.

d) **msrpEnabledStatus:** MSRP shall have the ability to be enabled (true) or disabled (false) on a device. When MSRP is enabled on a device it shall cause a reset of all MSRP state machines on all ports. This affects the Applicant and Registrar state machines. The state of this parameter shall be persistent over power-up restart/reboot.

e) **msrpPortEnabledStatus:** MSRP shall have the ability to be enabled (true) or disabled (false) on the ports of a device. When MSRP is enabled or disabled on a port of a device it shall cause MAP to be rerun on all MSRP enabled ports so existing attributes can be propagated to the port just enabled. This affects the Applicant and Registrar state machines. The state of this parameter shall be persistent over power-up restart/reboot.

f) **msrpMaxFanInPorts:** The total number of ports on a Bridge that are allowed to establish reservations for inbound Streams. This number may be less than the total number of ports with msrpPortEnabledStatus set TRUE, which will result in lower maximum latency because of limits on the amount of possible interfering traffic. A value of zero (0) indicates no fan-in limit is being specified and calculations involving fan-in will only be limited by the number of MSRP enabled ports. Example calculations of delay associated with fan-in can be found in the paper "Calculating the Delay Added by Qav Stream Queue" [B3].

g) **msrpLatencyMaxFrameSize:** Calculation of the maximum latency through a Bridge is in-part related to the maximum size of an interfering frame. The maximum size is defined to be 2000 octets by default. This parameter allows a smaller or larger value to be used in the latency calculations for the particular Bridge implementation. msrpLatencyMaxFrameSize does not imply any type of policing of frame size, it is only used in the latency calculations.

h) **SRPdomainBoundaryPort (35.1.4)**: A per-port, per-SR class, Boolean parameter that contains the value TRUE if the port is an SRP Domain Boundary Port; otherwise, it contains the value FALSE. The parameter for a given SR class and Port shall be set to TRUE if any of the following conditions are met:

1) The port is declaring an MSRP Domain attribute for that SR class, and the port has no MSRP Domain attribute registrations for that SR class, or
2) The port is declaring an MSRP Domain attribute for that SR class, and the port has at least one MSRP Domain attribute registration for that SR class with a different priority, or
3) One or more ports which support that SR class are declaring MSRP Domain attributes for that SR class, and this port does not support that SR class.

In all other cases the parameter shall be set to FALSE.

i) **SR_PVID:** The Stream Reservation Port VLAN Identifier is a per-port parameter that contains the default VID for Stream-related traffic. It shall contain a valid VID value (Table 9-2) and may be configured by management. If the value has not been explicitly configured, the SR_PVID shall assume the default SR_PVID defined in Table 9-2. This value is passed to the Talker via the SRclassVID (35.2.2.9.4) contained in the MSRP Domain attribute.

j) ***neighborProtocolVersion:*** Each Port provides a neighborProtocolVersion parameter that specifies the MSRP ProtocolVersion of the neighboring MSRP Participant on that Port. The initial value is 0x00. When an MSRP Domain attribute is registered (received) on the Port, the value of the attribute's MRP ProtocolVersion (35.2.2.1) is copied to this parameter.

k) ***talkerPruningPerPort:*** When the talkerPruning parameter is disabled (false), each Port provides a talkerPruningPerPort parameter to control MAC address pruning for that Port. For more information, refer to 35.2.4.3.3.

l) ***talkerVlanPruning:*** Enabling this parameter on the Bridge will limit the Talker declarations to Ports that have the Stream's vlan_identifier [item b) in 35.2.2.8.3] registered as a member in the VLAN Registration Entries (8.8). For more information, refer to 35.2.4.3.4.

m) ***maxSRclasses:*** This parameter provides the maximum number of SR classes supported by the Bridge.

35.2.2 Definition of MRP elements

35.2.2.1 MSRP application address

The group MAC address used as the destination address for MRPDUs destined for MSRP Participants shall be the group MAC address for "Individual LAN Scope group address, Nearest Bridge group address" as specified in Table 8-1, Table 8-2, and Table 8-3 (C-VLAN, S-VLAN, and TPMR component Reserved addresses, respectively).

NOTE—Using this address will guarantee that MSRPDUs are never forwarded by an 802.1 Bridge, although MSRP-aware Bridges do propagate the MSRP attributes.

35.2.2.2 MSRP application EtherType

The EtherType used for MRPDUs destined for MSRP Participants shall be the MSRP EtherType identified in Table 10-2.

35.2.2.3 MSRP ProtocolVersion

The ProtocolVersion for the version of MSRP defined in this standard takes the hexadecimal value 0x01.

NOTE—Although an MSRP Participant for this standard transmits MSRPDUs using ProtocolVersion 0x01, the MSRP Participant must process received MSRPDUs using ProtocolVersion 0x01 or 0x00, as specified in 10.8.3.5.

35.2.2.4 MSRP AttributeType definitions

MSRP defines six AttributeTypes (10.8.2.2) that are carried in MRP exchanges. The numeric values for the AttributeType are shown in Table 35-1 and their use is defined by the following list:

a) **Talker Advertise Vector Attribute Type:** Attributes identified by the Talker Advertise Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify a sequence of values of Talker advertisements for related Streams that have not been constrained by insufficient bandwidth or resources. This Attribute Type applies to all versions of MSRP.

b) **Talker Failed Vector Attribute Type:** Attributes identified by the Talker Failed Vector Attribute Type are instances of VectorAttributes, used to identify a sequence of values of Talker advertisements for related Streams that have been constrained by insufficient bandwidth or resources.This Attribute Type applies to all versions of MSRP.

c) **Listener Vector Attribute Type:** Attributes identified by the Listener Vector Attribute Type are instances of VectorAttributes, used to identify a sequence of values of Listener requests for related Streams regardless of bandwidth constraints. Listener Vector Attribute Types are subdivided into individual Declaration Types via the MSRP FourPackedEvents (35.2.2.7.2).This Attribute Type applies to all versions of MSRP.

d) **Domain Vector Attribute Type:** Attributes identified by the Domain Vector Attribute Type are instances of VectorAttributes, used to identify a sequence of values that describe the characteristics of an SR class. This Attribute Type applies to all versions of MSRP.

e) **Talker Enhanced Vector Attribute Type:** Attributes identified by the Talker Enhanced Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify a sequence of values of Talker advertisements for related Streams. Talker Enhanced Vector Attribute Types are subdivided into individual Declaration Types (35.2.1.3) via the Status.StatusInfo.TalkerStatus (35.2.2.10.9). This Attribute Type applies to ProtocolVersion 0x01 or higher.

f) **Listener Enhanced Vector Attribute Type:** Attributes identified by the Listener Enhanced Vector Attribute Type are instances of VectorAttributes, used to identify a sequence of values of Listener requests for related Streams. Listener Enhanced Vector Attribute Types are subdivided into individual Declaration Types (35.2.1.3) via the Status.StatusInfo.ListenerStatus (35.2.2.10.9). This Attribute Type applies to ProtocolVersion 0x01 or higher.

35.2.2.5 MSRP AttributeLength definitions

The AttributeLength field (10.12.1.8) in instances of the Talker Advertise Vector Attribute Type shall be encoded in MRPDUs (10.8) as an unsigned binary number, equal to the value shown in Table 35-2.

The AttributeLength field in instances of the Talker Failed Vector Attribute Type shall be encoded in MRPDUs as an unsigned binary number, equal to the value shown in Table 35-2.

The AttributeLength field in instances of the Listener Vector Attribute Type shall be encoded in MRPDUs as an unsigned binary number, equal to the value shown in Table 35-2.

Table 35-1—AttributeType Values

AttributeType	Value	Used when neighborProtocolVersion is 0x00	Used when neighborProtocolVersion is 0x01 or higher
Talker Advertise Vector	1	yes	yes
Talker Failed Vector	2	yes	yes
Listener Vector	3	yes	yes
Domain Vector	4	yes	yes
Talker Enhanced Vector	5	no	yes
Listener Enhanced Vector	6	no	yes

Table 35-2—AttributeLength Values

AttributeType	Value
Talker Advertise Vector	25 (0x19)
Talker Failed Vector	34 (0x22)
Listener Vector	8
Domain Vector	4
Talker Enhanced Vector	variable
Listener Enhanced Vector	variable

The AttributeLength field in instances of the Domain Vector Attribute Type shall be encoded in MRPDUs as an unsigned binary number, equal to the value shown in Table 35-2.

The AttributeLength field in instances of the Talker Enhanced Vector Attribute Type and Listener Enhanced Vector Attribute Type shall be encoded in MRPDUs as an unsigned binary number. The value of AttributeLength varies according to the TLVs contained in the attribute's value, but shall not change during the duration of the attribute's declaration.

35.2.2.6 MSRP AttributeListLength definitions

The AttributeListLength field (10.12.1.9) shall be encoded in MRPDUs (10.8) as an unsigned binary number, equal to the number of octets contained within the AttributeList. This field can be used when calculating the number of octets to skip to proceed to the next Message (or Message EndMark) in the MRPDU.

35.2.2.7 MSRP Vector definitions

35.2.2.7.1 MSRP ThreePackedEvents

The ThreePackedEvent vectors are encoded as defined in 10.8.2.10.1.

35.2.2.7.2 MSRP FourPackedEvents

MSRP FourPackedEvents are only used by the Listener Vector Attribute Type [item c) in 35.2.2.4]. Within the FourPackedEvent, there are four possible values for the FourPackedType (10.8.2.10.2) as explained in the following list. The numeric values for the MSRP FourPackedEvents are shown in Table 35-3.

a) **Ignore:** The StreamID referenced by FirstValue+n is not defined in this MSRPDU. When using this FourPackedType, the AttributeEvent (10.8.2.10.1) value, encoded in the ThreePackedEvent, shall be set to zero on transmit and ignored on receive.
b) **Asking Failed:** The StreamID referenced by FirstValue+n has a declaration type of Listener Asking Failed.
c) **Ready:** The StreamID referenced by FirstValue+n has a declaration type of Listener Ready.
d) **Ready Failed:** The StreamID referenced by FirstValue+n has a declaration of type Listener Ready Failed.

Table 35-3—FourPackedEvent Values

FourPackedType	Value
Ignore	0
Asking Failed	1
Ready	2
Ready Failed	3

NOTE 1—In terms of efficient use of octets within an MSRP packet, placing nineteen (19) Ignores between two Listener declarations uses less octets than using two VectorAttributes to declare the Listener attributes separately. A single Listener VectorAttribute takes 12 octets, two attributes would take 24 octets. Declaring 21 attributes (two valid attributes with 19 Ignores in between) takes 12 octets, plus 6 additional ThreePackedEvents, plus 5 additional FourPackedEvents for a total of 23 octets.

NOTE 2—MSRP FourPackedEvents are not used for the Listener Enhanced Vector Attribute Type [item f) in 35.2.2.4], which uses the Status.StatusInfo.ListenerStatus (35.2.2.10.9) to distinguish Declaration Types (35.2.1.3).

35.2.2.8 MSRP FirstValue definitions (Stream reservations, original)

There are four Attribute Declarations defined for the original ProtocolVersion 0x00 of MSRP (35.2.2.4), three of which are related to stream reservations: Talker Advertise, Talker Failed, and Listener. The fourth attribute type, Domain, is used to discover the SRP domain, as well as the ProtocolVersion of each Port's neighbor, and is described in 35.2.2.9.

NOTE—This version of MSRP requires implementation of the original attributes of 35.2.2.8 and the enhanced attributes of 35.2.2.10. The specifications for enhanced attributes are based on the specifications for original attributes.

The Talker Advertise attribute contains all the characteristics that a Bridge needs in order to understand the resource requirements and importance of the referenced stream.

The Talker Failed attribute contains all the fields carried in the Talker Advertise Attribute, plus additional information regarding resource or bandwidth availability failures.

Listener attributes carry three subtypes: Ready, Ready Failed, and Asking Failed. These Listener subtypes are encoded in the FourPackedEvent (35.2.2.7.2).

FirstValue shall be incremented one or more times when NumberOfValues is greater than one. Incrementing FirstValue within MSRP is defined as follows:

a) Add 1 to Unique ID [item b) in 35.2.2.8.2], and
b) Add 1 to Stream destination_address [item a) in 35.2.2.8.3].

The example shown in Table 35-4 illustrates the use of FirstValue and NumberOfValues within MSRP. This example shows four Streams (a, b, c, and d) to be declared. In order to use the efficient packing techniques of MRP it would be preferable to assign these Streams sequential StreamIDs and destination_addresses as shown. Notice that StreamID yy-yy-yy-yy-yy-yy:00-04 is missing from this table (between Stream "c" and "d"). MSRP allows declaration of all four StreamIDs in a single VectorAttribute by setting NumberOfValues=5, with the StreamID = yy-yy-yy-yy-yy-yy:00-01 and a destination_address of xx-xx-xx-xx-xx-25. Setting the fourth FourPackedEvent to Ignore [item a) in 35.2.2.7.2] notifies MSRP that the StreamID between "c" and "d" is not in use.

Table 35-4—MSRP FirstValue NumberOfValues example

Stream	StreamID	destination_address
a	yy-yy-yy-yy-yy-yy:00-01	xx-xx-xx-xx-xx-25
b	yy-yy-yy-yy-yy-yy:00-02	xx-xx-xx-xx-xx-26
c	yy-yy-yy-yy-yy-yy:00-03	xx-xx-xx-xx-xx-27
d	yy-yy-yy-yy-yy-yy:00-05	xx-xx-xx-xx-xx-29

The FirstValue field within MSRP comprises several components: StreamID (35.2.2.8.2), DataFrameParameters (35.2.2.8.3), TSpec (35.2.2.8.4), PriorityAndRank (35.2.2.8.5), Accumulated Latency (35.2.2.8.6), and FailureInformation (35.2.2.8.7). MSRP does not support changes in any of the FirstValue fields for an existing StreamID. If a Talker wishes to tear an old Stream down and bring a new Stream up, with a different FirstValue, utilizing the same StreamID, there must be at least two LeaveAllTime (Table 10-7) time periods between when the Talker removes the existing Stream registration and declares the new Stream. This guarantees that MRP has enough time to remove the current attribute from all devices in the network. If the new declaration were to occur too quickly the associated Streaming data could be corrupted because the FDB may allow the new Stream data to start flowing while the old Stream bandwidth constraints are still configured. When the Bridge detects this occurring it will fail the Talker Advertise with the appropriate FailureInformation (35.2.2.8.7). Talkers may tear a Stream down and bring the same Stream back up immediately, as long as the FirstValue has not changed.

35.2.2.8.1 Structure definition

The FirstValue for Talker Advertise, Talker Failed, and Listener attributes in MSRPDUs exchanged according to the protocol specified in this subclause shall have the following structure:

a) The first eight octets contain the *StreamID* (35.2.2.8.2).

   This is the end of the Listener attribute. If this is a Talker Advertise or Talker Failed attribute continue as follows:

b) Following the StreamID are eight octets containing the *DataFrameParameters* (35.2.2.8.3).
c) Following the DataFrameParameters are four octets containing the *TSpec* (35.2.2.8.4).
d) Following the TSpec is one octet containing the *PriorityAndRank* (35.2.2.8.5).
e) Following the PriorityAndRank are four octets containing the *AccumulatedLatency* (35.2.2.8.6).

   This is the end of the Talker Advertise attribute. If this is a Talker Failed attribute continue as follows:

f) Following the AccumulatedLatency are nine octets containing the *FailureInformation* (35.2.2.8.7).

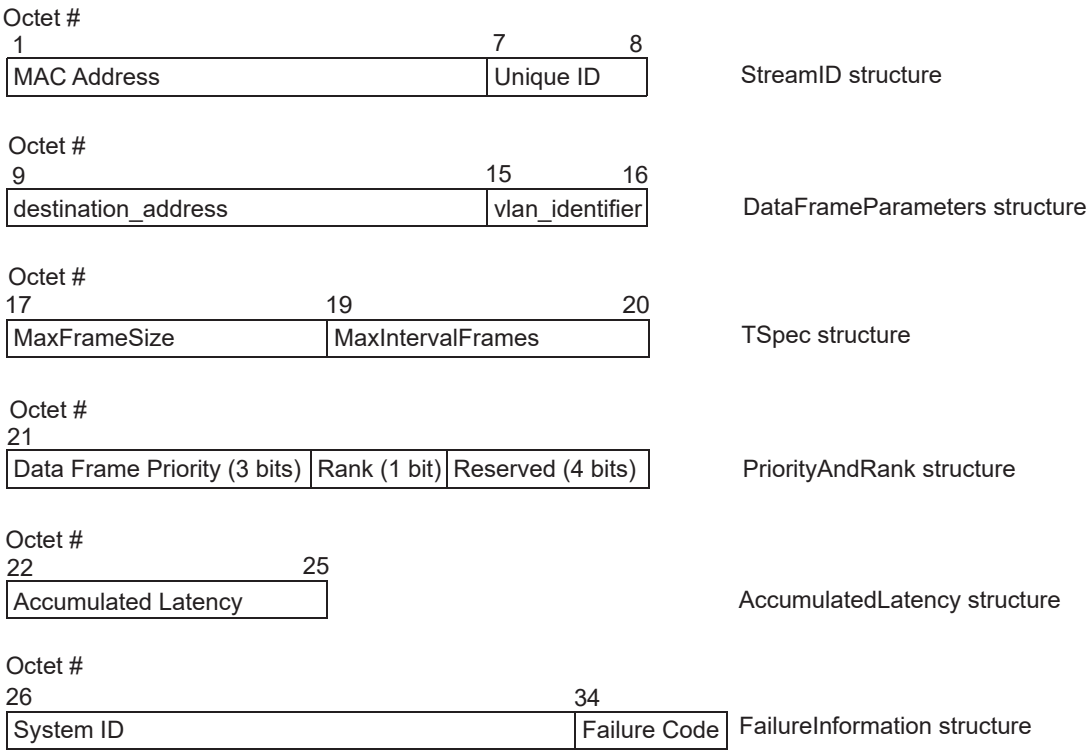


Figure 35-2—Format of the components of the reservation FirstValue fields

The following partial BNF production gives the formal description of the MSRPDU FirstValue structure for the Talker Advertise attribute:

FirstValue ::= StreamID, DataFrameParameters, TSpec, PriorityAndRank, AccumulatedLatency

The following partial BNF production gives the formal description of the MSRPDU FirstValue structure for the Talker Failed attribute:

FirstValue ::= StreamID, DataFrameParameters, TSpec, PriorityAndRank, AccumulatedLatency, FailureInformation

The following partial BNF production gives the formal description of the MSRPDU FirstValue structure for the Listener attribute:

FirstValue ::= StreamID

Figure 35-2 illustrates the structure of the MSRPDU FirstValue components. Each MSRP Attribute shall only use those structures as defined by the partial BNF productions described previously. The octet numbers shown represent the octet location within the FirstValue field.

35.2.2.8.2 StreamID

The 64-bit StreamID is used to match Talker registrations with their corresponding Listener registrations (35.2.4). The StreamID comprises the following two subcomponents:

a) A 48-bit MAC Address associated with the Talker sourcing the stream to the bridged network. The entire range of MAC addresses are acceptable.
b) A 16-bit unsigned integer value, Unique ID, used to distinguish among multiple streams sourced by the same Talker.

StreamIDs are unique across the entire bridged network and are generated by the system offering the stream, or possibly a device controlling that system. A system reserving resources for more than one stream in the same bridged network shall use a StreamID that is unique among all StreamIDs in that bridged network. The combination of these two subcomponents ensure that such an assignment is possible.

NOTE 1—The spanning tree protocol ensures that there can be at most one path from a Talker to its Listener(s). Multiple Declarations for the same StreamID can therefore occur briefly, during changes in the active topology of the bridged network.

NOTE 2—The MAC address component of the StreamID can, but does not necessarily, have the same value as the source_address parameter of any frame in the actual data stream. For example, the StreamID can be assigned by a TSN CUC (see 46.1.3.3), using a pool of MAC addresses that the TSN CUC maintains.

NOTE 3—If the MAC addresses used to construct StreamIDs are not unique within the network, duplicate StreamIDs can be generated, with unpredictable results for SRP.

35.2.2.8.3 DataFrameParameters

The DataFrameParameters component of the MSRP Attribute specifies the EISS parameters that are common to all frames belonging to the data stream for which this MAD is reserving resources. This information is used by Bridges to create Dynamic Reservation Entries (8.8.7). The parameters are as follows:

a) The destination_address
b) The vlan_identifier

The destination_address specifies the destination MAC address of the streaming data frames. Only one Stream is allowed per destination_address. MSRP does not describe the actual streaming data, only the bandwidth associated with that stream.

The use of destination_address for both a Stream and “best effort” traffic (34.5) is outside the scope of SRP. SRP only supports destination_addresses that are multicast or locally administered addresses.

NOTE—MSRP enforces reserved bandwidth guarantees by filtering Stream destination addresses (35.2.4.4.2) for Streams that do not have a reservation. This blocks all traffic to that destination address. If that destination address was also being used for “best effort” traffic that device would no longer be reachable.

Systems that are not VLAN aware shall use the value SRclassVID (35.2.2.9.4) for the vlan_identifier in the DataFrameParameters. VLAN-aware systems may use any valid VID (1 through 4094).

35.2.2.8.4 TSpec

The 32-bit TSpec component is the TSpec associated with a Stream. It consists of the following two elements (which are encoded as described in 10.8.1.1):

a) **MaxFrameSize:** The 16-bit unsigned MaxFrameSize component is used to allocate resources and adjust queue selection parameters in order to supply the QoS requested by an MSRP Talker Declaration. It represents the maximum frame size that the Talker will produce, excluding any overhead for media-specific framing (e.g., preamble, IEEE 802.3 header, Priority/VID tag, CRC, interframe gap). As the Talker or Bridge determines the amount of bandwidth to reserve on the egress port it will calculate the media-specific framing overhead on that port and add it to the number specified in the MaxFrameSize field.
b) **MaxIntervalFrames:** The 16-bit unsigned MaxIntervalFrames component is used to allocate resources and adjust queue selection parameters in order to supply the QoS requested by an MSRP Talker Declaration. It represents the maximum number of frames that the Talker may transmit in one classMeasurementInterval (34.3).

NOTE—Consider the example of a Class A 48kHz stereo audio stream encapsulated in an Ethernet frame (see IEEE Std 1722™ [B16]). The audio data within the frame would contain two sets of six 32-bit samples, plus a 32-octet header, for a total of 80 octets per frame sent once every class measurement interval (34.4). Therefore, MaxFrameSize=80, and MaxIntervalFrames=1. An IEEE 802.3 port on a Bridge would also add 42 octets of media-

specific framing overhead (8-octet preamble, 14-octet IEEE 802.3 header, 4-octet IEEE 802.1Q priority/VID Tag, 4-octet CRC, 12-octet IFG). When the Bridge calculates the amount of bandwidth to reserve it would combine 42 octets of media-specific framing overhead with the MaxFrameSize of 80 octets, to arrive at a total frame size of 122 octets per class measurement interval. This represents a total bandwidth of approximately 7.7 Mb/s (122 octets × 8 b/octet × 8000 frames/s).

Table 35-5 contains some examples of various forms of audio and video Streams with their associated TSpec components.

Table 35-5—TSpec components examples

Source	Raw bit rate	Media-specific framing overhead	TSpec MaxFrameSize	TSpec MaxIntervalFrames
48kHz stereo audio stream (32-bit samples) Class A (IEEE Std 1722 [B16])	~3 Mb/s	~4.7 Mb/s	80	1 (8 000 frames/s)
96kHz stereo audio stream (32-bit samples) Class A (IEEE Std 1722 [B16])	~6 Mb/s	~4.7 Mb/s	128	1 (8 000 frames/s)
MPEG2-TS video Class B (IEEE Std 1722 [B16])	~24 Mb/s	~2.5 Mb/s	786	1 (4 000 frames/s)[a]
SD SDI (Level C) uncompressed Class A (SMPTE 259M-2008 [B60])	270 Mb/s	~15 Mb/s	1442	3 (24 000 frames/s)
SD SDI (Level D) uncompressed Class A (SMPTE 259M-2008 [B60])	360 Mb/s	~20 Mb/s	1442	4 (32 000 frames/s)
HD SDI 1080i uncompressed Class A (SMPTE 292M-2008 [B61])	1.485 Gb/s	~80 Mb/s	1486	16 (128 000 frames/s)
HD SDI 1080p uncompressed Class A (SMPTE 424M-2008 [B62])	2.97 Gb/s	~160 Mb/s	1486	32 (256 000 frames/s)

[a] The MPEG-2 TS entry in this table (third row) is shown as Class B traffic, which runs at a default frame rate of 250 μs/frame or 4000 frames/s. Class A traffic runs at a default rate of 8000 frames/s.

35.2.2.8.5 PriorityAndRank

a) **Data Frame Priority:** The 3-bit Data Frame Priority component specifies the priority value used to generate the Priority Code Point the referenced data streams will be tagged with. It indicates the priority EISS or ISS parameter that will be used in all frames belonging to the data stream for which this MAD is reserving resources. This parameter determines which queue the frame is placed into on an output Bridge Port. In accordance with 10.8.1.1 these three bits are in the most significant positions (8, 7, and 6). The priority specified here is associated with the SR Classes as described in 34.5.

b) **Rank:** The single-bit Rank component is used by systems to decide which streams can and cannot be served, when the MSRP registrations exceed the capacity of a Port to carry the corresponding data streams. If a Bridge becomes oversubscribed (e.g., network reconfiguration, IEEE 802.11 bandwidth reduction), the Rank will also be used to help determine which Stream or Streams can be dropped. A lower numeric value is more important than a higher numeric value. In accordance with 10.8.1.1 this bit is in position 5.

   For streams that carry emergency data such as North America 911 emergency services telephone calls, or fire safety announcements, the Rank shall be 0. Nonemergency traffic shall set this bit to a 1.

   NOTE—It is expected that higher layer applications and protocols can use the Rank to indicate the relative importance of streams based on user preferences expressed by means beyond the scope of this standard. The values and defaults provided by this Standard are sufficient to order streams on a first-come-first-served basis, with special priority provided for emergency services.

c) **Reserved:** This 4-bit field shall be zero filled on transmit and ignored on receive. In accordance with 10.8.1.1 these four bits are in the least significant positions (4, 3, 2, and 1).

35.2.2.8.6 Accumulated Latency

The 32-bit unsigned Accumulated Latency component is used to determine the worst-case latency that a Stream can encounter in its path from the Talker to a given Listener. The latency reported here is not intended to increase during the life of the reservation. If some event occurs that would increase the latency beyond the original guarantee, MSRP will change the Talker Advertise to a Talker Failed and report Failure Code=7 (Table 35-6).

NOTE 1—An example of how latency could increase is if the speed of the underlying media where to decrease, such as one might see on a wireless link.

The initial value sent by the Talker is set to *portTcMaxLatency* plus any amounts specified in the REGISTER_STREAM.request, and its value is increased by each Bridge as the Talker Declaration propagates through the network.

The *portTcMaxLatency* per hop is equal to the sum of the following:

a) (equal or higher priority traffic) the time required to empty the queue in which frames of that priority are placed, if that queue and all higher priority queues are full.
b) (lower priority traffic) the time required to transfer one lower priority frame of maximum size that could have just started transmitting as the current priority frame was queued up.
c) (internal processing) the worst-case time required by the Bridge to transfer a received frame from the input port to the output queue.
d) (wire propagation time) the time required for the first bit of the frame to propagate from the output port to the receiving device.
e) (media access delay) the time required to wait for the media to become available for transmission.

For item a) the total number of ports with msrpPortEnabledStatus set TRUE, and the msrpMaxFanInPorts will effect these calculations.[48]

For item a) and item b) the maximum size of the interfering traffic is limited to msrpLatencyMaxFrameSize octets.

For item d), the propagation time, if the managed object for Propagation Delay (12.32.2) is supported, txPropagationDelay shall be used. Otherwise, in the absence of better information, a value of 500 ns shall be used.

NOTE 2—This implies that no type of frame flow control can be used on the associated data stream frames.

The Listener can use this information to decide if the Latency is too large for acceptable presentation of the stream. The Accumulated Latency component is in units of nanoseconds.

35.2.2.8.7 FailureInformation

At the point when a Talker Advertise Declaration is transformed into a Talker Failed Declaration, the system making the transformation adds information that indicates, to the Listeners registering the Talker Failed Declaration, the cause of the failure and the identity of the system at which the failure occurred. The subcomponents of the FailureInformation include:

a) The system identifier, which is the Bridge Identifier (13.26.2) of the Bridge or the 48-bit MAC Address of the end station's port extended to 64-bits by prepending 16 bits of zero, that changed the Declaration Type from Advertise to Failed.

NOTE 1—Bridge Identifiers are normally constructed from MAC Addresses that are unique in the bridged LAN but are not required to be constructed in that manner; therefore, there is a possibility of an end station MAC Address colliding with the Bridge ID.

b) The Failure Code, which is represented by a single octet containing the value shown in Table 46-15.

NOTE 2—Although the table of failure codes (Table 46-15) is located in a subclause associated with MSRPv1, the codes are compatible with MSRPv0.

35.2.2.9 MSRP FirstValue definitions (Domain discovery)

The Domain attribute contains all the information that a Bridge Port needs in order to determine the location of the SRP domain boundary [item h) in 35.2.1.4]. The Domain attribute is also used to detect the ProtocolVersion of the neighboring MSRP Participant on each Bridge Port [item j) in 35.2.1.4].

The MSRP Participant shall declare (transmit) its Domain attribute after MAC_Operational (IEEE Std 802.1AC) transitions to TRUE and prior to declaring a Talker Advertise, Talker Failed, or Listener attribute.

FirstValue shall be incremented one or more times when NumberOfValues is greater than one. Incrementing FirstValue for the MSRP Domain attribute is defined as follows:

a) Add 1 to SRclassID (35.2.2.9.2), and
b) Add 1 to SRclassPriority (35.2.2.9.3).

The choice of encoding and incrementing with this rule means that if one class (e.g., class B) is supported, with the default values, then the FirstValue will be {5,2,VID} (class B, priority 2, and a VID) and the NumberOfValues field will be set to 1. If class A and class B are supported, with the default values, the FirstValue will again be {5,2,VID}, but the NumberOfValues fields will be set to 2. Applying the above incrementing rule to {5,2,VID} generates the value {6,3,VID}, i.e., class A, priority 3, and a VID, which is needed for the default case.

NOTE—If the SR Class to Priority Mapping Table (12.20.4) is configured through management such that SR class ID values do not increment contiguously with priority values, the declared domains need to be encoded in multiple Domain Vector Attributes. For example, if the SR class ID and priority rows are {2,4}, {3,0}, {4,1}, {5,2}, and {6,3}, two Domain attributes are needed: one Domain with FirstValue {2,4,VID} and NumberOfValues one, and a second Domain with FirstValue {3,0,VID} and NumberOfValues four.

[48] Example calculations for latency are contained in the paper "Calculating the Delay Added by Qav Stream Queue" [B3].

35.2.2.9.1 Structure definition

The FirstValue for the Domain attribute in MSRPDUs exchanged according to the protocol specified in this subclause shall have the following structure:

a) The first octet contains the *SRclassID* (35.2.2.9.2).
b) Following the SRclassID is an octet containing the *SRclassPriority* (35.2.2.9.3).
c) Following the SRclassPriority are two octets containing the *SRclassVID* (35.2.2.9.4).

The following BNF production gives the formal description of the MSRPDU FirstValue structure for the Domain attribute:

FirstValue ::= SRclassID, SRclassPriority, SRclassVID

Figure 35-3 illustrates the structure of the MSRPDU FirstValue components for the Domain attribute.

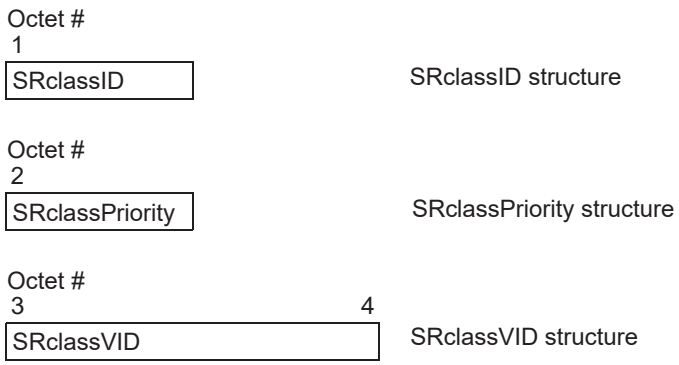


Figure 35-3—Format of the components of the Domain FirstValue

35.2.2.9.2 SRclassID

SRclassID is a numeric representation of the SR classes that are supported by a particular Bridge Port. The mapping of SR class letter to SR class ID is shown in Table 35-6.

Table 35-6—SR class ID

SR class	SR class ID
A	6
B	5
C	4
D	3
E	2
F	1
G	0

NOTE—When SRP is supported, only one SR class is required. Only SR classes A and B can be enabled by default. Additional SR classes must be configured through use of management (12.20.4, 34.5).

35.2.2.9.3 SRclassPriority

This fields holds the Data Frame Priority [item a) in 35.2.2.8.5] value that will be used for streams that belong to the associated SR class. Whenever an end station's MAC_Operational (IEEE Std 802.1AC) transitions to TRUE, its SRclassPriority shall be set to the default SR class priority (Table 6-5) until an SRclassPriority declaration is received from a neighboring device, at which time it shall be set to the declared value. An end station cannot change its default mapping of SR class to priority (see 12.20.4).

NOTE—This allows two end stations that are connected back-to-back to share streams, while also providing an end station the flexibility to change to the SRclassPriority of a attached network (i.e., neighboring Bridge).

35.2.2.9.4 SRclassVID

This field contains the SR_PVID [item i) in 35.2.1.4] that the associated streams will be tagged with by the Talker. Whenever an end station's MAC_Operational (IEEE Std 802.1AC) transitions to TRUE, its SRclassVID shall be set to the default SR_PVID (Table 9-2) until an SRclassVID declaration is received from a neighboring device, at which time it shall be set to the declared value.

NOTE—This allows two end stations that are connected back-to-back to share streams, while also providing an end station the flexibility to change to the SRclassVID of a attached network.

35.2.2.10 MSRP FirstValue definitions (Stream reservations, enhanced)

This subclause specifies two Attribute Types for enhanced stream reservations: Talker Enhanced and Listener Enhanced.

The specifications of the enhanced Attribute Types (35.2.2.10) are based on the specifications of the original Attribute Types (35.2.2.8), with differences stated explicitly.

As compared to the original Attribute Types, the enhanced Attribute Types use a Type-Length-Value (TLV) encoding for MSRP FirstValue. MSRP FirstValue contains a list of TLVs. Each TLV consists of a Type field that specifies what the Value field contains, a Length field that specifies the number of octets in the Value field, and the Value field. The Value contains one or more elements encoded in binary. The TLV encoding enables flexibility in the structure of MSRP FirstValue, such as support for optional features.

This subclause specifies the structure of MSRP FirstValue as well as the Type and Length for each TLV. This subclause also specifies the binary encoding of the elements within the Value of each TLV. The semantic specification of each element in the TLV's Value is provided as a reference to the corresponding group of elements in TSN User/network configuration information (46.2).

The transmission of octets in MSRP FirstValue is specified in 10.8.1.1. The encoding of the Value of each TLV is specified in a figure, and the representation in the figure is specified in 10.8.1.1. Elements marked as "reserved" shall be transmitted as zero and ignored on reception. When an element is not a multiple of 8 bits in length, the element is organized from most significant bit of the octet to least significant bit. Boolean elements are a single bit. When an element's Length in the figure is a decimal number only, Length specifies the number of octets for the element. When an element's Length in the figure is a decimal number followed by "bits," Length specifies the number of bits for the element.

FirstValue shall be incremented one or more times when NumberOfValues is greater than one, as follows:

a) Add 1 to Unique ID of the StreamID TLV (46.2.3.1), and
b) Add 1 to each element of the DataFrameSpecification TLV (46.2.3.4) that identifies the Stream:
    1) If the IEEE802-MacAddresses TLV is used, add 1 to DestinationMacAddress.
    2) If the IPv4-tuple TLV is used, add 1 to DestinationIpAddress.
    3) If the IPv6-tuple TLV is used, add 1 to DestinationIpAddress.

This rule for incrementing FirstValue is the same as the original Attribute Types (35.2.2.8), with the addition of optional support for IP destination address as the unique identification of the Stream.

NOTE 1—For an example of incrementing FirstValue for DestinationMacAddress, refer to 35.2.2.8.

NOTE 2—As compared to the fixed attribute values of the original AttributeTypes, the use of TLVs in the enhanced AttributeTypes allows each attribute value to vary based on the use of sub-TLVs. This imposes an additional constraint when NumberOfValues is greater than one such that all FirstValues must use the same sub-TLVs.

NOTE 3—As specified in 35.2.3.1, when a Talker or Listener has a *neighborProtocolVersion* of 0x00 (i.e., Nearest Bridge is MSRPv0), declarations must use only the original Attribute Types (35.2.2.8). If the application of the Talker/Listener is using the enhanced features of this subclause (35.2.2.10), an internal translation is needed in order to determine if the original Attribute Type can be declared. This internal translation is similar to the translation specified for MAP in a Bridge (Table 35-11 and Table 35-16), but it is outside the scope of this standard. If the enhanced features do not translate successfully to an original Attribute Type, the Talker or Listener can choose to either a) declare the failure to the network using an original Attribute Type (e.g., Talker Failed Vector of Table 35-1) or b) return an error up to the application of the Talker/Listener.

Some of the enhanced features of this subclause require the assistance of a Centralized Network Configuration (CNC) entity. As described in the introduction to Clause 35, in order to use a CNC with SRP, the MRP External Control (12.32.4) feature is enabled in the Nearest Bridge (8.6.3) to each Talker and Listener. Therefore, when a Talker or Listener uses an enhanced feature, the success or failure of the Stream reservation depends on the externalControl (12.32.4.1) parameter on the Port connected to the Talker/Listener, as follows:

a) externalControl TRUE

SRP messages are exchanged with the CNC, and the CNC uses those SRP messages to learn the requirements for each Stream. The CNC uses remote management protocols (e.g., SNMP, NETCONF) in order to learn the capabilities of the Bridges between each Talker and its Listeners. The CNC is not required to support all Bridge features, but for the Bridge features that it supports, it compares the Bridge's capabilities to the configuration needed in order to meet each Stream's requirements. If the CNC successfully configures the Bridges for the Stream, the CNC shall use MRP External Control to declare a Talker Advertise attribute to each Listener and a Listener Ready attribute to the Talker. If the CNC fails to configure the Bridges for the Stream, the CNC shall use MRP External Control to declare a Talker Failed attribute to each Listener and a Listener Ready Failed or Listener Asking Failed attribute to the Talker.

b) externalControl FALSE

When MRP External Control is not used, SRP messages propagate through Bridges, and the Bridges configure themselves for the Stream reservation. Some enhanced features can be supported with this model, and other enhanced features cannot be supported. In the specifications of this subclause, the phrase "When the externalControl attribute is FALSE" is used to specify failure conditions when MRP External Control is not used for the Talker/Listener. If this phrase is not used, the feature is fully supported in the absence of MRP External Control (i.e., CNC).

35.2.2.10.1 Structure definition

The FirstValue of each attribute shall consist of a list of one or more TLVs. Each TLV shall contain a single octet TLV type, followed by a single octet TLV length, followed by multiple octets for the TLV value.

The TLV type shall use a value specified in Table 35-7.

Table 35-7—TLV types

TLV	TLV type	TLV length
Talker	1	variable
StreamID	2	8
StreamRank	3	1
EndStationInterfaces	4	variable
InterfaceID	5	variable
DataFrameSpecification	6	18
IEEE802-MacAddresses	7	12
IEEE802-VlanTag	8	2
IPv4-tuple	9	15
IPv6-tuple	10	39
TrafficSpecification	11	9
TSpecTimeAware	12	12
UserToNetworkRequirements	13	5
InterfaceCapabilities	14	variable
Listener	15	variable
Status	16	variable
StatusInfo	17	3
AccumulatedLatency	18	4
InterfaceConfiguration	19	variable
TimeAwareOffset	20	4
FailedInterfaces	21	variable

The TLV length shall contain the number of octets in the TLV value that follows. The TLV value is specified in subsequent subclauses for each TLV.

The following Backus-Naur Form (BNF) production gives the formal description of the MSRPDU FirstValue structure for the Talker Enhanced attribute:

TalkerEnhanced_FirstValue ::= Talker, Status
Talker ::= Type, Length,
StreamID,
StreamRank,
[EndStationInterfaces,]
[DataFrameSpecification,]
TrafficSpecification,
[TSpecTimeAware,]
[UserToNetworkRequirements,]
[InterfaceCapabilities,]
Status ::= Type, Length,
StatusInfo,
AccumulatedLatency
[InterfaceConfiguration]
[FailedInterfaces]
StreamID ::= Type, Length, *value specified in 35.2.2.10.2*
StreamRank ::= Type, Length, *value specified in 35.2.2.10.3*
EndStationInterfaces ::= Type, Length, *value specified in 35.2.2.10.4*, *35.2.2.10.4*
DataFrameSpecification ::= Type, Length, *value specified in 35.2.2.10.5*, *35.2.2.10.5*
TrafficSpecification ::= Type, Length, *value specified in 35.2.2.10.6*
TSpecTimeAware ::= Type, Length, *value specified in 35.2.2.10.6*
UserToNetworkRequirements ::= Type, Length, *value specified in 35.2.2.10.7*
InterfaceCapabilities ::= Type, Length, *value specified in 35.2.2.10.8*, *35.2.2.10.8*
StatusInfo ::= Type, Length, *value specified in 35.2.2.10.9*
AccumulatedLatency ::= Type, Length, *value specified in 35.2.2.10.10*
InterfaceConfiguration ::= Type, Length, *value specified in 35.2.2.10.11*
FailedInterfaces ::= Type, Length, *value specified in 35.2.2.10.12*
Type BYTE ::= *corresponding TLV Type from Table 35-7*
Length BYTE ::= *corresponding TLV Length (number of octets in TLV Value)*

The following Backus-Naur Form (BNF) production gives the formal description of the MSRPDU FirstValue structure for the Listener Enhanced attribute:

ListenerEnhanced_FirstValue ::= Listener, Status
Listener ::= Type, Length,
StreamID,
[EndStationInterfaces,]
[UserToNetworkRequirements,]
[InterfaceCapabilities]
StatusGroup ::= Type, Length,
StatusInfo,
[InterfaceConfiguration]
[FailedInterfaces]
StreamID ::= Type, Length, *value specified in 35.2.2.10.2*
EndStationInterfaces ::= Type, Length, *value specified in 35.2.2.10.4, 35.2.2.10.4*
UserToNetworkRequirements ::= Type, Length, *value specified in 35.2.2.10.7*
InterfaceCapabilities ::= Type, Length, *value specified in 35.2.2.10.8, 35.2.2.10.8*
StatusInfo ::= Type, Length, *value specified in 35.2.2.10.9*
InterfaceConfiguration ::= Type, Length, *value specified in 35.2.2.10.11*
FailedInterfaces ::= Type, Length, *value specified in 35.2.2.10.12*
Type BYTE ::= *corresponding TLV Type from Table 35-7*
Length BYTE ::= *corresponding TLV Length (number of octets in TLV value)*

35.2.2.10.2 StreamID

The StreamID group is specified in 46.2.3.1.

Figure 35-4 specifies the encoding of the value for the StreamID TLV.

	Octet	Length
MacAddress	1	6
UniqueID	7	2

Figure 35-4—Value of StreamID TLV

The MacAddress is encoded in a manner consistent with the MAC address of a frame header.

The semantics of the MacAddress and UniqueID elements of the enhanced StreamID TLV are the same as the semantics of the Mac Address and Unique ID of the original StreamID structure (35.2.2.8.2).

Requirements for incrementing UniqueID are specified in 35.2.2.10.

35.2.2.10.3 StreamRank

The StreamRank group is specified in 46.2.3.2.

Figure 35-5 specifies the encoding of the value for the StreamRank TLV.

	Octet	Length
reserved	1	7 bits
Rank	1	1 bit

Figure 35-5—Value of StreamRank TLV

The semantics of the Rank element of the enhanced StreamRank TLV are the same as the semantics of the Rank of the original PriorityAndRank structure (35.2.2.8.5).

35.2.2.10.4 EndStationInterfaces

The EndStationInterfaces group is specified in 46.2.3.3.

The Value of the EndStationInterfaces TLV shall consist of one or more InterfaceID TLVs. An InterfaceID TLV is provided for each interface used by the Stream’s Talker/Listener.

Figure 35-6 specifies the encoding of the value for the InterfaceID TLV.

Group length: 6 + NameLength	Octet	Length
MacAddress	1	6
InterfaceName	7	NameLength

Figure 35-6—Value of InterfaceID TLV

The MacAddress is encoded in a manner consistent with the MAC address of a frame header.

If the InterfaceName element is not used, its NameLength is zero, and InterfaceName does not exist in the InterfaceID’s Value.

EndStationInterfaces does not exist in the original Attribute Types (MSRPv0). EndStationInterfaces enhances MSRP for optional support of CNC.

EndStationInterfaces specifies the identification of physical interfaces (distinct points of attachment) in the end station acting as a Talker/Listener. EndStationInterfaces is used by the CNC to locate the Talker/Listener in the topology. EndStationInterfaces can also be used by end stations with two or more interfaces.

When the externalControl attribute is TRUE (12.32.4.1), EndStationInterfaces should be included in the attribute declared by the Talker or Listener. If the CNC does not have the information needed to identify the Talker/Listener Ports in the topology, the CNC is likely to fail the Stream reservation (35.2.2.10).

When the externalControl attribute is FALSE (12.32.4.1), if EndStationInterfaces contains more than one interface, the Nearest Bridge shall fail the Stream reservation. The fully distributed model does not specify support for multiple interfaces. To fail the Stream reservation, the Nearest Bridge shall change Talker Advertise to Talker Failed and report Failure Code=25 (Table 46-15) and also change Listener Ready or Listener Ready Failed to Listener Asking Failed and report Failure Code=25.

Since the EndStationInterfaces is only used by MRP External Control (12.32.4) for communication with a CNC, the EndStationInterfaces TLV shall be removed from the MSRP FirstValue prior to propagation with MAP (35.2.4).

35.2.2.10.5 DataFrameSpecification

The DataFrameSpecification group is specified in 46.2.3.4.

The TLV for DataFrameSpecification shall consist of Type and Length, followed by a Value that consists of a list of one or more TLVs for each field in the user's frame. The list of TLVs within the DataFrameSpecification value shall be ordered from start of frame to end of header.

Figure 35-7 specifies the encoding of the value for the IEEE802-MacAddresses TLV. The MAC addresses are encoded in a manner consistent with the MAC address of a frame header.

	Octet	Length
DestinationMacAddress	1	6
SourceMacAddress	7	6

Figure 35-7—Value of IEEE802-MacAddresses TLV

Figure 35-8 specifies the encoding of the value for the IEEE802-VlanTag TLV.

	Octet	Length
Priority Code Point	1	3 bits
Reserved	1	1 bit
VLAN ID	1	12 bits

Figure 35-8—Value of IEEE802-VlanTag TLV

Figure 35-9 specifies the encoding of the value for the IPv4-tuple TLV. The IP addresses are encoded in a manner consistent with the IP address of a packet header.

	Octet	Length
SourceIpAddress	1	4
DestinationIpAddress	5	4
Dscp	9	1
Protocol	10	2
SourcePort	12	2
DestinationPort	14	2

Figure 35-9—Value of IPv4-tuple TLV

Figure 35-10 specifies the encoding of the value for the IPv6-tuple TLV. The IP addresses are encoded in a manner consistent with the IP address of a packet header.

	Octet	Length
SourceIpAddress	1	16
DestinationIpAddress	17	16
Dscp	33	1
Protocol	34	2
SourcePort	36	2
DestinationPort	38	2

Figure 35-10—Value of IPv6-tuple TLV

The semantics of the DestinationMacAddress of the enhanced DataFrameSpecification TLV (IEEE802-MacAddresses sub-TLV) are the same as the semantics of the destination_address of the original DataFrameParameters structure (35.2.2.8.3). The semantics of the VlanId of the enhanced DataFrameSpecification TLV (IEEE802-VlanTag sub-TLV) are the same as the semantics of the vlan_identifier of the original DataFrameParameters structure (35.2.2.8.3). The semantics of the PriorityCodePoint element of the enhanced DataFrameSpecification TLV are the same as the semantics of the Data Frame Priority of the original PriorityAndRank structure (35.2.2.8.5).

Requirements for incrementing destination addresses of DataFrameSpecification are specified in 35.2.2.10.

In order to apply TSN behavior to Streams (e.g., reserved bandwidth guarantees), MSRP must be able to distinguish one Stream from another Stream and to distinguish Streams from non-TSN traffic (e.g., best-effort). This requires unique identification of each Stream within the user (i.e., Talker and Listener) as well as the network (i.e., Bridges).

As compared to the original Attribute Types (MSRPv0), the enhancements of the DataFrameSpecification TLV support Stream transformation (46.1.4).

Stream transformation is an optional feature in MSRP Participants. Since Stream Transformation can be supported in either end station or Bridge, one of the following methodologies may be chosen:

a) No Stream Transformation

When Stream transformation (46.1.4) is not supported, the user's identification of the Stream must be the same as the network's identification (i.e., destination MAC address and VLAN ID). This is the methodology used for MSRPv0. This methodology requires the following in each end station (Talker/Listener):

1) The destination MAC address of the user's data frame shall be either multicast (group) or a locally administered unicast (individual). A multicast MAC address is allocated by the user (e.g., a higher layer protocol like IEEE Std 1722 [B16]). Only one Stream is allowed per destination MAC address. The destination MAC address shall be provided as the DestinationMacAddress element of the IEEE802-MacAddresses sub-TLV of the DataFrameSpecification TLV.

   NOTE—When Stream transformation is not supported, MSRP prohibits a DestinationMacAddress element that is universal unicast (i.e., individual MAC address of the Listener). Since the Listener's universal unicast MAC address is used for non-TSN traffic, it does not uniquely identify the Stream. The VLAN ID alone does not distinguish the Stream's traffic because Bridges can be configured to egress non-TSN traffic using the same VLAN ID that the Stream is using.

2) The Talker uses its individual MAC address as the source MAC address of the data frame. The source MAC address shall be provided as the SourceMacAddress element of the IEEE802-MacAddresses sub-TLV of the DataFrameSpecification TLV.
3) The data frame shall use a VLAN tag containing a Priority Code Point (PCP) and a VLAN ID, both provided in the IEEE802-VlanTag sub-TLV of the DataFrameSpecification TLV. The Talker uses the value SRclassPriority of the Domain attribute (35.2.2.9.3) for the PriorityCodePoint. If the Talker has knowledge of a specific VLAN ID to use, any valid VlanId can be specified (1 to 4094). If the Talker does not have knowledge of a specific VLAN ID to use, the VlanId uses the value from the SRclassVID of the Domain attribute (35.2.2.9.4).

b) Stream Transformation in end station

When Stream transformation (46.1.4) is performed in the end station (Talker/Listener), the end station relies on the network to provide the network's identification of the Stream (i.e., destination MAC address and VLAN ID). The network identification is provided by the CNC through the use of MRP External Control (12.32.4) in the Nearest Bridge (8.6.3). This methodology requires the following in each end station (Talker/Listener):

1) The Talker's DataFrameSpecification TLV shall not be included in the Talker attribute. This indicates to the CNC that Stream transformation is performed in the end station. Since the user's data frame identification is not used in the network, the DataFrameSpecification is not relevant to Bridges.
2) The end station's InterfaceCapabilities TLV (46.2.3.7) shall set VlanTagCapable=true and CB-StreamIdenTypeList containing the Active Destination MAC and VLAN Stream identification type (46.2.3). If the user's data frame uses either IPv4-tuple or IPv6-tuple, the CB-StreamIdenTypeList shall contain the IP Stream identification type. These InterfaceCapabilities specify that the end station supports the IEEE 802.1CB stream identification functions that transform between the user's identification and the corresponding network identification.
3) When the externalControl attribute is FALSE (12.32.4.1), if the Talker's DataFrameSpecification TLV is missing from Talker Advertise, the Nearest Bridge shall fail the Stream reservation. The fully distributed model does not specify support for stream transformation in end station. To fail the Stream reservation, the Nearest Bridge shall change Talker Advertise to Talker Failed and report Failure Code=22 (Table 46-15).
4) The CNC shall allocate a multicast MAC address for the network identification and use MRP External Control to declare an MSRP attribute containing a InterfaceConfiguration sub-TLV (35.2.2.10.11) with configuration values for IEEE802-MacAddresses and IEEE802-VlanTag.

These configuration values provide the network identification for the end station's transformation. For an end station acting as Talker, the Nearest Bridge includes InterfaceConfiguration in the declared Listener Ready or Listener Ready Failed. For an end station acting as Listener, the Nearest Bridge includes InterfaceConfiguration in the declared Talker Advertise.

5) When the Stream is withdrawn (i.e., MRP Leave of Talker Advertise), the CNC can free the multicast MAC address for use by subsequent Streams.

c) Stream Transformation in Bridge

When Stream transformation (46.1.4) is performed in the Bridge, the end station relies on the CNC to configure the Bridge to perform all transformation. The user identification (i.e., DataFrameSpecification) is provided to the CNC through the use of MRP External Control (12.32.4) in the Nearest Bridge (8.6.3). The CNC uses management to configure IEEE 802.1CB features in the Nearest Bridge to transform the Stream between user and network identification. This methodology requires the following:

1) The Talker's DataFrameSpecification TLV provides unique user identification of the Stream, but that user identification does not meet the requirements for no stream transformation [item a) in 35.2.2.10.5]. If the destination address alone does not distinguish the Stream from other Streams and non-TSN traffic, other elements of the DataFrameSpecification shall be unique. For example, if the data frame is untagged with unicast DestinationMacAddress and unicast DestinationIpAddress, a unique DestinationPort can distinguish the Stream.
2) When the externalControl attribute is FALSE (12.32.4.1), since the Talker's DataFrameSpecification TLV does not meet the requirements for no stream transformation [item a) in 35.2.2.10.5], the Nearest Bridge shall fail the Stream reservation. The fully distributed model does not specify support for stream transformation in Bridge. To fail the Stream reservation, the Nearest Bridge shall change Talker Advertise to Talker Failed and report Failure Code=22 (Table 46-15).
3) If the CNC determines that the Nearest Bridge does not support IEEE Std 802.1CB, it shall use MRP External Control to declare an MSRP attribute containing a StatusInfo sub-TLV (35.2.2.10.9) with Failure Code=23 (Table 46-15). For an end station acting as Talker, the Nearest Bridge declares Listener Asking Failed. For an end station acting as Listener, the Nearest Bridge declares Talker Failed.
4) If the CNC determines that the Nearest Bridge does not support the IEEE 802.1CB stream identification types for the DataFrameSpecification, it shall use MRP External Control to declare an MSRP attribute containing a StatusInfo sub-TLV (35.2.2.10.9) with Failure Code=24 (Table 46-15). For an end station acting as Talker, the Nearest Bridge declares Listener Asking Failed. For an end station acting as Listener, the Nearest Bridge declares Talker Failed.
5) If the CNC successfully configures the IEEE 802.1CB stream identification types for the DataFrameSpecification, it shall use MRP External Control to declare a successful MSRP attribute (assuming no other failures). For an end station acting as Talker, the Nearest Bridge declares Listener Ready or Listener Ready Failed. For an end station acting as Listener, the Nearest Bridge declares Talker Advertise.
6) When the Stream is withdrawn (i.e., MRP Leave of Talker Advertise), the CNC can free the multicast MAC address for use by subsequent Streams. The CNC can also remove IEEE 802.1CB configurations for the withdrawn Stream.

35.2.2.10.6 TrafficSpecification and TSpecTimeAware

The TrafficSpecification group and optional TSpecTimeAware group are specified in 46.2.3.5.

The TrafficSpecification shall consist of a required TrafficSpecification TLV, followed by an optional TSpecTimeAware TLV.

Figure 35-11 specifies the encoding of the value for the TrafficSpecification TLV.

	Octet	Length
Interval	1	4
MaxFramesPerInterval	5	2
MaxFrameSize	7	2
TransmissionSelection	9	1

Figure 35-11—Value of TrafficSpecification TLV

Figure 35-12 specifies the encoding of the value for the TSpecTimeAware TLV. The presence of the optional TSpecTimeAware TLV is handled as specified in 46.2.3.5 for the presence of the TSpecTimeAware group.

	Octet	Length
EarliestTransmitOffset	1	4
LatestTransmitOffset	5	4
Jitter	9	4

Figure 35-12—Value of TSpecTimeAware TLV

The semantics of the MaxFramesPerInterval element of the enhanced TrafficSpecification TLV are the same as the semantics of the MaxIntervalFrames of the original TSpec structure (35.2.2.8.4). The semantics of the MaxFrameSize element of the enhanced TrafficSpecification TLV are the same as the semantics of the MaxFrameSize of the original TSpec structure (35.2.2.8.4).

A Talker that assumes usage of the fully distributed model should use TrafficSpecification as follows:

a) Set the Interval element of the TrafficSpecification TLV to the classMeasurementInterval (34.3) of the stream's SR class (35.2.2.9.2).
b) Set the TransmissionSelection element to the value 1 for use of the credit-based shaper (8.6.8.2).
c) Do not use the TSpecTimeAware TLV.

When the externalControl attribute is FALSE (12.32.4.1), if the Talker's TrafficSpecification TLV does not meet the preceding recommendations a) through c), a Bridge may fail the Stream reservation. Bridges using the fully distributed model are not required to support Talker-specific intervals or shaping beyond those of MSRPv0. To fail the Stream reservation, the Bridge shall change Talker Advertise to Talker Failed and report Failure Code=25 (Table 46-15).

NOTE—In IEEE Std 802.1BA [B9], the AccumulatedLatency computation assumes consistent use of the credit-based shaper at the classMeasurementInterval for the Talker and all Bridges using the SR class. This assumption aligns with the preceding recommendations. The Talker's TrafficSpecification specifies the interval, shaping, and/or scheduling of the Talker only, and TrafficSpecification does not change as it propagates through Bridges. Therefore, when MRP External Control is not in use, in order to support TrafficSpecifications beyond those of IEEE Std 802.1BA, each Bridge must be able to 1) distinguish whether the Port registering Talker Advertise is connected directly to the Talker (i.e., end station) or another Bridge, to determine where TrafficSpecification impacts the AccumulatedLatency, and 2) understand the shaping and scheduling used in each Bridge in the path from Talker to the current Bridge since that also impacts AccumulatedLatency. Specifications for these tasks are not provided in this standard.

35.2.2.10.7 UserToNetworkRequirements

The UserToNetworkRequirements group is specified in 46.2.3.6.

Figure 35-13 specifies the encoding of the value for the UserToNetworkRequirements TLV.

	Octet	Length
NumSeamlessTrees	1	1
MaxLatency	2	4

Figure 35-13—Value of UserToNetworkRequirements TLV

UserToNetworkRequirements does not exist in the original Attribute Types (MSRPv0). UserToNetworkRequirements provides an optional mechanism for the Stream's Talker and/or Listeners to specify requirements to the network.

As specified in the MSRP structure definition (35.2.2.10.1), the UserToNetworkRequirements TLV may be used for either Talker or Listener attributes.

If UserToNetworkRequirements.MaxLatency is greater than zero, when an MSRP Participant detects that the AccumulatedLatency (35.2.2.10.10) of the Stream is greater than UserToNetworkRequirements.MaxLatency, the Stream's status is reported as failed (35.2.4.6).

If UserToNetworkRequirements.MaxLatency is zero (or UserToNetworkRequirements is not provided), when an MSRP Participant detects that the AccumulatedLatency of the Stream is greater than the initial AccumulatedLatency when the Stream was successfully configured, the Stream's status is reported as failed. This technique is compatible with MSRPv0 (35.2.2.8.6).

As specified in 46.2.3.6 and 35.2.4.6, UserToNetworkRequirements.MaxLatency specified by a Talker applies to all Listeners of the stream. UserToNetworkRequirements.MaxLatency specified by a Listener applies to that Listener alone.

Additional specifications for UserToNetworkRequirements.MaxLatency are provided in 35.2.6.

A Talker that assumes usage of the fully distributed model should use UserToNetworkRequirements as follows:

a) Set the NumSeamlessTrees element to one.

When the externalControl attribute is FALSE (12.32.4.1), if the Talker's UserToNetworkRequirements TLV does not meet the preceding recommendation a), a Bridge may fail the Stream reservation. Bridges using the fully distributed model are not required to support configuration of seamless redundancy. To fail the Stream reservation, the Bridge shall change Talker Advertise to Talker Failed and report Failure Code=25 (Table 46-15).

NOTE—NumSeamlessTrees greater than one is intended for use with MRP External Control (i.e., externalControl TRUE), which passes SRP attributes to a CNC, and the CNC configures Bridges for seamless redundancy (e.g., IEEE Std 802.1CB or IEC 62439-3:2016 [B4]). When MRP External Control is not in use, in order to support NumSeamlessTrees greater than one, each Bridge must be able to either 1) determine that seamless redundancy has already been configured for all Bridges between the Talker and its Listeners or 2) solicit such configuration from an external entity. Specifications for these tasks are not provided in this standard.

35.2.2.10.8 InterfaceCapabilities

The InterfaceCapabilities group is specified in 46.2.3.7.

Figure 35-14 specifies the encoding of the value for the InterfaceCapabilities TLV. NumITL represents the number of elements in the CB-StreamIdenTypeList. NumSTL represents the number of elements in the CB-SequenceTypeList.

TLV Length: 3 + (4 × NumITL) + (4 × NumSTL)	Octet	Length
reserved	1	7 bits
VlanTagCapable	1	1 bit
NumITL	2	1
NumSTL	3	1
CB-StreamIdenTypeList	4	4 × NumITL
CB-SequenceTypeList	4	4 × NumITL

Figure 35-14—Value of InterfaceCapabilities TLV

InterfaceCapabilities does not exist in the original Attribute Types (MSRPv0). InterfaceCapabilities provides an optional mechanism for stream transformation as specified in 35.2.2.10.5.

The InterfaceCapabilities TLV is used only for negotiation between an end station and the neighboring MRP Participant on the link. The InterfaceCapabilities TLV shall be removed from the MSRP FirstValue prior to propagation with MAP (35.2.4).

35.2.2.10.9 StatusInfo

The StatusInfo group is specified in 46.2.5.1.

Figure 35-15 specifies the encoding of the value for the StatusInfo TLV.

	Octet	Length
TalkerStatus	1	1
ListenerStatus	2	1
FailureCode	3	1

Figure 35-15—Value of StatusInfo TLV

The semantics of the FailureCode element of the enhanced StatusInfo TLV are the same as the semantics of the Failure Code of the original FailureInformation structure (35.2.2.8.7), and both use the same Table 46-15 for values.

The original Attribute Types (MSRPv0) did not provide a FailureCode from a Listener. The enhanced StatusInfo provides a mechanism for a Listener to provide a FailureCode as status to the Talker.

The StatusInfo in the Talker attribute is used to communicate status information to Listeners. The StatusInfo in the Listener attribute is used to communicate status information to the Talker. In SRP, status flows in one direction. Unless stated otherwise in these specifications, elements of StatusInfo are not copied from a Talker attribute to a Listener attribute, or vice versa.

A StatusInfo TLV for Declaration Type (35.2.1.3) of Talker Advertise shall use a TalkerStatus of Ready.

A StatusInfo TLV for Declaration Type of Talker Failed shall use a TalkerStatus of Failed.

A StatusInfo TLV for Declaration Type of Listener Asking Failed shall use a ListenerStatus of Failed.

A StatusInfo TLV for Declaration Type of Listener Ready shall use a ListenerStatus of Ready.

A StatusInfo TLV for Declaration Type of Listener Ready Failed shall use a ListenerStatus of PartialFailed.

For Talker and Listener attributes, the value for the FailureCode element is specified in Table 46-15.

Refer to 35.2.4.4.6 for information on merging nonzero FailureCode values from multiple Listeners.

NOTE—MSRPv1 adds new values for FailureCode (Table 46-15) that did not exist in MSRPv0 (i.e., 20 and higher). MSRPv0 participants that register Talker Failed with these values are expected to handle the failure without complete understanding of the cause.

35.2.2.10.10 AccumulatedLatency

The AccumulatedLatency group is specified in 46.2.5.2.

Figure 35-16 specifies the encoding of the value for the AccumulatedLatency TLV.

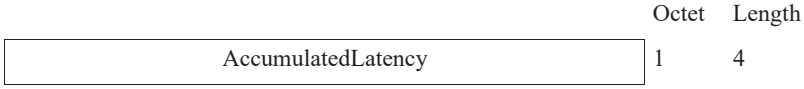


Figure 35-16—Value of AccumulatedLatency TLV

The semantics of the enhanced AccumulatedLatency TLV are the same as the semantics of the original Accumulated Latency structure (35.2.2.8.6).

The original Attribute Types (MSRPv0) failed the Stream when Accumulated Latency increased beyond its initial value. In addition to supporting that mechanism by default, the enhanced AccumulatedLatency (MSRPv1) provides an optional mechanism to fail the Stream when AccumulatedLatency exceeds specified UserToNetworkRequirements for MaxLatency (35.2.2.10.7).

35.2.2.10.11 InterfaceConfiguration

The InterfaceConfiguration group is specified in 46.2.5.3.

The encoding of the value for the InterfaceConfiguration TLV consists of one or more interface configurations. Each interface configuration consists of a single InterfaceID TLV (35.2.2.10.4), followed by a list of configuration values for that interface.

The values in each InterfaceID shall match one of the InterfaceID entries in the Talker/Listener EndStationInterfaces group.

The list of configuration values uses zero or more of the following TLVs:

— IEEE802-MacAddresses TLV (35.2.2.10.5)
— IEEE802-VlanTag TLV (35.2.2.10.5)
— IPv4-tuple TLV (35.2.2.10.5)
— IPv6-tuple TLV (35.2.2.10.5)
— TimeAwareOffset TLV with a value as specified in Figure 35-17

Group length: 4	Octet	Length
TimeAwareOffset	1	4

Figure 35-17—Value of TimeAwareOffset TLV

InterfaceConfiguration does not exist in the original Attribute Types (MSRPv0). InterfaceConfiguration provides an optional mechanism for stream transformation as specified in 35.2.2.10.5.

The InterfaceConfiguration TLV is used only for negotiation between an end station and the neighboring MRP Participant on the link. The InterfaceConfiguration TLV shall be removed from the MSRP FirstValue prior to propagation with MAP (35.2.4).

35.2.2.10.12 FailedInterfaces

The FailedInterfaces group is specified in 46.2.5.4.

The FailedInterfaces TLV may be contained within the Talker or Listener attribute. When a failure occurs in network configuration (i.e., nonzero FailureCode in StatusInfo TLV), FailedInterfaces provides a list of one or more physical interfaces (distinct points of attachment) in the failed Bridge or end station. Each entry in the list is sufficient to locate the interface in the physical topology.

The Value of the FailedInterfaces TLV consists of a sequence of zero or more TLV entries, and each TLV entry uses the InterfaceID TLV specified in 35.2.2.10.4.

The semantics of the enhanced FailedInterfaces TLV is similar to the system identifier of the original FailureInformation structure (35.2.2.8.7), but with enhanced ability to identify more than one failed interface.

The FailedInterfaces TLV is associated with the single FailureCode in the StatusInfo TLV, and it is not used to communicate multiple failures.

Elements of FailedInterfaces are not copied from a Talker attribute to a Listener attribute, or vice versa.

35.2.3 Provision and support of Stream registration service

35.2.3.1 Initiating MSRP registration and deregistration

MSRP utilizes the following five declaration types (35.2.1.3) to communicate: Talker Advertise, Talker Failed, Listener Ready, Listener Ready Failed, and Listener Asking Failed.

When a Port's *neighborProtocolVersion* is 0x00, declarations shall use only the original Attribute Types (35.2.2.8). When a Port's *neighborProtocolVersion* is 0x01 or higher, declarations shall use either the original Attributes Types or the enhanced Attributes Types (35.2.2.10).

An end station behaving as a Talker will send a Talker Advertise declaration to inform the network about the characteristics of the Stream it can provide. Bridges register this declaration, update some of the information contained within the Talker declaration, and forward it out the nonblocked (35.1.3.1) Ports on the Bridge. If *talkerPruning* is enabled and the Bridge has the Stream's destination_address registered on one or more Ports (e.g., using MMRP) it shall only forward the declarations out those Ports. Eventually the Talker declaration will be registered by other end stations.

If *talkerPruning* is enabled and the Stream's destination_address is not registered on any Ports the Talker declaration shall not be forwarded (35.2.4.3.2). When the *talkerPruning* parameter is disabled (false) for the Bridge, each Port provides a *talkerPruningPerPort* parameter to control MAC address pruning for that Port (35.2.4.3.3).

If *talkerVlanPruning* is enabled (35.2.4.3.4), the Bridge will limit the Talker declarations to Ports that have the Stream's VLAN identifier [item b) in 35.2.2.8.3] registered as a member in the VLAN Registration Entries (8.8).

An end station behaving as a Listener will receive the Talker Advertise declaration and register it. If the Listener is interested in receiving that Stream it will send a Listener Ready declaration back toward the Talker. The Bridge's MSRP MAP function will use the StreamID (35.2.2.8.2, 35.2.2.10.2) to associate the Listener Ready with the Talker Advertise and forward the Listener Ready declaration only on the Port that registered the Talker Advertise. This is referred to as Listener Pruning since the declarations are not forwarded out any other Ports. The Bridge will also reserve the required bandwidth and configure its queues and the FDB.

If any Bridge along the path from Talker to Listener does not have sufficient bandwidth or resources available its MSRP MAP function will change the Talker Advertise declaration to a Talker Failed declaration before forwarding it. Similarly a Listener Ready declaration will be changed to a Listener Asking Failed declaration if there is not sufficient bandwidth or resources available. This way both the Talker and Listener will know whether the reservation was successful.

In the case where there is a Talker attribute and Listener attribute(s) registered within a Bridge for a StreamID and a MAD_Leave.request is received for the Talker attribute, the Bridge shall act as a proxy for the Listener(s) and automatically generate a MAD_Leave.request back toward the Talker for those Listener attributes. This is a special case of the behavior described in 35.2.4.4.1.

Finally, there is the Listener Ready Failed declaration. This is used when there are two or more Listeners for a Stream. To simplify the explanation assume there are only two Listeners and one has sufficient bandwidth back to the Talker (signified by a Listener Ready), and the other does not (signified by a Listener Asking Failed). At some point in the network topology there will be a single Bridge that will receive the Listener Ready on one port from the first Listener and the Listener Asking Failed on another port from the second Listener. That Bridge's MSRP MAP function will merge (35.2.4.4.3) those two declarations into a single Listener Ready Failed declaration that will be forwarded to the Talker. When the Talker receives the Listener Ready Failed it will know there are one or more Listeners that want the Stream and can receive it, and there are one or more Listeners that want the Stream but have insufficient bandwidth or resources somewhere along the path to receive it. The Talker may still send the Stream, but it will realize that not all Listeners are going to receive it.

MSRP provides a set of Service Primitives that control the declarations of the attributes defined previously. The primitives associated with the Talker application entities are summarized in Table 35-8. Listener application entities have a corresponding set of primitives summarized in Table 35-9.

Table 35-8—Summary of Talker primitives

Name	Request	Indication
REGISTER_STREAM	35.2.3.1.1	—
DEREGISTER_STREAM	35.2.3.1.3	—
REGISTER_ATTACH	—	35.2.3.1.6
DEREGISTER_ATTACH	—	35.2.3.1.8

Table 35-9—Summary of Listener primitives

Name	Request	Indication
REGISTER_STREAM	—	35.2.3.1.2
DEREGISTER_STREAM	—	35.2.3.1.4
REGISTER_ATTACH	35.2.3.1.5	—
DEREGISTER_ATTACH	35.2.3.1.7	—

35.2.3.1.1 REGISTER_STREAM.request

A Talker application entity shall issue a REGISTER_STREAM.request to the MSRP Participant to initiate the advertisement of an available Stream.

A Talker may choose to enter a nonzero value in the Accumulated Latency that indicates the amount of latency in nanoseconds that a Stream will encounter before being passed to the MAC Service interface.

On receipt of a REGISTER_STREAM.request the MSRP Participant shall issue a MAD_Join.request service primitive (10.2, 10.3). The attribute_type (10.2) parameter of the request shall carry the appropriate Talker Attribute Type (35.2.2.4), depending on the Declaration Type and *neighborProtocolVersion*. The attribute_value (10.2) parameter shall carry the values from the REGISTER_STREAM.request primitive.

```
REGISTER_STREAM.request (
                         StreamID,
                         Declaration Type,
                         DataFrameParameters,
                         TSpec,
                         Data Frame Priority,
                         Rank,
                         Accumulated Latency,
                         FailureInformation
                         )
```

35.2.3.1.2 REGISTER_STREAM.indication

A REGISTER_STREAM.indication notifies the Listener application entity that the referenced Stream is being advertised by a Talker somewhere on the attached network.

On receipt of a MAD_Join.indication service primitive (10.2, 10.3) with an attribute_type of Talker Advertise, Talker Failed, or Talker Enhanced (35.2.2.4), the MSRP application shall issue a REGISTER_STREAM.indication to the Listener application entity. The REGISTER_STREAM.indication shall carry the values from the attribute_value parameter.

```
REGISTER_STREAM.indication (
                           StreamID,
                           Declaration Type,
                           DataFrameParameters,
                           TSpec,
                           Data Frame Priority,
                           Rank,
                           Accumulated Latency,
                           FailureInformation
                           )
```

35.2.3.1.3 DEREGISTER_STREAM.request

A Talker application entity shall issue a DEREGISTER_STREAM.request to the MSRP Participant to remove the Talker's advertisement declaration, and thus remove the advertisement of a Stream, from the network.

On receipt of a DEREGISTER_STREAM.request the MSRP Participant shall issue a MAD_Leave.request service primitive (10.2, 10.3) with the attribute_type set to the Declaration Type currently associated with the StreamID. The attribute_value parameter shall carry the StreamID and other values that were in the associated REGISTER_STREAM.request primitive.

```
DEREGISTER_STREAM.request (
                          StreamID
                          )
```

35.2.3.1.4 DEREGISTER_STREAM.indication

A DEREGISTER_STREAM.indication notifies the Listener application entity that the referenced Stream is no longer being advertised by a Talker.

On receipt of a MAD_Leave.indication service primitive (10.2, 10.3) with an attribute_type of Talker Advertise, Talker Failed, or Talker Enhanced (35.2.2.4), the MSRP application shall issue a DEREGISTER_STREAM.indication to the Listener application entity.

```
DEREGISTER_STREAM.indication (
                             StreamID
                             )
```

35.2.3.1.5 REGISTER_ATTACH.request

A Listener application entity shall issue a REGISTER_ATTACH.request to the MSRP Participant to request attachment to the referenced Stream.

On receipt of a REGISTER_ATTACH.request the MSRP Participant shall issue a MAD_Join.request service primitive (10.2, 10.3). The attribute_type parameter of the request shall carry the appropriate Listener Attribute Type (35.2.2.4), depending on *neighborProtocolVersion*. The attribute_value shall contain the StreamID and the Declaration Type.

```
REGISTER_ATTACH.request (
                        StreamID,
                        Declaration Type
                        )
```

35.2.3.1.6 REGISTER_ATTACH.indication

A REGISTER_ATTACH.indication notifies the Talker application entity that the referenced Stream is being requested by one or more Listeners.

On receipt of a MAD_Join.indication service primitive (10.2, 10.3) with an attribute_type of Listener (35.2.2.4), the MSRP application shall issue a REGISTER_ATTACH.indication to the Talker application entity. The REGISTER_ATTACH.indication shall carry the values from the attribute_value parameter.

```
REGISTER_ATTACH.indication (
                           StreamID,
                           Declaration Type
                           )
```

35.2.3.1.7 DEREGISTER_ATTACH.request

A Listener application entity shall issue a DEREGISTER_ATTACH.request to the MSRP Participant to remove the request to attach to the referenced Stream.

On receipt of a DEREGISTER_ATTACH.request the MSRP Participant shall issue a MAD_Leave.request service primitive (10.2, 10.3) with the attribute_type set to the appropriate Listener Attribute Type (35.2.2.4). The attribute_value parameter shall carry the StreamID and the Declaration Type currently associated with the StreamID.

```
DEREGISTER_ATTACH.request (
                          StreamID
                          )
```

35.2.3.1.8 DEREGISTER_ATTACH.indication

A DEREGISTER_ATTACH.indication notifies the Talker application entity that the referenced Stream is no longer being requested by any Listeners.

On receipt of a MAD_Leave.indication service primitive (10.2, 10.3) with an attribute_type of Listener (35.2.2.4), the MSRP application shall issue a DEREGISTER_ATTACH.indication to the Talker application entity. The DEREGISTER_ATTACH.indication shall contain the StreamID.

```
DEREGISTER_ATTACH.indication (
                             StreamID
                             )
```

35.2.4 MSRP Attribute Propagation

There is no MSRP MAP function for Domain attributes. MSRP simply declares the characteristics of the SR classes that are supported on the Bridge Port regardless of what has been learned from Domain registrations on other Bridge Ports. Registration of the neighbor's Domain attribute determines the value of the *SRPDomainBoundaryPort* and *neighborProtocolVersion* variables (35.2.1.4).

This clause describes the following:

a) Rules for combining and propagating Listener attributes toward the associated Talker
b) How MSRP adjusts the Talker and Listener attributes before propagating them
c) How MSRP translates Attribute Types when propagating from a ProtocolVersion (35.2.2.1) on a registering Port to a different ProtocolVersion on declaring Ports.

Unless stated otherwise, Talker and Listener attributes are propagated as described in 10.3.

In principle, the MAP performs MSRP Attribute Propagation when any of the following conditions occur:

d) A MAD_Join.indication adds a new attribute to MAD (with the *new* parameter, 10.2, set to TRUE).
e) A MAD_Leave.indication is issued by the MAD.
f) An internal application declaration or withdrawal is made in a station.
g) When the bandwidth of the underlying media changes (see *bandwidthAvailabilityChanged* notification in 34.3.3).
h) A Port becomes an SRP domain core port (3.261).
i) If talkerPruning (35.2.4.3.2) or *talkerPruningPerPort* (35.2.4.3.3) is enabled and there is a change in the MAC Address Registration Entries (8.8.4) of a Port.
j) If *talkerVlanPruning* (35.2.4.3.4) is enabled and there is a change in the VLAN Registration Entries on a Port (8.8).
k) A Port changes its *neighborProtocolVersion* parameter (35.2.1.4(j).

The MSRP MAP function is responsible for adjusting and propagating Talker and Listener attributes throughout the bridged network. It also updates the Dynamic Reservation Entries (8.8.7) to specify which Streams shall be filtered and which shall be forwarded, along with updating the associated *streamAge* [item c) in 35.2.1.4]. The bandwidth associated with those Streams is reported to the queuing algorithms via the *operIdleSlope(N)* parameter [item d) in 34.3] on a per-port per-traffic class basis.

Streams of higher importance are given available bandwidth before streams of lower importance.

If insufficient bandwidth or resources are available the streams destination_address will be filtered and the failure will be noted in the Talker and Listener attributes declared from that Bridge.

A port shall only forward MSRP declarations for SR classes it supports. This will eliminate unnecessary priority remapping for traffic related to unsupported SR classes.

The following subclauses describe what the MSRP MAP function shall accomplish.

35.2.4.1 Stream importance

MSRP utilizes the stream Rank [item b) in 35.2.2.8.5, 35.2.2.10.3] to decide which stream is more important than another.

In the case where two streams have the same Rank, the *streamAge* will be compared. If the Ranks are identical and the *streamAge*s are identical the StreamIDs (35.2.2.8.2, 35.2.2.10.2) will be compared and the numerically lower StreamID is considered to be more important.

35.2.4.2 Stream bandwidth calculations

As referenced in Table 35-5, the bandwidth requirements of a Stream include more than just the amount specified in the REGISTER_STREAM.request (35.2.3.1.1). SRP shall add the *perFrameOverhead* (34.4) associated with the media attached to the port.

If this port is on a Shared Media (35.1.1) the bandwidth requirements may need to be further increased. For example, a Stream transmitted from one station to another may have to be sent across the media twice. One time from the Talker station to the DMN, and a second time from the DMN to the Listener station. In this case the bandwidth requirements would need to be doubled.

The *totalFrameSize* for a stream on an outbound Port is therefore the sum of the following three amounts (doubled if each frame is transmitted on the media twice):

a) MaxFrameSize [item a) in 35.2.2.8.4].
b) *perFrameOverhead* (34.4) associated with the media attached to the port.
c) One (1) additional octet to account for slight differences (up to 200 ppm) in the class measurement interval between neighboring devices.

Multiply *totalFrameSize* by MaxIntervalFrames [item b) in 35.2.2.8.4] to arrive at the associated bandwidth (in bits per second), which is then used to update *operIdleSlope(N)* as shown in Table 35-14.

Streams that are in the Listener Ready or Listener Ready Failed state reduce the amount of bandwidth available to other Streams. Streams that have no Listeners, or the Listeners are in the Asking Failed state, do not reduce available bandwidth for other Streams since the Stream data will not be flowing through this outbound Port. These details are considered when calculating how many Streams can flow through a particular Port. The total amount of bandwidth available to a particular traffic class on a Port is represented by *deltaBandwidth(N)* [item b) in 34.3]. Subclauses 34.3.1 and 34.3.2 describe the relationship of available bandwidth between traffic classes.

35.2.4.3 Talker attribute propagation

Table 35-10 describes the propagation of Talker attributes for a StreamID from one port of a Bridge to another. If no Talker attributes are registered for a StreamID then no Talker attributes for that StreamID will be declared on any other port of the Bridge. If a Talker Failed is registered then it will be propagated as a Talker Failed out all other nonblocked (35.1.3.1) ports on the Bridge.

Table 35-10—Talker attribute propagation per port

		Talker		
		(none)	**Advertise**	**Failed**
Listener	**(none)**	(none)	Talker Advertise or Talker Failed	Talker Failed
	Ready	(none)	Talker Advertise or Talker Failed	Talker Failed
	Ready Failed	(none)	Talker Advertise or Talker Failed	Talker Failed
	Asking Failed	(none)	Talker Advertise or Talker Failed	Talker Failed

Talker Advertise registrations require further processing by the MAP function. MAP will analyze available bandwidth and other factors to determine if the outbound port has enough resources available to support the Stream. MAP will also verify msrpMaxFanInPorts, if nonzero, will not be exceeded. If there are sufficient resources and bandwidth available MAP will declare a Talker Advertise. Otherwise, MAP will declare a Talker Failed on the outbound port and add appropriate FailureInformation.

If the outbound Port is an SRP domain boundary port for a given SR class, then for that SR class, the MAP function shall operate such that any Talker Advertise declaration for that SR class that would otherwise propagate through that Port is converted to a Talker Failed declaration with a failure code of 8 (Table 46-15), meaning "Egress Port is not AVB-capable." The consequence of this behavior is that stream reservations can be established only in circumstances where the Talker and the Listener(s) for the stream are located within the same SRP domain.

35.2.4.3.1 ProtocolVersion Translation

Ports with *neighborProtocolVersion* [item j) in 35.2.1.4] of 0x00 shall use only the original Attribute Types (35.2.2.4) of Talker Advertise and Talker Failed. Ports with *neighborProtocolVersion* of 0x01 or higher shall use either the original Attribute Types or the enhanced Attribute Type of Talker Enhanced.

In order to propagate an enhanced Attribute Type (e.g., registered from a Port with *neighborProtocolVersion* of 0x01) to an original Attribute Type (e.g., declared to a Port with *neighborProtocolVersion* of 0x00), fields of the attribute's FirstValue shall be translated as specified in Table 35-11.

NOTE—Original Attribute Types always propagate without translation, even if *neighborProtocolVersion* is 0x01 or higher.

Table 35-11—Translation of Talker attributes

Enhanced field	Original field	Enhanced to original translation
StreamID, MacAddress	StreamID, MAC Address	No change: Copy the field's contents from enhanced to original without change.
StreamID, UniqueID	StreamID, Unique ID	No change: Copy the field's contents from enhanced to original without change.
StreamRank, Rank	PriorityAndRank, Rank	No change: Copy the field's contents from enhanced to original without change.
EndStationInterfaces	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.
DataFrameSpecification, IEEE802-MacAddresses, DestinationMacAddress	DataFrameParameters, destination_address	No change: Copy the field's contents from enhanced to original without change.
DataFrameSpecification, IEEE802-MacAddresses, SourceMacAddress	—	Lost: The declaration type does not change (i.e., fail), because MSRPv0 does not use the source MAC address for Stream identification.
DataFrameSpecification, IEEE802-VlanTag, PriorityCodePoint	PriorityAndRank, Data Frame Priority	No change: Copy the field's contents from enhanced to original without change.
DataFrameSpecification, IEEE802-VlanTag, VlanId	DataFrameParameters, vlan_identifier	No change: Copy the field's contents from enhanced to original without change.

Table 35-11—Translation of Talker attributes *(continued)*

Enhanced field	Original field	Enhanced to original translation
TrafficSpecification, Interval	—	Lost: If this field does not match the default classMeasurementInterval (34.3) of the stream's SR class, a Talker Advertise declaration is converted to a Talker Failed declaration with a failure code of 20.
TrafficSpecification, MaxFramesPerInterval	TSpec, MaxIntervalFrames	No change: Copy the field's contents from enhanced to original without change.
TrafficSpecification, MaxFrameSize	TSpec, MaxFrameSize	No change: Copy the field's contents from enhanced to original without change.
TrafficSpecification, TransmissionSelection	—	Lost: If this field is not one, a Talker Advertise declaration is converted to a Talker Failed declaration with a failure code of 20.
TrafficSpecification, TSpecTimeAware TLV	—	Lost: If this TLV is present, a Talker Advertise declaration is converted to a Talker Failed declaration with a failure code of 20.
UserToNetworkRequirements, NumSeamlessTrees	—	Lost: If this field is not one, a Talker Advertise declaration is converted to a Talker Failed declaration with a failure code of 20.
UserToNetworkRequirements, MaxLatency	—	Lost: If this field is not zero, a Talker Advertise declaration is converted to a Talker Failed declaration with a failure code of 20.
InterfaceCapabilities	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.
StatusInfo, TalkerStatus	—	No change: This field determines the original Attribute Type to declare (Talker Advertise or Talker Failed).
StatusInfo, ListenerStatus	—	No change: This field is set according to the ListenerStatus that the Bridge last propagated in the Listener attribute of the Stream. If no Listener attribute has been propagated, this field is set to zero (None).
StatusInfo, FailureCode	FailureInformation, Failure Code	For Talker Failed, this field has no change (i.e., copy from enhanced to original). For Talker Advertise, this field is lost, but the declaration type does not change (i.e., fail).
AccumulatedLatency	AccumulatedLatency, AL	No change: Copy the field's contents from enhanced to original without change.
InterfaceConfiguration	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.
FailedInterfaces, MacAddress	FailureInformation, system identifier	No change: This field applies to Talker Failed only. The most significant 16 bits of system identifier are set to zero, and the MacAddress is copied to the least significant 48 bits of system identifier.
FailedInterfaces, InterfaceName	FailureInformation	Lost: This field applies to Talker Failed only.

35.2.4.3.2 Talker Pruning

The *talkerPruning* parameter (35.2.1.4) is disabled by default, and Talker declarations are sent out all nonblocked Ports. If *talkerPruning* is enabled and the destination_address [item a) in 35.2.2.8.3] of the Stream is found in the MAC Address Registration Entries (8.8.4) for the Port, the declaration shall be forwarded. If the destination_address is not found the declaration shall be blocked and no Talker declaration of any type shall be forwarded.

35.2.4.3.3 Talker Pruning Per Port

When the *talkerPruning* parameter is disabled (false) for the Bridge, each Port may provide a *talkerPruningPerPort* parameter (35.2.1.4) to control MAC address pruning for that Port.

When the *talkerPruningPerPort* feature is provided, all *talkerPruningPerPort* parameters are disabled by default.

When *talkerPruning* is enabled (true), the *talkerPruningPerPort* parameters are ignored.

Each *talkerPruningPerPort* parameter controls MAC address pruning for that Port when *talkerPruning* is disabled (false). If *talkerPruningPerPort* is disabled for the Port, Talker declarations are forwarded on that Port regardless of the destination_address [item a) in 35.2.2.8.3] of the Stream. If *talkerPruningPerPort* is enabled for the Port and the destination_address of the Stream is found in the MAC Address Registration Entries (8.8.4) for the Port, the declaration shall be forwarded. If *talkerPruningPerPort* is enabled for the Port and the destination_address of the Stream is not found in the MAC Address Registration Entries for the Port, the declaration shall be blocked, and no Talker declaration of any type shall be forwarded.

35.2.4.3.4 Talker VLAN Pruning

The *talkerVlanPruning* parameter (35.2.1.4) may be provided on the Bridge in order to limit the Talker declarations to Ports that have the Stream's vlan_identifier [item b) in 35.2.2.8.3] registered as a member in the VLAN Registration Entries (8.8).

When the *talkerVlanPruning* feature is provided, it is disabled (false) by default.

When *talkerVlanPruning* is disabled (false), the MAP context for MSRP propagates Talker declarations according to the VLAN spanning tree (35.1.3.1), regardless of the registration of the Stream's vlan_identifier in the Filtering Database (8.8.10). This allows potential Listeners to receive Talker declarations prior to registering the VLAN with MVRP.

When *talkerVlanPruning* is enabled (true), in addition to propagating along the VLAN spanning tree, the MAP context for MSRP filters propagation according to the registration of the Stream's vlan_identifier in the Filtering Database (8.8.10). If *talkerVlanPruning* is enabled and registration of the Stream's vlan_identifier on a Port is not member (Registration Forbidden, Not Registered, or No Dynamic Registration Entry Present), MSRP shall not propagate the declaration on that Port. This propagation is effectively the same as propagation for the Stream's data frames. Potential Listeners can join the VLAN dynamically with MVRP in order to receive Talker declarations for that vlan_identifier (35.1.2.1).

The *talkerVlanPruning* parameter filters by VLAN, and it operates independently from the parameters that filter by MAC address (*talkerPruning* and *talkerPruningPerPort*).

35.2.4.4 Listener attribute propagation

Listener Attributes, unlike Talker Attributes, can be merged (35.2.4.4.3) from several Listeners on different ports into a single Listener declaration. There are two steps involved:

a) Processing of incoming Listener attribute registration on a port based upon the status of the associated Talker attribute registration,
b) Merging all the individual ports Listener attributes gathered in step 1, above, into a single Listener attribute to be declared on the nonblocked (35.1.3.1) outbound port which has the associated Talker registration. If no Talker attribute is registered within the Bridge for the StreamID associated with the Listener, the Listener attribute will not be propagated.

35.2.4.4.1 Incoming Listener attribute processing

Table 35-12 describes how Listener attributes are propagated from the incoming ports.

Table 35-12—Incoming Listener attribute propagation per port

		Talker		
		(none)	**Advertise**	**Failed**
Listener	**(none)**	(none)	(none)	(none)
	Ready	(none)	Listener Ready	Listener Asking Failed
	Ready Failed	(none)	Listener Ready Failed	Listener Asking Failed
	Asking Failed	(none)	Listener Asking Failed	Listener Asking Failed

If no Listener attributes are registered on a particular port then no Listener attribute will be propagated to the Listener attribute merging (35.2.4.4.3) from that port.

If a Listener Asking Failed is registered on a port then it will be propagated as a Listener Asking Failed and merged with other Listener Attributes from other ports.

If no Talker attributes are associated with the Listener attribute, the Listener attribute will not be propagated.

If a Talker Failed is registered on another port for the associated Listener Ready or Listener Ready Failed then a Listener Asking Failed will be propagated and merged with other Listener attributes from other ports.

If a Talker Advertise is registered on another port for the StreamID associated with a Listener Ready or Listener Ready Failed then that Listener attribute will be forwarded as-is and merged with Listener Attributes from other ports.

35.2.4.4.2 Updating Queuing and Forwarding information

When Incoming Listener attribute processing (35.2.4.4.1) has been completed for a port the Dynamic Reservation Entries (8.8.7) shall be updated as shown in Table 35-13.

The *operIdleSlope(N)* [item d) in 34.3] shall be updated as shown in Table 35-14, dependent on the change to the Dynamic Reservation Entries. MSRP MAP processing can occur at any time (35.2.4), resulting in a change to which Streams are filtered and to which streams are forwarded. These changes in bandwidth requirements shall be reflected in the *operIdleSlope(N)* variable. Streams that have had their bandwidth removed shall decrease *operIdleSlope(N)*. Streams that have just been allocated bandwidth shall increase *operIdleSlope(N)*.

NOTE—The order of operations is important when updating the Dynamic Reservation Entries and the *operIdleSlope(N)* in order not to allow any associated streaming frames to be dropped. If the bandwidth utilization of a port is going to be increased (i.e., a Stream is going to be forwarded) the *operIdleSlope(N)* is updated before the Dynamic Reservation Entries. If the bandwidth utilization of a port is going to be decreased (i.e., a Stream is going to be filtered) the Dynamic Reservation Entries are updated before the *operIdleSlope(N)*.

Table 35-13—Updating Dynamic Reservation Entries

		Talker		
		(none)	**Advertise**	**Failed**
Listener	**(none)**	(no entry)	Filtering	Filtering
	Ready	Filtering	Forwarding	Filtering
	Ready Failed	Filtering	Forwarding	Filtering
	Asking Failed	Filtering	Filtering	Filtering

Table 35-14—Updating *operIdleSlope(N)*

		Dynamic Reservation Entries prior to MSRP MAP running		
		(none)	**Filtering**	**Forwarding**
Dynamic Reservation Entries after MSRP MAP running	**(none)**	(no change)	(no change)	Decrease *operIdleSlope(N)*
	Filtering	(no change)	(no change)	Decrease *operIdleSlope(N)*
	Forwarding	Increase *operIdleSlope(N)*	Increase *operIdleSlope(N)*	(no change)

35.2.4.4.3 Merge Listener Declarations

Listener Registrations with the same StreamID shall be merged into a single Listener Declaration that will be declared on the port with the associated Talker registration. If no such Talker registration exists the Listener attribute is not declared. When this Declaration is sent,

a) The Direction (35.2.1.2) is Listener.
b) The Declaration Type (35.2.1.3) is determined according to Table 35-15.
c) The StreamID (35.2.2.8.2) is that of the Listener Registrations.

Table 35-15—Listener Declaration Type Summation

First Declaration Type	Second Declaration Type	Resultant Declaration Type
Ready	none or Ready	Ready
	Ready Failed or Asking Failed	Ready Failed
Ready Failed	any	Ready Failed
Asking Failed	Ready or Ready Failed	Ready Failed
	none or Asking Failed	Asking Failed

35.2.4.4.4 ProtocolVersion Translation

Ports with *neighborProtocolVersion* [item j) in 35.2.1.4] of 0x00 shall use only the original Attribute Type (35.2.2.4) of Listener. Ports with *neighborProtocolVersion* of 0x01 or higher shall use either the original Attribute Type or the enhanced Attribute Type of Listener Enhanced.

In order to propagate an enhanced Attribute Type (e.g., registered from a Port with *neighborProtocolVersion* of 0x01) to an original Attribute Type (e.g., declared to a Port with *neighborProtocolVersion* of 0x00), fields of the attribute's FirstValue shall be translated as specified in Table 35-16.

NOTE—Original Attribute Types always propagate without translation, even if neighborProtocolVersion is 0x01 or higher.

Table 35-16—Translation of Listener attributes

Enhanced field	Original field	Enhanced to original translation
StreamID, MacAddress	StreamID, MAC Address	No change: This field determines the original Attribute Type to declare (Talker Advertise or Talker Failed).
StreamID, UniqueID	StreamID, Unique ID	No change: This field determines the original Attribute Type to declare (Talker Advertise or Talker Failed).
EndStationInterfaces	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.
UserToNetworkRequirements, NumSeamlessTrees	—	Lost: If this field is not one, a Listener Ready or Listener Ready Failed declaration is converted to a Listener Asking Failed declaration.
UserToNetworkRequirements, MaxLatency	—	Lost: If this field is not zero, a Listener Ready or Listener Ready Failed declaration is converted to a Listener Asking Failed declaration.
InterfaceCapabilities	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.
StatusInfo, TalkerStatus	—	No change: This field is set according to the TalkerStatus that the Bridge last propagated in the Talker attribute of the Stream. If no Talker attribute has been propagated, this field is set to zero (None).
StatusInfo, ListenerStatus	—	No change: This field determines the original FourPackedType (35.2.2.10) to declare.
StatusInfo, FailureCode	—	Lost: The declaration type does not change (i.e., fail).
InterfaceConfiguration	—	Not propagated: This TLV is not propagated through MAP, so translation is not applicable.

35.2.4.4.5 Merge MaxLatency

When more than one Listener provides the UserToNetworkRequirements TLV, multiple values of MaxLatency shall be merged by using the largest MaxLatency value in that set of multiple values. This ensures that Bridges closer to the Talker support the most flexible requirement for any Listener. The requirements of an individual Listener continue to be met in Bridges closer to that Listener.

35.2.4.4.6 Merge Listener Failures

As specified in 35.2.4.4.3, it is possible for a Bridge to merge failed Declaration Types for Listeners (e.g., Ready Failed with Asking Failed). Each failed Declaration Type uses a nonzero FailureCode (35.2.2.10.9) and a FailedInterfaces TLV associated with that FailureCode.

When merging failures, the FailedInterfaces TLV shall always be transferred with its corresponding StatusInfo TLV since the FailureCode is associated with the FailedInterfaces.

When merging a Ready Failed declaration with an Asking Failed declaration, the StatusInfo and FailedInterfaces shall be transferred from the Asking Failed declaration. When merging failed declarations with the same Declaration Type, the StatusInfo and FailedInterfaces shall be transferred from the declaration with the Failure Code of the lowest numeric value. When merging failed declarations with the same Declaration Type and Failure Code, the decision of which failure to transfer is left to the Bridge's implementation.

35.2.4.5 MAP Context for MSRP

MSRPDUs can carry information about Streams in multiple VLANs, which in an MST environment, can be in different spanning tree instances. Queue resources, however, are allocated and used according to priority parameters, not according to VID. Furthermore, on a shared medium, Streams can use the shared medium even on VLANs that are blocked on the Bridge's Port to that shared medium (e.g., consider an IEEE 802.11 AP that transmits frames between two stations that are on a VLAN that is blocked on the AP). Therefore, there is a single context for MSRP Attribute Propagation that includes all Bridge Ports. The Declarations are filtered according to the requirements of 35.2.4 and its subclauses and according to the state of the spanning tree per 35.1.3.1.

All MSRPDUs are transmitted as untagged frames.

35.2.4.6 MaxLatency Comparison

The comparison for UserToNetworkRequirements.MaxLatency greater than zero determines whether to fail the Stream due to AccumulatedLatency (35.2.2.8.6, 35.2.2.10.10) that exceeds the requirement specified by Talkers and/or Listeners. The comparison is performed separately for the Talker and each Listener.

For the Talker, the UserToNetworkRequirements.MaxLatency from the Talker is compared to AccumulatedLatency for all Listeners of the Stream. For example, if the Bridge forwards the Stream to three Ports (three Listeners registered), the Talker's UserToNetworkRequirements.MaxLatency is compared to three values of AccumulatedLatency. For any of the comparisons, if any Listener's AccumulatedLatency is greater than the Talker's UserToNetworkRequirements.MaxLatency, the Talker fails the MaxLatency comparison.

If the Talker fails the MaxLatency comparison and the Declaration Type of the Talker is Advertise, the Bridge shall change Talker Advertise to Talker Failed and report Failure Code=21 (Table 46-15).

For the Listener, the UserToNetworkRequirements.MaxLatency from the Listener is compared to AccumulatedLatency for the corresponding Listener. If the Listener's AccumulatedLatency is greater than the Listener's UserToNetworkRequirements.MaxLatency, the Listener fails the MaxLatency comparison.

If the Listener fails the MaxLatency comparison, the Bridge shall change Listener Ready to Listener Asking Failed for the failed Listener and report Failure Code=21. The Listener Asking Failed is merged with declarations of other Listeners to determine the resultant Declaration Type to the Talker (35.2.4.4.3).

In the fully distributed model (46.1.3.1), the comparison for the Talker's UserToNetworkRequirements.MaxLatency is performed in each Bridge in the path from the Talker to each Listener, in the same direction as AccumulatedLatency. In the fully distributed model, the comparison for the Listener's UserToNetworkRequirements.MaxLatency is performed in each Bridge in the path from the Listener to each Talker, using the AccumulatedLatency from the Talker's attribute.

In the centralized network/distributed user model (46.1.3.2), the comparison for the Talker's and Listener's UserToNetworkRequirements.MaxLatency is performed in the CNC, using the capabilities of each Bridge as learned through remote management (e.g., Bridge Delay of 12.32.1). When the CNC detects failure of the MaxLatency comparison, Failure Code 21 is declared to the Talker and Listener as specified in item a) in 35.2.2.10.

35.2.5 Operational reporting and statistics

35.2.5.1 Dropped Stream Frame Counter

An implementation may support the ability to maintain a per-port per-traffic class count of data stream frames that are dropped for any reason. These are not MRP frames, but the data stream frames that flow between Talker and Listener(s) through the reservations established by MSRP.

35.2.6 Encoding

If an MSRP message is received from a Port with an event value specifying the JoinIn or JoinMt message, and if the StreamID (35.2.2.8.2, 35.2.2.10.2), and Direction (35.2.1.2) all match those of an attribute already registered on that Port, and the Attribute Type (35.2.2.4) or FourPackedEvent (35.2.2.7.2) has changed, then the Bridge should behave as though an **rLv!** event (with immediate leavetimer expiration in the Registrar state table) was generated for the MAD in the Received MSRP Attribute Declarations before the **rJoinIn!** or **rJoinMt!** event for the attribute in the received message is processed. This allows an Applicant to indicate a change in a stream reservation, e.g., a change from a Talker Failed to a Talker Advertise registration, without having to issue both a withdrawal of the old attribute, and a declaration of the new. A Listener attribute is also updated this way, for example, when changing from a Listener Ready to a Listener Ready Failed.

NOTE—This rule ensures that there is at most one Listener Declaration or one Talker Declaration for any given value of StreamID on any given port. In the unlikely situation where a Talker Advertise and a Talker Failed are received for the same Stream on the same port, the Talker Failed declaration takes precedence.

The following examples will help clarify the intent of this subclause. The first example describes the behavior when one attribute (Talker Advertise) is replaced by another (Talker Failed). The second example describes the behavior when the MSRP FourPackedEvents changes with a single Listener attribute.

This example illustrates processing of Talker Declaration changes. Assume a Bridge is receiving Talker Advertise declarations on an inbound Port. An emergency situation occurs and a 911 call is being placed via an entirely different Stream. The bandwidth that was available for the first Stream is now no longer available so the Bridge begins receiving Talker Failed declarations for that original stream. The MAP function realizes the Talker declaration has changed for the Stream and generates an internal leave event for the Talker Advertise and a join event for the Talker Failed. This behavior guarantees there will not be a declaration for a Talker Advertise and a Talker Failed for a single Stream existing within the Bridge at the same time.

As another example assume the same situation has occurred as described in the example above (a 911 call). For this scenario consider the Listener declarations flowing in the opposite direction. When there was bandwidth available the Bridge was declaring a Listener Ready, which was then changed to a Listener Asking Failed as soon as the 911 call came through. The other Bridge receiving these Listener declarations

realized that the Listener attribute MSRP FourPackedEvents had changed and acted as if the Listener declaration had been withdrawn and replaced by the updated Listener declaration.

35.2.7 Attribute value support requirements

Implementations of MSRP shall maintain state information for all attribute values that support the Stream registrations (35.2.2.8, 35.2.2.10).

Implementations of MSRP shall be capable of supporting any attribute value in the range of possible values that can be registered using Stream registrations; however, the maximum number of attribute values for which the implementation is able to maintain current state information is an implementation decision, and may be different for Talker attributes and Listener attributes. The number of values that the implementation can support shall be stated in the PICS.

36. Priority-based Flow Control (PFC)

This clause specifies the operation of PFC (see 36.1) and the architecture of Priority-based Flow Control in a PFC-aware system (see 36.2).

The models of operation in this clause provide a basis for specifying the externally observable behavior of PFC and are not intended to place additional constraints on implementations; these can adopt any internal model of operation compatible with the externally observable behavior specified.

36.1 PFC operation

36.1.1 Overview

Operation of PFC is limited to a data center environment. PFC enables to not discard frames due to congestion for protocols that require this property. However, PFC can cause congestion spreading behavior; therefore, it is intended for use on networks of limited extent. When PFC is used, deployment of congestion notification (see Clause 30) can reduce the frequency with which PFC is invoked.

PFC is a function defined only for a pair of full duplex MACs (e.g., IEEE 802.3 MACs operating in point-to-point full-duplex mode) connected by one point-to-point link. Use of PFC on shared media such as EPON is out of the scope of this standard. Figure 36-1 shows an example of PFC peering when IEEE 802.3 point-to-point full-duplex MACs are used.

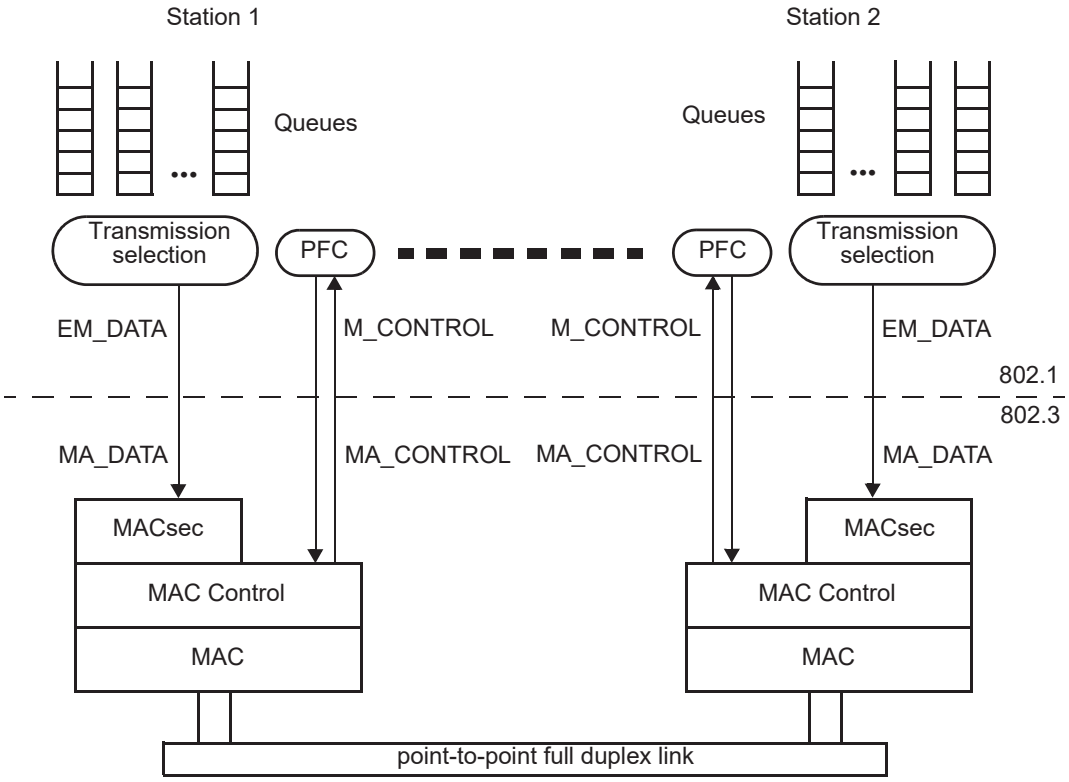


Figure 36-1—PFC peering

PFC allows link flow control to be performed on a per-priority basis. In particular, PFC is used to inhibit transmission of data frames associated with one or more priorities for a specified period of time. PFC can be enabled for some priorities on the link and disabled for others.

Given that BPDUs, for example, are sent untagged and can bypass the output queues, it is strongly recommended for the default priority of a port to not have PFC enabled.

NOTE—The LLC-SAP of a Bridge Port can host a management protocol stack that uses PFC-enabled priorities, and these management frames can bypass the output queues. In this situation PFC can fail to provide insurance against these frames overflowing the buffer in the remote station of the link.

36.1.2 PFC primitives

PFC is invoked through the M_CONTROL PFC primitives (11.4 of IEEE Std 802.1AC-2016 [B8]). A system client wishing to inhibit transmission of data frames on certain priorities from the remote system on the link generates an M_CONTROL.request primitive specifying the following:

a) The globally assigned 48-bit multicast address 01-80-C2-00-00-01.
b) The PFC opcode (i.e., 01-01).
c) A request_operand_list with two operands indicating, respectively, the set of priorities addressed and the lengths of time for which it wishes to inhibit data frame transmission of the corresponding priorities.

NOTE—By definition, a point-to-point full-duplex link comprises exactly two stations, thus there is no ambiguity regarding the destination station's identity. The use of a well-known multicast address does not require a station to know, and maintain knowledge of, the individual 48-bit address of the other station.

As specified in IEEE Std 802.3, when PFC is enabled on a port for at least one priority over an IEEE 802.3 link layer, the IEEE Std 802.3 PAUSE mechanism is not used for that port.

As a result of the processing of the PFC M_CONTROL.request, the peering PFC station receives a PFC M_CONTROL.indication primitive.

The parameters of the PFC M_CONTROL.indication are as follows:

d) The PFC opcode (i.e., 01-01).
e) A indication_operand_list with two operands indicating, respectively, the set of priorities addressed and the lengths of time for which data frame transmission of the corresponding priorities has to be inhibited.

The request_operand_list of a PFC M_CONTROL.request and the indication_operand_list of a PFC M_CONTROL.indication are composed of the following operands:

f) priority_enable_vector: a 2-octet field, with the most significant octet being reserved (i.e., set to zero on transmission and ignored on receipt). Each bit of the least significant octet indicates if the corresponding field in the time_vector parameter is valid. The bits of the least significant octet are named e[0] (the LSB) to e[7] (the MSB). Bit e[n] refers to priority n. For each e[n] bit set to one, the corresponding time[n] value is valid. For each e[n] bit set to zero, the corresponding time[n] value is invalid.
g) time_vector: a list of eight 2-octet fields, named time[0] to time[7]. The eight time[n] values are always present regardless of the value of the corresponding e[n] bit. Each time[n] field is a 2-octet, unsigned integer containing the length of time for which the receiving station is requested to inhibit transmission of data frames associated with priority n. The field is transmitted most significant octet first, and least significant octet second. The time[n] fields are transmitted sequentially, with time[0] transmitted first and time[7] transmitted last. Each time[n] value is measured in units of pause_quanta, equal to the time required to transmit 512 bits of a frame at the data rate of the MAC. Each time[n] field can assume a value in the range of 0 to 65 535 pause_quanta.

36.1.3 Detailed specification of PFC operation

36.1.3.1 Processing PFC M_CONTROL.requests

Invoking the PFC M_CONTROL.request results in the invocation of the appropriate link layer service request. For IEEE 802.3 link layers the PFC M_CONTROL.request is mapped to a PFC MA_CONTROL.request (IEEE Std 802.1AC). If PFC is not enabled for priority n, then PFC requests with e[n] set to one and time[n] different than zero (see 36.1.2) should not be generated.

NOTE—In the IEEE 802.1Q architecture frames coming from the LLC, including BPDUs, bypass the priority queues and therefore are not subject to PFC. However, in some implementations frames coming from the LLC can pass through the priority queues. In this case, it is not recommended to enable PFC for the priority to which BPDUs are assigned (usually priority 7).

36.1.3.2 Processing PFC M_CONTROL.indications

The PFC Receiver entity (see 36.2.2) maintains and makes available to Transmission Selection the vector of the Priority_Paused[n] variables, indicating the state of each of the eight priorities. Each Priority_Paused[n] variable is a boolean. When Priority_Paused[n] is FALSE, priority n is not in paused state. When Priority_Paused[n] is TRUE, priority n is in paused state.

Figure 36-2 shows the PFC state diagram for priority n. If PFC is not enabled for priority n, then the PFC state diagram does not apply to priority n and Priority_Paused[n] is FALSE.

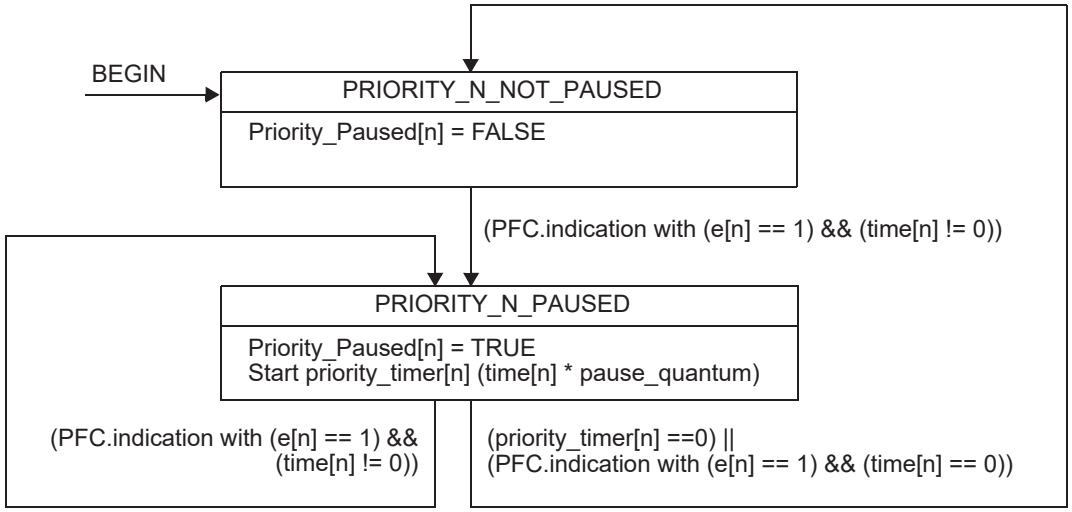


Figure 36-2—PFC Receiver state diagram for priority n

Upon receipt of a PFC M_CONTROL.indication, the PFC Receiver programs up to eight separate timers, each associated with a different priority, depending on the priority_enable_vector. For each bit in the priority_enable_vector that is set to one, the corresponding timer value is set to the corresponding time value in the time_vector parameter. Priority_Paused[n] is set to TRUE when the corresponding timer value (i.e., priority_timer[n]) is nonzero. Priority_Paused[n] is set to FALSE when the corresponding timer value (i.e., priority_timer[n]) counts down to zero. A time value of zero in the time_vector parameter has the same effect as the timer having counted down to zero. If PFC is not enabled for priority n and a PFC indication is received with e[n] set to one, then the time[n] parameter is ignored (i.e., the primitive is processed as if e[n] was set to zero).

NOTE—A priority_enable_vector with all bits set to zero is legal and equivalent to a no-op.

36.1.3.3 Timing considerations

For effective flow control on a point-to-point full-duplex link, it is necessary to place an upper bound on the length of time that a device can transmit data frames after receiving a PFC M_CONTROL.indication with e[n] set to one in the priority_enable_vector and a nonzero time[n] in the time_vector operands.

If MACsec is not supported, a queue shall go into paused state in no more than 614.4 ns since the reception of a PFC M_CONTROL.indication that paused that priority. This delay is equivalent to 12 pause quanta (i.e., 6144 bit times) at the speed of 10 Gb/s, 48 pause quanta (i.e., 24 576 bit times) at the speed of 40 Gb/s, and 120 pause quanta (i.e., 61 440 bit times) at the speed of 100 Gb/s.

If MACsec is used, a queue shall go into paused state in no more than 614.4 ns + 'SecY transmit delay' (see IEEE Std 802.1AE) since the reception of a PFC M_CONTROL.indication that paused that priority. The 'SecY transmit delay' is defined as the wire transmit time for a maximum sized MPDU + 4 times the wire transmit time for 64 octet MPDUs. For a 2000-byte frame the 'SecY transmit delay' is $8 \times (2000 + 20) + 8 \times 4 \times (64 + 12 + 4 + 20) = 19\,360$ bit times.

NOTE 1—19 360 bit times is an appropriate value for 'SecY transmit delay' for speeds up to 10 Gb/s. Support for the speeds of 40 Gb/s and 100 Gb/s can require a higher value.

If MACsec is supported but not used, the delay computation has to take into account the MACsec Bypass Capability (MBC) bit in the PFC configuration TLV of DCBX (D.2.10), that indicates if the link peer needs the extra time for MACsec. If the MBC bit is set to zero, the maximum PFC delay is 614.4 ns. If the MBC bit is set to one, the maximum PFC delay is 614.4 ns + 'SecY transmit delay'.

NOTE 2—In addition to the above delays, system designers should take into account the delay of the PHY and of the link segment when designing devices that implement the PFC operation to ensure frames are not lost due to congestion (see Annex O for additional discussion on this topic).

36.2 PFC-aware system queue functions

Figure 36-3 illustrates the architecture of the queue functions of a PFC-aware system when Link Aggregation is not used. These functions offer a service to higher layers that utilizes a single instance of the ISS or EISS to connect to the lower layers. In Figure 36-3, two major blocks are outlined with dotted boundaries:

a) The PFC Initiator block, in the right of Figure 36-3 (see 36.2.1)
b) The outbound queue block, in the left of Figure 36-3 (see Figure 22-2)

The remaining entities illustrated in Figure 36-3, other than the PFC Receiver entity, are part of the IEEE 802.1 architecture and are not further discussed here.

36.2.1 PFC Initiator

The PFC Initiator entity generates M_CONTROL PFC requests using the M_CONTROL.request primitive (see 36.1.3.1) when appropriate (e.g., when an input buffer reaches a certain threshold).

36.2.2 PFC Receiver

The PFC Receiver entity processes the M_CONTROL.indication primitives as specified in 36.1.3.2. In addition, the PFC Receiver maintains and makes available to Transmission Selection the vector of the Priority_Paused[n] variables, indicating the state of each of the eight priorities.

The PFC Receiver entity acts per physical port. When Transmission Selection is running above Link Aggregation, each PFC Receiver entity processes the M_CONTROL.indication primitives as specified in 36.1.3.2, and maintains and makes available to Transmission Selection the vector of the Priority_Paused[n]

variables, indicating the state of each of the eight priorities of that physical link, as shown in Figure 36-4.

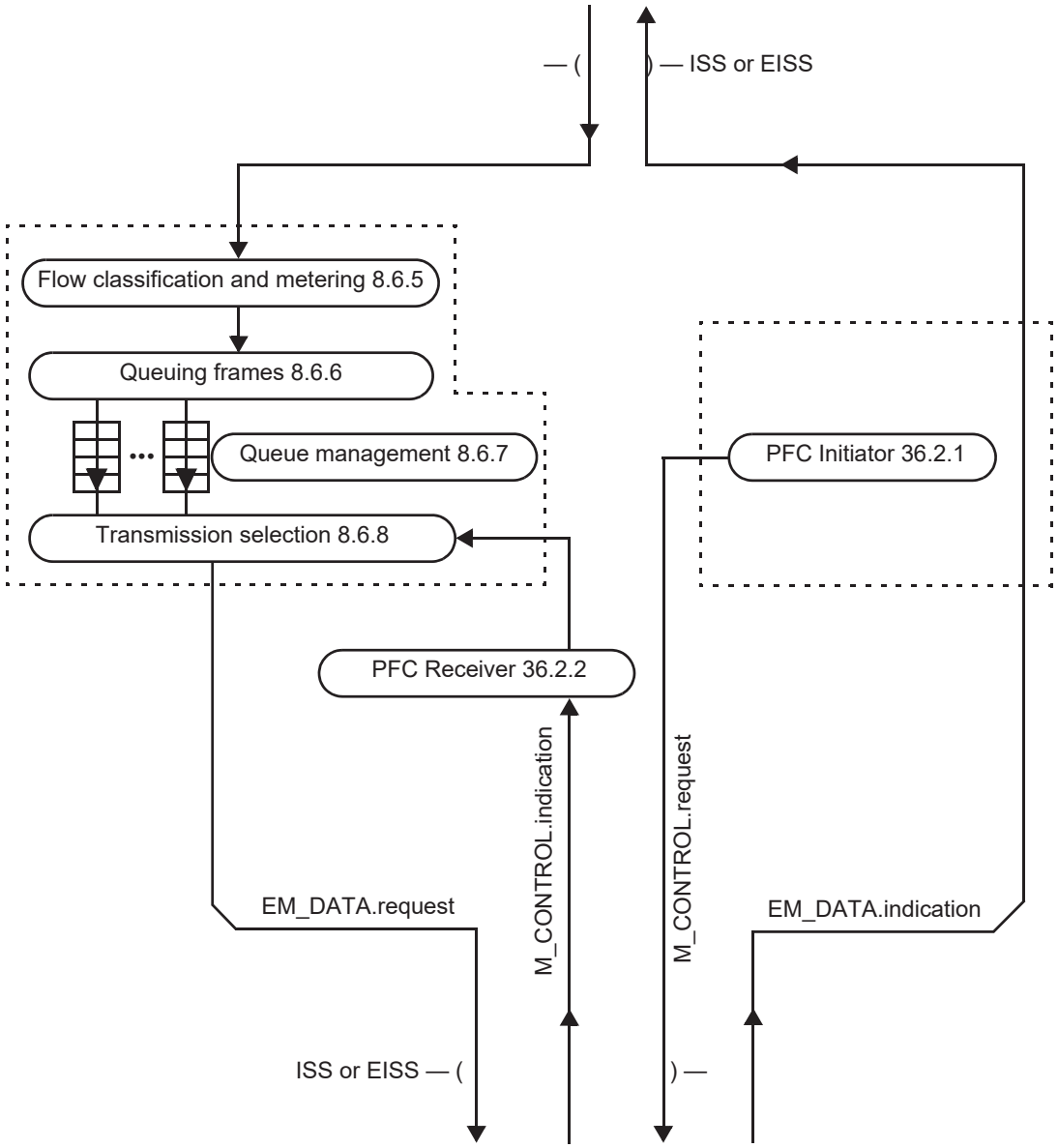


Figure 36-3—PFC-aware system queue functions

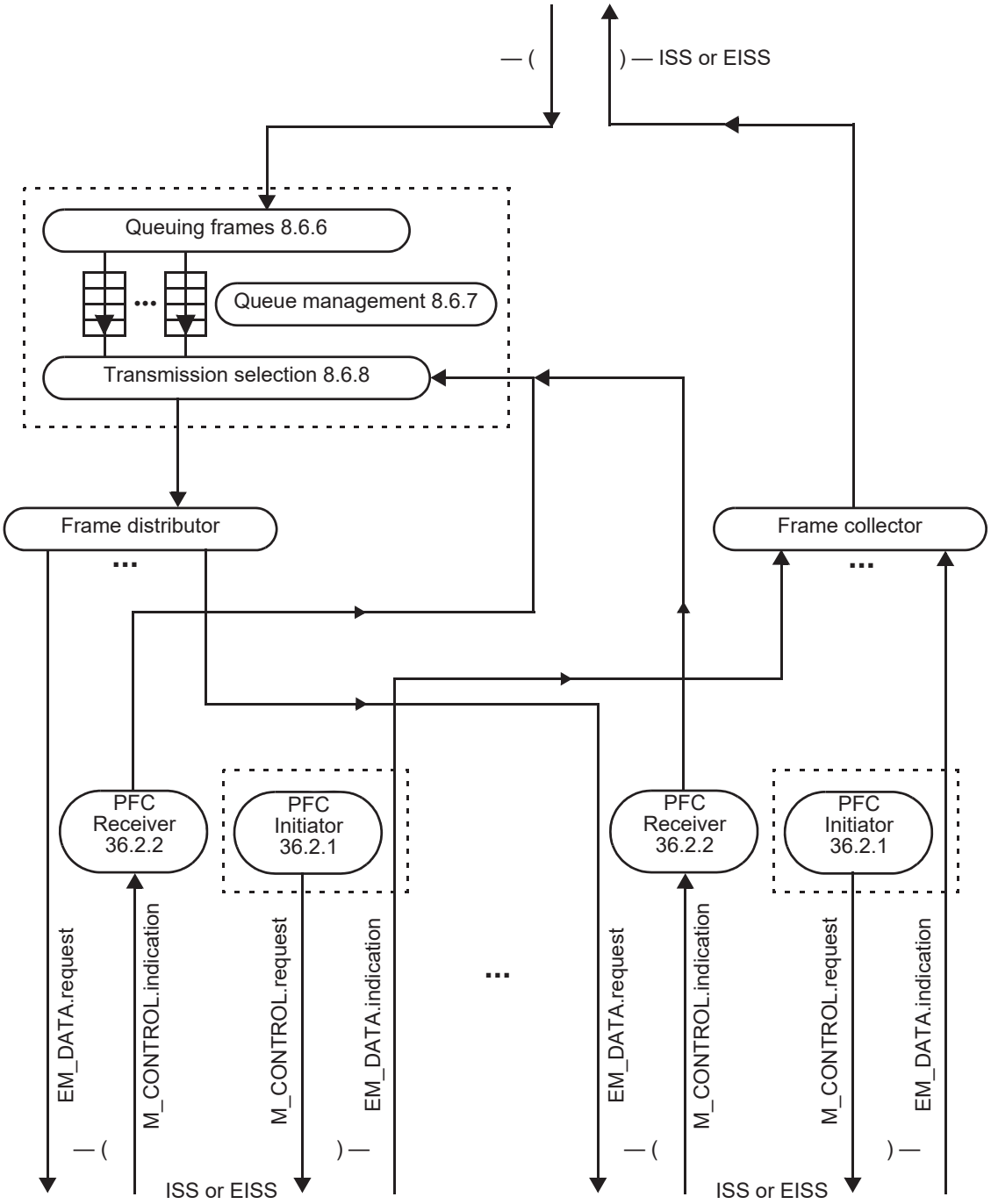


Figure 36-4—PFC-aware system queue functions with Link Aggregation

37. Enhanced Transmission Selection (ETS)

37.1 Overview

This clause provides definitions and an operational model for priority processing and bandwidth allocation in end stations and Bridges in a Data Center Bridging (DCB) environment. Using Priority-based processing and bandwidth allocations, different traffic classes with different types of traffic such as LAN, Storage Networking, Clustering, and management can be configured to provide bandwidth allocation, or best effort transmit characteristics.

In order to accomplish this, the following are provided:

a) A set of bandwidth configuration parameters that are used to configure the percentage of bandwidth assigned to each traffic class.
b) A set of characteristics that an ETS enabled transmitter is required to follow.
c) A means of communicating priority-to-traffic class allocations to neighboring systems (DCBX; see Clause 38).

37.1.1 Relationship to other transmission selection algorithms

If ETS is used in conjunction with the strict priority and credit-based shaper algorithms, then attention should be paid to assignment of traffic classes as specified in 34.5.

37.2 ETS configuration parameters

The following ETS configuration parameters exist for each ETS enabled port:

a) *numTrafficClassesSupported*: Indicates the number of traffic classes supported by a port. This value has a minimum of 3 (see 37.3) and a maximum of 8.
b) *TCPriorityAssignment(P)*: For each supported priority, P, the traffic class to which that priority P is assigned (see 37.1.1). A traffic class only operates with the ETS algorithm if it is assigned to do so by the Transmission Selection Algorithm Table (see 8.6.8); i.e., the entry in the table for that traffic class is assigned the value 2 (see Table 8-6).
c) *TCBandwidth(N)*: For each traffic class N, the percentage of the available bandwidth assigned to that traffic class. The total for all traffic classes is equal to 100% (see 37.3).

Configuration of ETS parameters shall be done via DCBX (see Clause 38).

37.3 ETS algorithm

The ETS algorithm provides allocation of bandwidth to traffic classes. The algorithm allows bandwidth intensive and loss sensitive traffic to share the network while allowing coexistence with low latency traffic using the strict priority and credit-based shaper algorithms. Since there are a number of variants of bandwidth sharing algorithms (such as weighted round robin) that provide appropriate bandwidth sharing, a detailed algorithm is not specified. Any algorithm is allowed as long as it meets the specified performance requirements.

NOTE 1—The ETS algorithm is used to determine when an ETS traffic class has a frame available to transmit. The determination of which frame in the traffic class to send can be done in an implementation specific manner, subject to the ordering requirements in 8.6.6.

For the purposes of the ETS algorithm, Available Bandwidth is defined as the link bandwidth remaining after traffic classes not assigned to Transmission selection algorithm 2, and Vendor Specific (see Table 8-6)

are serviced. The effect of Vendor Specific algorithms to Available Bandwidth is outside the scope of this standard.

The ETS algorithm shall provide the ability to configure traffic classes to share bandwidth according to the following:

a) Allow one or more priorities to be assigned to a traffic class.

   NOTE 2—All priorities within a traffic class typically share similar traffic handling requirements (e.g., loss and bandwidth).

b) Allow bandwidth to be configured for each traffic class with a granularity of 1%. The configured bandwidth indicates the percentage of Available Bandwidth that can be used by the traffic class when all other traffic classes are consuming their configured bandwidth.

c) For traffic classes for which the transmission selection algorithm is ETS (i.e., Transmission selection algorithm 2 in Table 8-6), select frames for transmission from the traffic class queues such that the bandwidth consumed by the traffic class approaches its percentage of Available Bandwidth. The traffic class consumes less than its percentage of Available Bandwidth when the offered load for that traffic class is less than its percentage of Available Bandwidth, in that case the remainder of its percentage of Available Bandwidth can be used by other traffic classes. A traffic class can consume more than its percentage of Available Bandwidth when the offered load of other traffic classes results in those traffic classes consuming less than their percentage of Available Bandwidth. Allocation of any excess Available Bandwidth is implementation specific.

d) When all traffic classes are offered enough load to consume their share of available bandwidth, and there is no offered load in the traffic classes using transmission selection algorithms other than ETS, the bandwidth received from an ETS traffic class shall deviate from its allocation by no more than 10% of the available bandwidth when measured over a period of 10 000 000 bit times using maximum sized frames during a time period when no PFC frames are received (i.e., no congestion).

   NOTE 3—The measurement window is derived from an approximate number of bits in 500 frames (i.e., 500 frames × 2000 bytes per frame × 8 bits per byte rounded up to 10 000 000).

   NOTE 4—Allowed deviation of ± 10% allows for variations of traffic (e.g., burstiness) over the specified measurement window and provides balance between precision and implementation flexibility.

e) At least 3 traffic classes shall be supported per port. A minimum of 3 traffic classes allows a minimum configuration such that one ETS traffic class contains priorities that have PFC enabled, one ETS traffic class contains priorities that have PFC disabled, and one traffic class using strict priority.

37.4 Legacy configuration

Subclause 8.6.8 specifies strict priority scheduling as default behavior. This can be achieved by configuring the Transmission selection algorithm value for a traffic class to 0 (see Table 8-6).

Subclause 8.6.6 specifies the default priority to traffic class mapping. There is no change to such mapping when ETS is used.

38. Data Center Bridging eXchange protocol (DCBX)

38.1 Overview

This clause details the DCBX, which is used by DCB devices to exchange configuration information with directly connected peers. The protocol may also be used for misconfiguration detection and for configuration of the peer.

This standard describes the base protocol, which comprises state machines and TLVs for capability exchange. For each feature that is supported by DCBX, the attributes that are to be exchanged specify the following:

a) The attributes to be exchanged
b) How the attributes are used for detecting misconfiguration
c) What action needs to be taken when a misconfiguration is detected

The information listed above is specified for the following:

d) ETS
e) PFC
f) Application Priority TLV
g) Application VLAN TLV

38.2 Goals

The goals of DCBX are as follows:

a) Discovery of DCB capability in a peer port; for example, it can be used to determine if two link peer ports support PFC.
b) DCB feature misconfiguration detection: DCBX can be used to detect misconfiguration of a feature between the peers on a link. Misconfiguration detection is feature-specific because some features allow asymmetric configuration.
c) Peer configuration of DCB features: DCBX can be used by a device to perform configuration of DCB features in its peer port if the peer port is willing to accept configuration.

38.3 Types of DCBX attributes

Three types of DCBX attributes are exchanged:

a) Informational attributes (see 38.3.1)
b) Asymmetric attributes (see 38.4.1)
c) Symmetric attributes (see 38.4.2)

38.3.1 Informational attributes

Informational attributes are exchanged via LLDP without any participation in a DCBX state machine.

38.4 DCBX and LLDP

DCBX uses Link Layer Discovery Protocol (LLDP) (see IEEE Std 802.1AB) to exchange attributes between two link peers. LLDP is a unidirectional protocol. It advertises connectivity and management information about the local station to adjacent stations on the same IEEE 802 LAN.

DCB exchanged attributes are packaged into Organizationally Specific TLVs. The OUI used for the DCBX TLV is the IEEE 802.1 OUI (i.e, 00-80-C2).

DCBX state machine transitions are based on the DCBX objects in the LLDP MIB module. Operation of the DCBX state machine may affect the values of the DCBX objects in the LLDP MIB module.

A port capable of any DCB feature shall have the capability for DCBX to be administratively disabled. The default state for DCBX is enabled.

DCBX is expected to operate over a point-to-point link. If multiple LLDP peer ports running DCBX are detected, then DCBX should behave as if the peer port's DCBX TLVs are not present until the multiple LLDP peer port condition is no longer present. However, a transition in LLDP peer port may occur in some circumstances (e.g., such as a transition from system boot to system operation). Therefore, when it is detected that the number of peer ports running DCBX exceeds 1 for a period longer than the longest TTL of any of the peers, a multi-peer condition is detected. During the time when the multi-peer condition has not been detected the DCBX data from the most recent DCBX peer shall be used. An LLDP peer port is identified by a concatenation of the chassis ID and port ID values transmitted in the LLDPDU. A DCBX peer port is a LLDP peer port that is sending DCBX TLVs.

DCBX defines two different types of attribute passing mechanisms:

a) Asymmetric: the passing of a attribute from one port to its peer port. In this case, the desired configuration for the peer may not match the local configuration.
b) Symmetric: the passing of a attribute from one port to its peer port with objective of both ports utilizing the same attribute value.

38.4.1 Asymmetric attribute passing

38.4.1.1 Overview

Two types of TLV are passed for Asymmetric attribute Passing:

a) Configuration TLV: Provides current operational state and Willing bit. The received Willing bit is not used by the state machine, but instead provided to higher layers to provide an indication of the expected behavior of the remote port. The presence of the willing bit set to 1 indicates to the remote port that the local port is willing to accept a configuration for the specific attribute for which the willing bit is set.
b) Recommendation TLV: Provides recommendation for the operational state of remote port. Transmitted only if the local port is configured to make recommendations in which case it is transmitted in all LLDPDUs. Transmitted regardless of the "willingness" of the remote port.

NOTE—An implementation is allowed to send a recommendation TLV or a configuration TLV or both.

38.4.1.2 Asymmetric state variables

LocalWilling: Indicates that the local port has been administratively configured to accept recommendations. This value is included in the Willing bit of Configuration TLVs transmitted by this port. A local port may be configured as not Willing.

OperParam: The current operational value of the attribute on the local port. This value is included as the attribute in the Configuration TLVs.

LocalAdminParam: The administratively configured value for the attribute. This becomes the operational value of the attribute by default, and the operational value may be overridden if the local port accepts a recommendation from the remote port.

RemoteParam: The attribute received in the last Recommendation TLV. This variable is set to NULL if the remote LLDP database contains no Recommendation TLV.

DCBXMapping: A function that maps the received parameters to the capabilities of the receiving port.

38.4.1.3 Asymmetric state machine

The Asymmetric state machine is depicted in Figure 38-1.

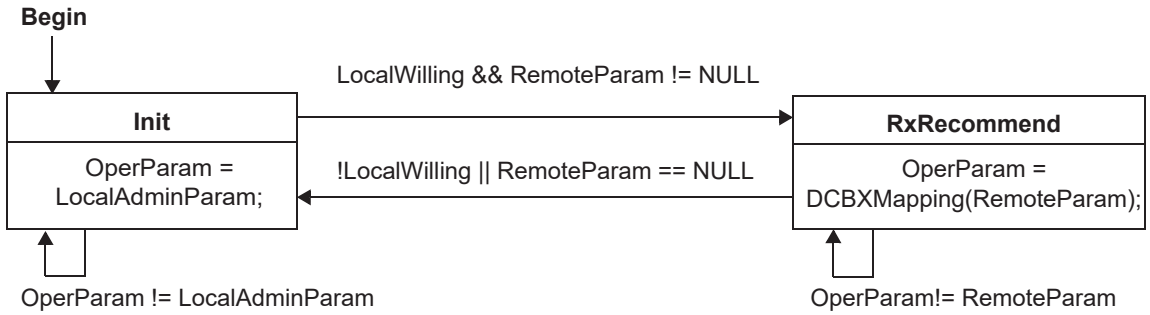


Figure 38-1—DCBX Asymmetric state machine

38.4.2 Symmetric attribute passing

38.4.2.1 Overview

For Symmetric attribute passing one type of TLV is used:

a) Configuration TLV. This TLV always carries the current local operational state and a Willing (W) bit.

A port that sets the W bit is considered Willing. A Willing port shall set its operational attribute to that indicated in the received TLV if the received TLV has the W bit set to zero. If both the local port and remote port are willing, then the attribute values of the port with the lower numerical MAC address shall take precedence.

38.4.2.2 Symmetric state variables

LocalWilling: Indicates that the local port has been administratively configured to accept the attribute from the remote port. This value is included in the Willing bit of DCBX TLVs transmitted by this port.

RemoteWilling: rwTrue indicates that the Willing bit was set in the last TLV received. rwFalse indicates that the Willing bit was not set in the last TLV received. This variable is set to rwNull if the remote LLDP database contains no Willing bit.

LocalMAC: The MAC address of the local port.

RemoteMAC: The MAC address of the remote port.

OperParam: The current operational value of the attribute on the local port. This value is included as the attribute in the DCBX TLV.

RemoteParam: Contains the value of the last attribute (i.e., the operational value of the remote port) received in the TLV. This variable is set to NULL if the remote LLDP database contains no TLV.

LocalAdminParam: The administratively configured value for the attribute. This becomes the operational value of the attribute by default, and may be overridden if the local port accepts the attribute from the remote port.

DCBXMapping: A function that maps the received parameters to the capabilities of the receiving port.

38.4.2.3 Symmetric state machine

The Symmetric state machine is depicted in Figure 38-2.

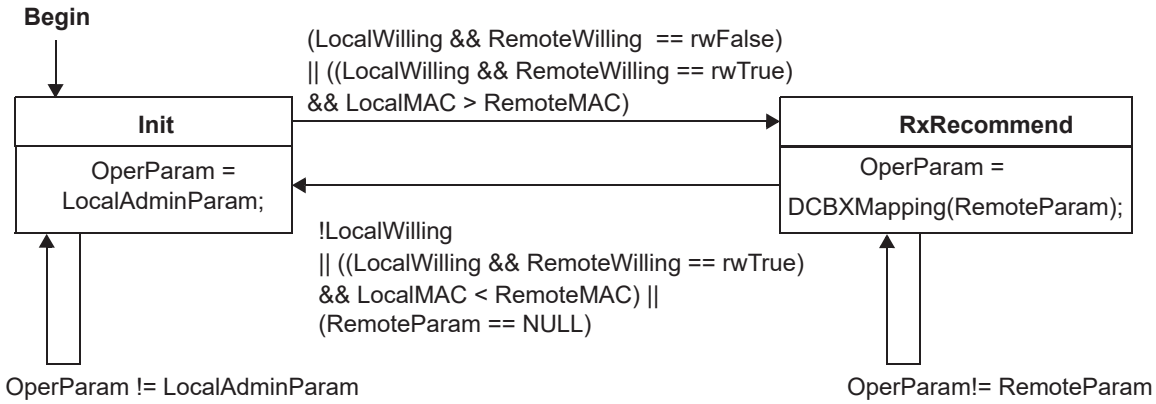


Figure 38-2—Symmetric state machine

NOTE—Through observation of the states and state variables it is possible to determine that the state machine is in the process of passing attributes. This knowledge may be useful for clients of DCBX. For example, a client may wish to delay use of the link while the DCBX state machine is in the process of passing and possibly setting attributes. A "Pending" indication indicating that the state machine is in this process may be created by the following equations:

```
Pending = RemoteParam == NULL
|| !LocalWilling && RemoteWilling == rwTrue && OperParam != RemoteParam;
```

39. Multiple I-SID Registration Protocol (MIRP)

MIRP defines an MRP application (10.1) that provides the ability to flush learned MAC Address Entries held in the FDB of an I-component on a per-I-SID basis. MIRP makes use of MRP Attribute Declaration (MAD) and MRP Attribute Propagation (MAP), which provide the common state machine descriptions and the common attribute propagation mechanisms defined for use in MRP-based applications. The MRP architecture, MAD, and MAP are defined in Clause 10.

In a PBBN, the assignment of S-VIDs and I-SIDs to VIPs is often fixed, and the overhead of signaling the creation of Dynamic VLAN Registration Entries among I-components is undesirable. It can nevertheless be necessary to signal the need to flush the I-components' FDBs of learned MAC address information. For example, one could configure a point-to-point service that is dual-homed (has two I-components) at each end of the service, only two of which (one at each end) are active at any one time. A failure that causes one I-component to take over from the other requires that the active I-component at the other end of the service forget its associations of C-MAC addresses to the failed I-component's B-MAC address. Therefore, the MIRP application supports the Registration Fixed (New propagated), instead of the Registration Fixed (New ignored), value in the Registrar Administrative Controls.

The function of MIRP can be performed by MVRP. However, in an I-component with one S-VID per VIP requires 4094 MVRPDUs, one for each VIP, to signal a simultaneous topology change on all 4094 S-VIDs, whereas it can signal those same topology changes with a single Multiple I-SID Registration Protocol Data Unit (MIRPDU) through the PIP.

39.1 MIRP overview

MIRP is an extension of MVRP (11.2) for use in I-components and B-components. The extensions in both I-components and B-components are as follows:

a) The attribute values carried by the MIRPDUs are 24-bit I-SID values, rather than 12-bit VIDs in an MVRPDU.
b) A MIRP Participant can only be a New-Only Participant (10.6), so the Registrar Administrative Controls can take only the value, Registration Fixed (New propagated).
c) MIRP uses the Nearest Customer Bridge group address (Table 8-1) or the Default Backbone Destination from the CBP's Backbone Service Instance table (6.11) instead of an MRP Application address from Table 10-1, so a Provider Bridge forwards frames containing MIRPDUs normally, while a Customer Bridge filters them.

In an I-component only, the extensions are as follows:

d) A VIP in an I-component can be attached to an MVRP Participant or to a MIRP Participant, but not to both.
e) An MVRP to MIRP attributes translation function (39.2.1.1) enables interoperation between the MVRP and MIRP Participants in the I-component.
f) There is only one MIRP Participant and one instance of the MIRP application per PIP.

In a B-component only, the extensions are as follows:

g) MIRP Participants are placed on zero or more CBPs, and on at most one non-CBP Port in the B-component.
h) MAP (10.3) operates among MIRP MAD components only, using 24-bit MIRP I-SID values.

Figure 39-1 illustrates the architecture of MVRP and MIRP in an I-component. The arrows showing the relationship between the MVRP or MIRP applications and the FDB in the MAC Relay Entity have been omitted from Figure 39-1, but these relationships are the same as those shown in Figure 11-1.

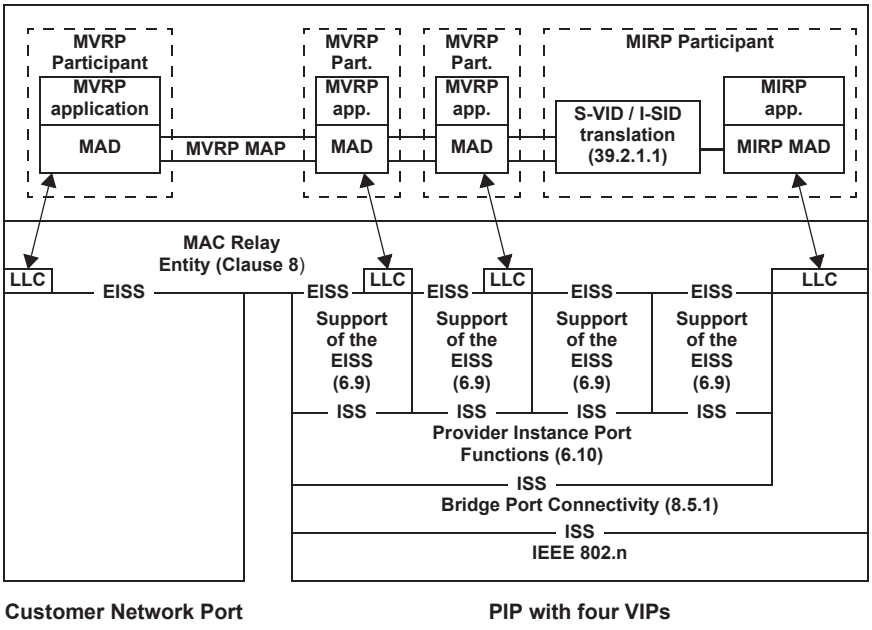


Figure 39-1—Operation of MIRP in an I-component

The architecture of MIRP in a B-component is illustrated in Figure 39-2. One management Port and one CBP are shown, although any number of CBPs can be supported. (See 39.2.2 for an alternate model.)

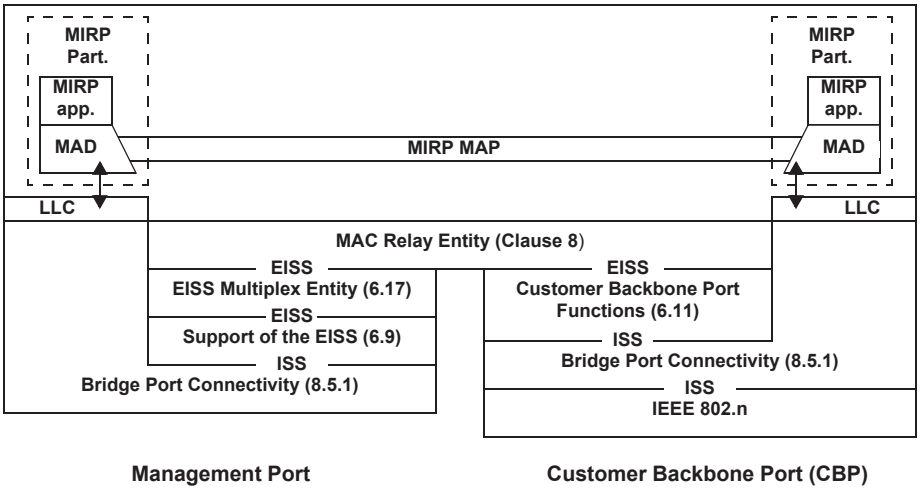


Figure 39-2—Operation of MIRP in a B-component

39.1.1 Behavior of I-components

Since PBBs are insulated from C-MAC addresses by the I-TAG, MVRP Participants in I-components are peers of MVRP Participants in other I-components, and not with MVRP Participants attached to PNPs in B-components or BCBs. In the case that an I-component is configured for some number of VIPs, each serving some number of VLANs, a single MIRPDU transmitted or received over the PIP takes the place of the individual MVRPDUs that would otherwise be transmitted or received over those VIPs.

An I-component supporting MIRP shall:

a) Implement the MIRP application as indicated in 39.2;
b) Implement an MVRP/MIRP attributes translation function as indicated in 39.2.1.1; and
c) Support operation only as an MRP New-Only Participant (10.6).

39.1.2 Behavior of B-components

As illustrated in Figure 39-2, there are any number of MIRP Participants in a B-component, each on a CBP, and each containing an instance of the MIRP application and a MIRP MAD, with the MADs interacting via MAP. In addition, at most one MIRP Participant is attached to a Port that is not a CBP. This port can be a PNP, or a Management Port with no attachment to an external LAN. The latter case is shown in Figure 39-2.

A B-component supporting MIRP shall:

a) Implement the MIRP application as indicated in 39.2; and
b) Support operation as an MRP New-Only Participant (10.6).

39.2 Definition of the MIRP application

39.2.1 Definition of MRP elements

39.2.1.1 S-VID and I-SID mapping in an I-Component

MVRP MAP (11.2.1, 10.3) propagates information among the MVRP MADs and the MIRP MAD. But, since MVRP MADs support 12-bit VID values, and the MIRP MAD supports 24-bit I-SID values, a translation function is required to map the VIP-ISID to or from S-VIDs statically configured on the VIP.

c) When a “new” MIRP declaration is received on a given VIP as a result of receiving an MIRPDU from the attached LAN (MAD_Join.indication), the MAD_Join.request with the *new* parameter set that is generated by the MIRP MAD is translated to a MAD_Join.request for each S-VLAN with a Static VLAN Registration Entry of Registration Fixed (New propagated) on that VIP. When any MIRP declaration with the *new* parameter is received on a given VIP as a result of a request from MAP (MAD_Join.request) for any S-VLAN with a Static VLAN Registration Entry of Registration Fixed (New propagated) on that VIP, it is translated to a MAD_Join.request for that VIP’s I-SID with the *new* parameter set. All other requests are discarded.

NOTE—If many S-VLANs are configured per VIP, then using an MVRP New-Only Participant (11.2.6) offers more detailed control of MAC address flushing than does MIRP, at some cost in bandwidth and processing effort.

39.2.1.2 I-SID translation in a B-component

If a Backbone Service Instance table (6.11) on a CBP implements the Local Service Instance Identifier (Local-SID) field, the attribute values encoded in MIRPDUs by the MIRP Participants in CBPs shall be Local-SID values. The attribute values transferred by MAP in the B-component and encoded in MIRPDUs by the MIRP Participant on a non-CBP Port shall be Backbone-SID values.

39.2.1.3 MAP Context for MIRP

The MIRP MAP Context identifies the set of Ports that form the applicable topology for the propagation of the MIRPDUs among the MIRP Participants. Within a single I-component, the MIRP Participants on PIPs behave as independent end stations from an I-SID registration perspective and correspondingly there is no further propagation of the MIRPDUs. As described in 39.2.1.1, the S-VID/I-SID translation function allows the MIRP MADs to communicate with MVRP MADs. Thus, New messages can propagate throughout a concatenated network of PBNs (via MVRP) and PBBNs (via MIRP).

Within a single B-component, there may be multiple MIRP MAP Contexts. The reason for having separate MIRP MAP Contexts is to collect and distribute MIRP information bound for or received from MIRPDUs that use different combinations of B-VIDs and MAC addresses, as chosen by the network administrator via managed objects (12.16.1). A Port in a B-component supporting a MIRP Participant, either an administratively chosen PNP or Management Port, or a CBP, can participate in more than one MIRP Context. The Ports of a B-component comprising a given MIRP Context is a PNP or Management Port, plus the set of CBPs on the B-component for which the following are true:

a) The CBP is in the Member set (8.8.9) for the B-VID.
b) If the MIPRDU destination_address for the CBP is the Default Backbone Destination address, the FDB does not filter that B-VID and MAC address on the Port.

In a B-component, the parameters controlling MIRPDU addressing (39.2.1.6) control the number of MIRP MAP Contexts as follows:

c) If a single destination_address and B-VID are used for all MIRPDUs [item a) in 39.2.1.6] then there is a single MIRP MAP Context.
d) If the Nearest Customer Bridge group address (Table 8-1) used with a B-VID from a Backbone Service Instance table [item b) in 39.2.1.6], then there is a separate MIRP MAP Context for each B-VID that appears in the CBP Backbone Service Instance table (6.11) of any CBP with a configured MIRP Participant.
e) If the Default Backbone Destination option for the MIRPDU destination_address is used [item c) in 39.2.1.6], then there is a separate MIRP MAP Context for each combination of Default Backbone Destination and B-VID in the CBP Backbone Service Instance table (6.11) of any CBP with a configured MIRP Participant.

The MIRP Participant on a CBP propagates information for a particular I-SID between the CBP MIRP MAD and the appropriate MIRP MAP Context, as determined by the CBP's Backbone Service Instance table and the addressing selection parameters (39.2.1.6). Thus, a CBP MIRP MAD may exchange requests and indications with multiple MIRP MAP Contexts.

NOTE 1—MIRPDUs cannot pass through the CBP functions (6.11) because they have no I-TAG. Readers can see from Figure 39-2 and Figure 39-3 that this isolates the MIRPDUs exchanged among PNPs, Management Ports (and CBPs in Figure 39-3) over the backbone from the MIRPDUs exchanged over the various I-component–to–CBP links.

NOTE 2—See 39.2.2 for an alternate model for MIRP operation in a B-component and the MIRP MAP Context.

39.2.1.4 MAP Context identification for MIRP

In an I-component, there is only one MAP Context.

In a B-component, the vlan_identifier and destination_address of an MIRPDU received on a PNP or Management Port serve to identify the MIRP MAP Context as defined in 39.2.1.3. In a CBP, the MIRP MAP Context used to propagate information is determined by CBP Backbone Service Instance table (6.11) entry for each I-SID value propagated. An MIRPDU that corresponds to no MAP Context configured on the receiving B-component is discarded.

39.2.1.5 MIRP application addressing in an I-component

The source MAC address for an MIRPDU is the MAC address of the PIP.

The destination MAC address for an MIRPDU transmitted from a PIP shall be the Nearest Customer Bridge group address, (01-80-C2-00-00-00, see Table 8-1).

MIRPDUs transmitted and received on a PIP carry no VLAN tag and have no vlan_identifier.

NOTE—An MIRPDU transmitted by a PIP needs no B-TAG because it is connected to a CBP (see Figure 25-4) that either has an MIRP Participant to receive the untagged MIRPDU, or if not, discards the MIRPDU (39.2.1.3).

39.2.1.6 MIRP application addressing in a B-component

The source MAC address for an MIRPDU is the MAC address of the Port from which it is transmitted.

For a MIRP Participant attached to a CBP, the destination MAC address for an MIRPDU transmitted shall be the Nearest Customer Bridge group address, (01-80-C2-00-00-00, see Table 8-1). MIRPDUs shall be transmitted from a CBP without a VLAN tag.

For the MIRP Participant attached to a PNP or Management Port, there are three choices, selectable via managed variables [see item k) in 12.16.1.1.3], for the destination MAC address and B-VLAN on transmitted MIRPDUs:

a) The destination_address is the Nearest Customer Bridge group address (Table 8-1), and the vlan_identifier is the MIRP B-VID [item c) in 12.16.1.2.2].
b) The destination_address is the Nearest Customer Bridge group address (Table 8-1), and the vlan_identifier is a B-VID from the CBPs' Backbone Service Instance tables (6.11).
c) The destination_address is a Default Backbone Destination from the CBPs' Backbone Service Instance tables (6.11), and the vlan_identifier is a B-VID from those tables.

In case b) or case c), it is possible that different CBPs in the serving I-SIDs in the same MIRP MAP Context (39.2.1.3) can be configured differently. For each I-SID value's message in the MIRPDU, the MIRP Participant on the PNP or Management Port uses the Backbone Service Instance table from the CBP with the lowest numerical Port Number to determine the {destination_address, vlan_identifier} pair to use for that I-SID value.

A separate MIRPDU is transmitted for each separate MIRP MAP Context. If multiple {destination_address, vlan_identifier} pairs are generated by different I-SIDs within a single MIRP MAP Context, then the MIRP Participant shall transmit at least one MIRPDU for each distinct pair.

NOTE 1—The network administrator can use the destination_address and vlan_identifier configuration choice to optimize either for the fewest transmitted MIRPDUs by using case a), for the fewest unnecessarily addressed I-components by using case c), or for a balance of these two conflicting optimizations by using b).

NOTE 2—If different B-components in a single PBBN are configured differently for MIRP application addressing, then MIRPDUs can be lost or misinterpreted, because the different B-components can classify MIRPDUs in different MAP Contexts.

NOTE 3—See 39.2.2 for an alternate model for MIRP operation in a B-component and MIRPDU addressing.

39.2.1.7 MIRP application EtherType

The EtherType used for MIRPDUs shall be the MIRP EtherType identified in Table 10-2.

39.2.1.8 MIRP ProtocolVersion

The ProtocolVersion for the version of MIRP defined in this standard takes the hexadecimal value 0x00.

39.2.1.9 MIRP AttributeType definitions

MIRP defines a single Attribute Type (10.8.2.2) that is carried in MRP exchanges, as follows:

Attributes identified by the I-SID Vector Attribute Type are instances of VectorAttributes (10.8.1), used to identify a sequence of values of I-SIDs. The value of AttributeType used to identify the I-SID Vector Attribute Type in MRPDUs (10.8.2.2) shall be 1.

39.2.1.10 MIRP FirstValue definitions

The FirstValue field in instances of the I-SID Vector Attribute Type shall be encoded in MRPDUs (10.4) as three octets, taken to represent an unsigned binary number, and equal to the value of the VIP-ISID parameter for the VIP.

The range of permitted I-SID values that can be encoded in the FirstValue fields in MIRP is restricted to those not listed in Table 9-3.

39.2.1.11 Administrative controls

MIRP supports only the Registration Fixed (New propagated) value of the Registrar Administrative Controls (10.7.2) and this value cannot be manipulated by management. Therefore, the MRP Registrar Administrative Control (12.7.7.1, 12.7.7.2) can only take the value New propagated.

The provision of static control over the ability of Applicant state machines to participate in protocol exchanges is achieved by means of the Applicant Administrative Control parameters associated with the operation of MRP (10.7.3). Where management capability is implemented, the Applicant Administrative Control parameters can be applied and modified by means of the management functionality defined in 12.9.

The management controls in Clause 12 operate per Bridge Port, but a MIRP Participant is attached to a PIP, which is not a Bridge Port. Therefore, if MIRP is enabled on any VIP on a PIP, then the MIRP Participant is enabled on that PIP. If MIRP is disabled on all of the VIPs on a PIP, then the MIRP Participant on the PIP is disabled.

The choice of destination_address and vlan_identifier used in an MIRPDU from a B-component are made by an enumerated configuration parameter [item d) in 12.16.1.2.2] and a B-VLAN configuration parameter [item c) in 12.16.1.2.2].

39.2.2 Alternate MIRP model for B-components

An alternate model for the operation of MIRP in a B-component is illustrated in Figure 39-3. This model is perfectly interoperable with that presented in 39.2.1 and Figure 39-2, is indistinguishable in terms of required protocol behavior from that model, and thus can be used to implement MIRP. In this alternate model, there is a pair of communicating MIRP Participants in each CBP, separate from a similar pair in every other CBP, with no MIRP Participant on any PNP or management Port. The LAN-facing MIRP Participant (the right-hand MIRP Participant in Figure 39-3) corresponds to the CBP MIPR Participant described in 39.2.1. The Relay-facing MIRP Participant (the left-hand MIRP Participant in Figure 39-3) is attached to the EISS Connectivity (39.2.2.1). Its functions correspond to those of the MIRP Participant on a PNP or Management Port in 39.2.1 and Figure 39-2.

NOTE 1—Because the CBP functions (6.11) do not pass frames without I-TAGs, the Relay-facing MIRP Participant can exchange MIRPDUs only through the MAC Relay Entity, and the LAN-facing MIRP Participant only through the LAN.

NOTE 2—The only difference between the models in Figure 39-2 and Figure 39-3 that visible to an observer external to the B-component is that the alternate model can issue MIRPDUs with different source_address parameters, while a the PNP model issues all MIRPDUs with the same source_address. Since MRP and MIRP make no use of that parameter, this difference does not affect the operation of the protocol.

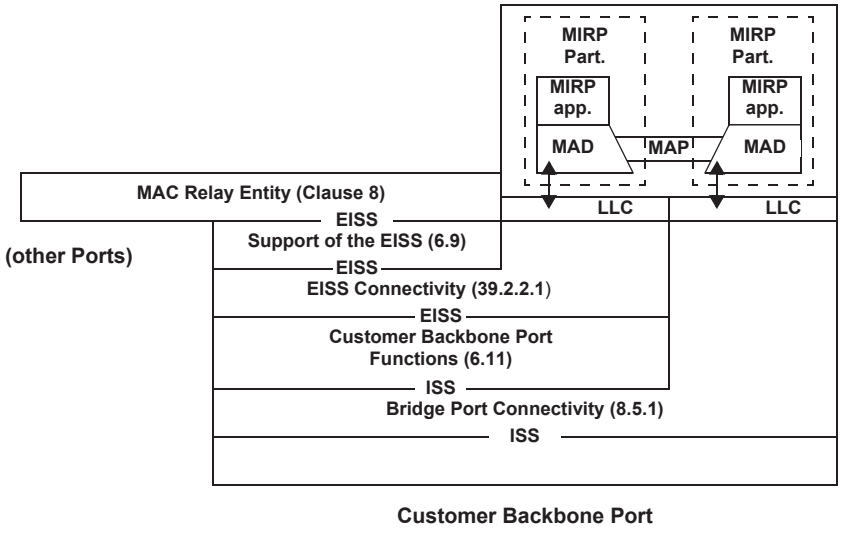


Figure 39-3—Alternate model for MIRP in a B-component

39.2.2.1 EISS Connectivity

The EISS Connectivity function is identical to the Bridge Port Connectivity of 8.5.1, except that it supports the EISS (6.8) instead of the ISS (IEEE Std 802.1AC).

Each EM_UNITDATA.indication provided by the lower EISS access point (Figure 39-3) shall result in a corresponding EM_UNITDATA.indication with identical parameters at each of the access points supporting the MAC Relay and Higher Layer Entities. (Only one such Higher Layer Entity is shown in Figure 39-3.) Each EM_UNITDATA.request from the EISS access point supporting the MAC Relay Entity shall result in a corresponding EM_UNITDATA.indication with identical parameters at each of the access points for the Higher Layer Entities, and a corresponding EM_UNITDATA.request with identical parameters at the lower access point. Each EM_UNITDATA.request from an ISS access point supporting a Higher Layer Entity shall result in a corresponding EM_UNITDATA.indication with identical parameters at the access points for the MAC Relay Entity, and at other access points for Higher Layer Entities, and a corresponding EM_UNITDATA.request with identical parameters at the access point for the LAN.

The MAC_Enabled, MAC_Operational, and operPointToPointMAC status parameters for the EISS access point for the MAC Relay Entity and Higher Layer Entities shall take the same value as that for the lower access point if that is present, and shall be True otherwise (i.e., if the Port is a Management Port).

39.2.2.2 Alternate MIRP MAP Context

There is a single MIRP MAP Context per CBP, that includes both of the MIRP Participants on that CBP but no MIRP Participant on any other CBP.

39.2.2.3 Alternate MIRPDU addressing

The addressing requirements for the two MIRP Participants on a CBP are different. The LAN-facing MIRP Participant behaves as described in 39.2.1.6. The Relay-facing MIRP Participant follows the rules described for the PNP or Management Port in 39.2.1.6. Since there is only one Backbone Service Instance table (6.11) per CBP, there is no ambiguity with regard to MIRPDU addressing. The MIRPDU addressing control parameters described in 39.2.1.6 apply to every Relay-facing MIRP Participant.

NOTE—The model in Figure 39-3 results in the CBPs communicating MIRP information via MIRPDUs, instead of via the MIRP MAP, as in Figure 39-2, and all of those MIRPDUs would be output to the rest of the PBBN, as well.

39.2.3 Use of “new” declaration capability

MIRP supports the Registration Fixed (New propagated) value for the Registrar Administrative Controls for a Port in a Static VLAN Registration Entry. MIRP will accept and propagate a New Message received on that Port for that VLAN and propagate it to all other Ports.

When any MIRP declaration marked as “new” is received on a given VIP, either as a result of receiving an MIRPDU from the attached LAN (MAD_Join.indication), or as a result of receiving a request from the MAP (via the S-VID/I-SID translation function [39.2.1.1]) for the MIRP Application (MAD_Join.request), any entries in the I-component’s FDB for that Port and for the VLANs corresponding to the attribute value in the MAD_Join primitive are removed.

39.2.4 Attribute value support requirements

Implementations of MIRP shall be capable of supporting all attribute values in the range of possible values that can be registered using MIRP. An I-component shall be capable of maintaining current state information for at least 4094 attributes in the range of possible values. A CBP implementation shall support the full range of attribute values that are supported, in turn, by its Backbone Service Instance table.

39.2.5 MRP Message filtering

A MIRP Participant operates in Registration Fixed (New propagated) mode only. Therefore, any MIRP Message for an attribute that is not a VIP-ISID (for an I-component) or a Local-SID or Backbone-SID (for a CBP) is ignored by a MIRP Participant.

40. Edge Virtual Bridging (EVB)

Figure 40-1 provides an overview of the EVB architecture. An end station that supports the attachment of one or more virtual stations is said to be an EVB station. Each virtual station has at least one Virtual Station Interface (VSI). Each virtual station communicates with other virtual stations or other stations on the Bridged Network via the edge relay (ER) to which it is attached (see 3.76).

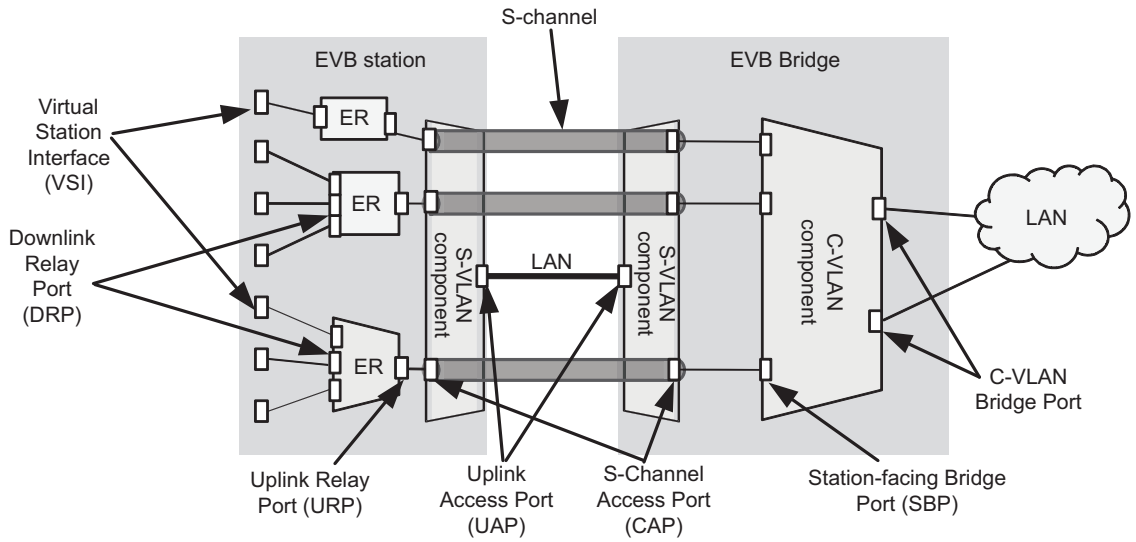


Figure 40-1—EVB architecture overview

An ER supports local relay among virtual stations and/or relay between a virtual station and other stations on the Bridged Network through an EVB Bridge. When forwarding of frames from one DRP to one or more other DRPs associated with the same ER (i.e., local relay) is not supported, then forwarding of traffic from one DRP to one or more other DRPs is performed by the EVB Bridge, utilizing reflective relay (8.6.1).

Connection between a DRP and a virtual station is achieved via a VSI. Traffic from a VSI traverses an internal LAN connecting the DRP to the virtual station. The operation of an ER does not result in any modifications to relayed frames over and above the normal tagging and untagging functions of a VLAN Bridge. ERs do not participate in, or affect, spanning tree operation; it is therefore necessary that the logical connectivity maintained within the station is always loop-free (5.24.1).

Figure 40-1 shows a 2-port ER within the EVB station; this illustrates the fact that even where a single VSI is supported by an S-channel, an ER is present in order to provide C-tagging, reserved address filtering (per Table 8-1) and support for the VSI Discovery and Configuration Protocol (VDP, Clause 41), the Edge Control Protocol (ECP), the EVB TLV (D.2.12), and LLDP (IEEE Std 802.1AB).

Each VSI instance is assigned a VSI manager ID, VSI Type Identifier (VTID), and VSI Instance Identifier (VSIID). VDP associates a VSI instance and its related VID(s), MAC address(es), GroupID(s), VSI manager ID, VTID,[49] and VSIID with an SBP. Similarly, VDP de-associates a VSI instance from an SBP.

VDP can also be used to associate a single VTID with, or de-associate a single VTID from the SBP. In this case, the VSI instance does not contain any MAC addresses, VIDs, or Group IDs, and uses the wildcard VID format (41.2.9.1). Only the most recent associate command is used to configure the VTID for the SBP.

[49] The meaning of the VTID is decided by local system and network management.

An ER supports relaying of frames associated with one or more VSIs. In order to achieve this, an ER can support two types of operation. In the first type, referred to as virtual edge bridge (VEB), traffic transferred from one DRP to another DRP of the same ER is forwarded directly by that ER. In the second type, referred to as VEPA, traffic transferred from one DRP to another DRP of the same ER is forwarded onto a single URP beyond the ER to the EVB Bridge. In this case, the EVB Bridge's SBP is enabled with reflective relay (40.4, 8.6.1); this allows the frame to be reflected back to the same ER from which it was received by the EVB Bridge. The ER can then forward the frame to the destination. Thus, in the second mode, all traffic transits the EVB Bridge's SBP and is subject to, for example, filtering or policing behavior associated with the EVB Bridge.

NOTE—Connection between an EVB Bridge and an ordinary end station takes place via a C-VLAN Bridge Port, not an SBP.

An S-channel is a point-to-point S-VLAN that spans a pair of Port-mapping S-VLAN components (22.6.4) and can be used to interconnect an ER and the C-VLAN component of an EVB Bridge. Multiple S-channels can share the use of a LAN. The use of multiple S-channels allows the EVB station to support multiple ERs. The endpoint of an S-channel is known as an S-channel Access Port (CAP); frames are S-tagged on entry to, and are untagged on exit from, the S-VLAN component through a CAP.

EVB TLVs (D.2.12) exchanged via LLDP allow an EVB station and an EVB Bridge to exchange information related to the use of reflective relay and other operational parameters. Each ER has an LLDP database at its URP. Each ER can also have an LLDP database at each DRP.

Each URP and each SBP has an instance of ECP (Clause 43) used to support the VDP. These instances of ECP use the Nearest Customer Bridge address as the destination for frames exchanged between the URP and SBP. VDP TLVs are packed into PDUs that are handed to ECP for delivery. ECP provides reliable delivery of VDP PDUs.

40.1 EVB architecture without S-channels

Figure 40-2 illustrates the relationship of the EVB entities to the Bridge architecture when no S-channels are supported and no Port-mapping S-VLAN components are implemented. In this configuration, the EVB station and EVB Bridge may exchange an S-channel Discovery and Configuration Protocol (CDCP) TLV over the Nearest non-TMPR Bridge address indicating that the S-VLAN component is not present. If the CDCP TLV managed object does not exist in the LLDP database, then the transmitting station or Bridge is assumed to not support S-channels. A URP or an SBP can send a CDCP TLV. If the EVB station supports the CDCP TLV then the nearest non-TPMR LLDP database is located at the URP. If the EVB Bridge supports the CDCP TLV then the nearest non-TPMR LLDP database is located at the SBP.

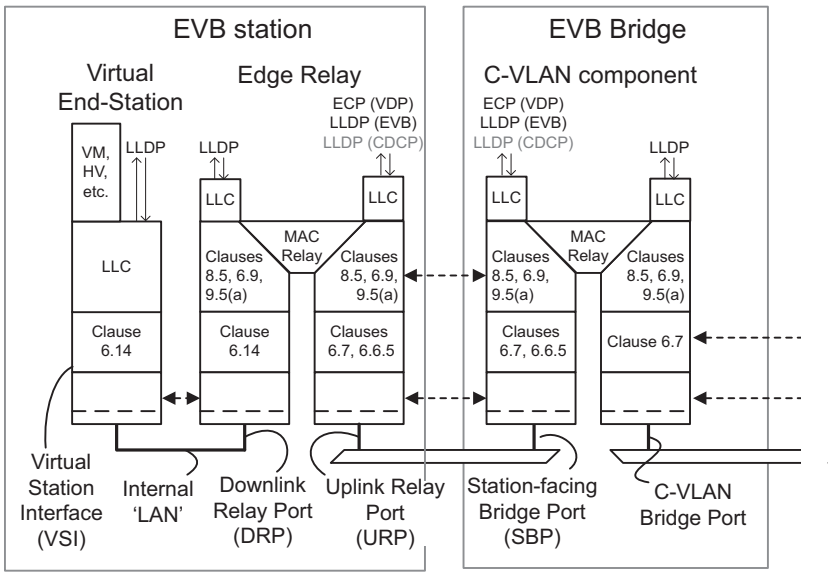


Figure 40-2—EVB architecture without S-channels

40.2 EVB architecture with S-channels

Figure 40-3 shows the relationship of the EVB entities to the Bridge architecture when S-channels are supported. In this configuration, the EVB station and Bridge build nearest non-TPMR LLDP databases at their Uplink Access Ports (UAPs) and use them to exchange CDCP TLVs. Both the EVB station and EVB Bridge set the SComp parameter in the CDCP TLV to TRUE indicating they have an S-VLAN component. The CDCP operating on the CDCP TLVs exchanged by LLDP is used to configure the S-channels.

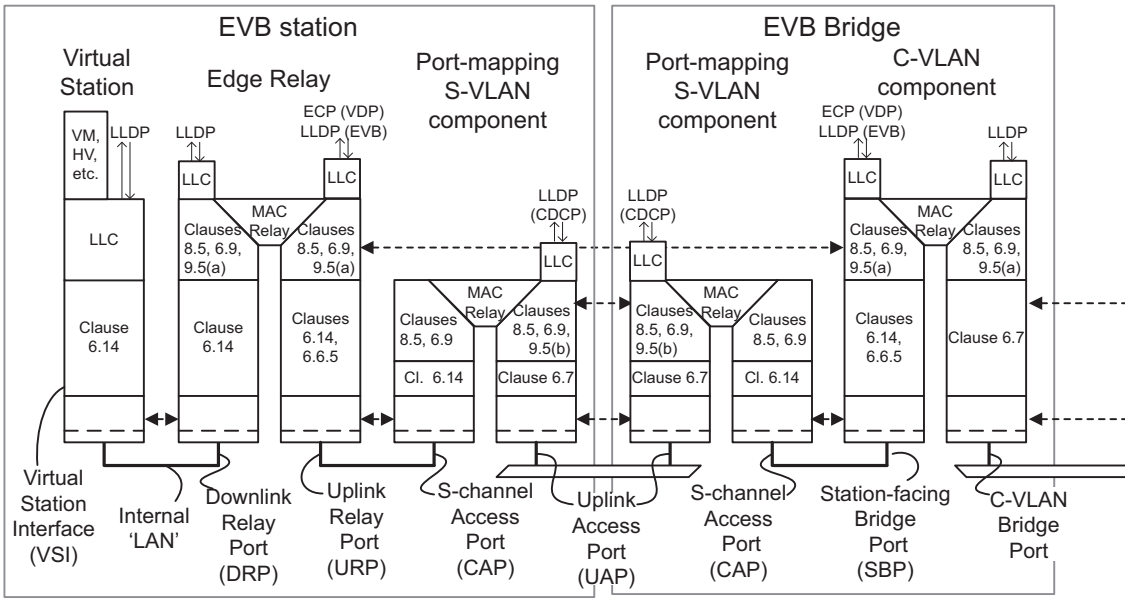


Figure 40-3—EVB architecture with S-channel

EVB stations and EVB Bridges use Port-mapping S-VLAN components (5.6, 22.6.4) to instantiate S-channels. Each S-channel connects a CAP on the EVB station to a CAP on the EVB Bridge. The CAP on an EVB station connects to a single URP on an ER via an internal LAN. The CAP on an EVB Bridge connects to a single SBP on the C-VLAN component via an internal LAN. There is a 1:1 relationship between a CAP and an SBP of the EVB Bridge, and a 1:1 relationship between a CAP and a URP of the EVB station. S-channel support allows the EVB station and EVB Bridge to support multiple ERs on a LAN. Each S-channel is associated with the URP of a distinct ER.

Figure 40-4 shows the relationship between S-channels and CAPs and the positioning of a station's internal and external LANs. When S-channels are supported, each physical LAN can be used to support multiple S-channels identified on the LAN by S-tagging. The S-channels are supported by one Port-mapping S-VLAN component for each UAP. Each Port-mapping S-VLAN component within an EVB station can be identified by its single UAP. A CAP is uniquely identified by the combination of the UAP of the S-VLAN component and the S-VID of the S-channel. Each CAP attaches by internal C-tagged LANs to a single URP or SBP. The C-VLANs carried over each S-channel are determined by configuration of the EVB station and of the C-VLAN component within the EVB Bridge.

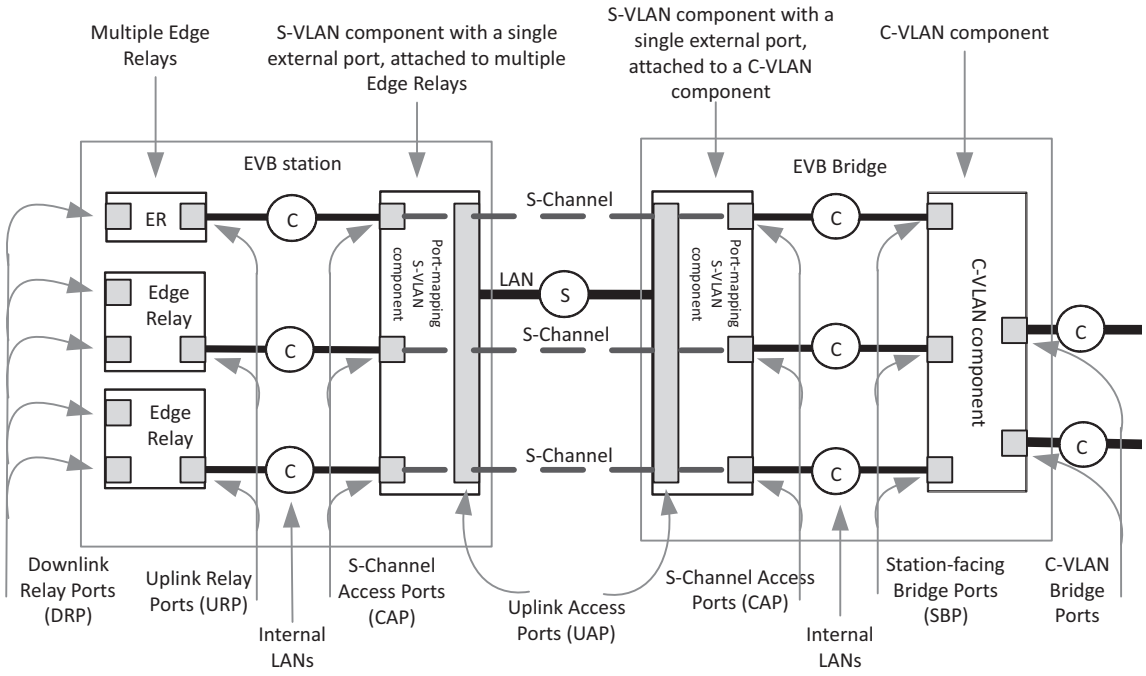


Figure 40-4—EVB components and internal LANs with S-channels

NOTE—As a result of normal Bridge behavior described in 6.9, the priority carried in the C-TAG is regenerated at the CAP to form the S-TAG priority.

The C-VLAN component of the EVB Bridge is a standard C-VLAN component (5.5) that additionally supports reflective relay (40.4, 8.6.1), the EVB LLDP TLV, and VDP.

When a UAP table entry (12.26.4.1) is created, a Port-mapping S-VLAN component is instantiated and the following actions are taken automatically:

a) The UAP is configured to perform as follows:
   1) Admit all frames (6.9).
   2) Have a PVID parameter equal to the default S-channel S-VID (6.9, 40.3).
   3) Be included in the member set for the default S-channel S-VID (8.8.10).
   4) Be a member of the untagged set for the default S-channel S-VID (8.8.2).
   5) Be included in the member set for all S-VIDs of active S-channels.
b) An S-channel Interface table entry is created if one does not already exist for the default S-channel. This table provides the equivalent functionality of the following:
   1) Creating a CAP for the default S-channel.
   2) Configuring the CAP to accept only un-S-tagged frames (6.9).
   3) Setting the member set for the default S-channel's S-VID to include the CAP.
   4) Setting the CAP's PVID to the default S-channel's S-VID.
   5) Adding the CAP to the default S-channel S-VID's untagged set.
   6) Setting filters on the CAP for the Nearest Bridge and Nearest non-TPMR Bridge group MAC addresses.
   7) In the case of an EVB Bridge allocating (or creating) an SBP on the C-VLAN component attached to the CAP by an internal LAN.
c) An instance of LLDP is started on the UAP transmitting a local database on the Nearest Non-TPMR Bridge Address and including the CDCP TLV.
d) CDCP is started on the UAP and configured with the parameters specified when the UAP was created.
   1) If the CDCP role is "B," then CDCP will wait for new S-channel creation requests. As new requests are found, CDCP creates new S-channel interface table entries for each new S-channel and deletes entries when S-channels are removed.
   2) If the CDCP role is "S," then CDCP uses the S-channel interface table to create the list of S-channel Identifiers (SCIDs) for the S-channels it is requesting from the "B" side.

40.3 Asymmetric EVB architecture without S-channels

Figure 40-5 and Figure 40-6 illustrate the relationship of the EVB entities to the Bridge architecture when S-channels are supported by only one side at a time; either the EVB Bridge or EVB station, but not both simultaneously. In these configurations, the EVB entity with S-channel support will advertise it has an S-VLAN component by building a nearest non-TPMR LLDP databases at its UAP and including the CDCP TLV with the parameter SComp set to TRUE. The EVB entity without S-channel support may advertise a Nearest non-TMPR Bridge LLDP database with the CDCP TLV indicating an SComp parameter set to FALSE. CDCP is assumed not to be supported by the peer EVB entity until a CDCP TLV has been received.

Each Port-mapping S-VLAN component within an EVB entity supports an internal default S-channel identified by S-VID 1 and uses it to pass untagged frames to its UAP. This default S-channel is always present in the entity supporting an S-VLAN component. In the asymmetric configurations, frames from the system without S-channel support are carried over the default S-channel within the system that has S-channel support.

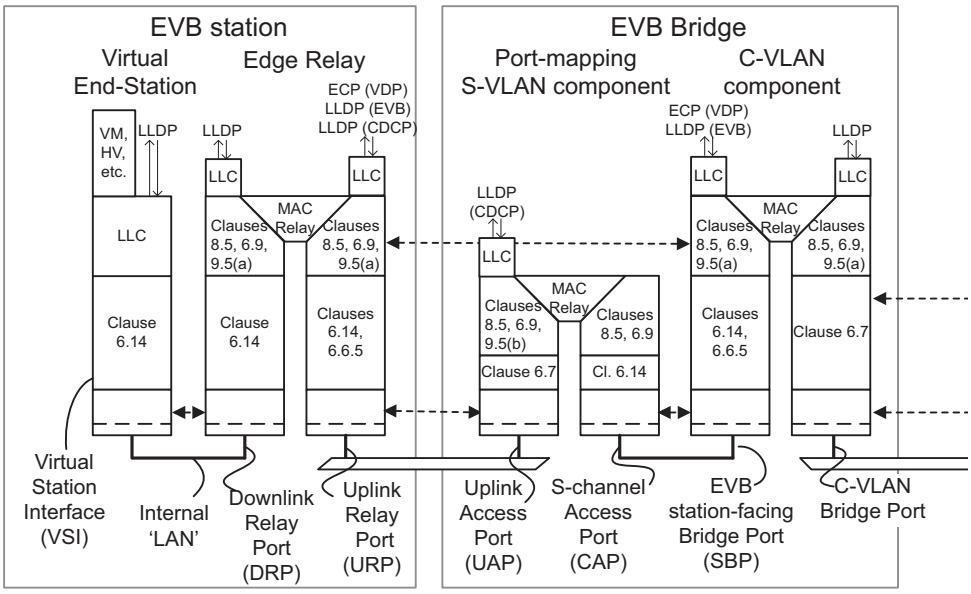


Figure 40-5—EVB architecture without S-channels, with EVB Bridge S-VLAN component

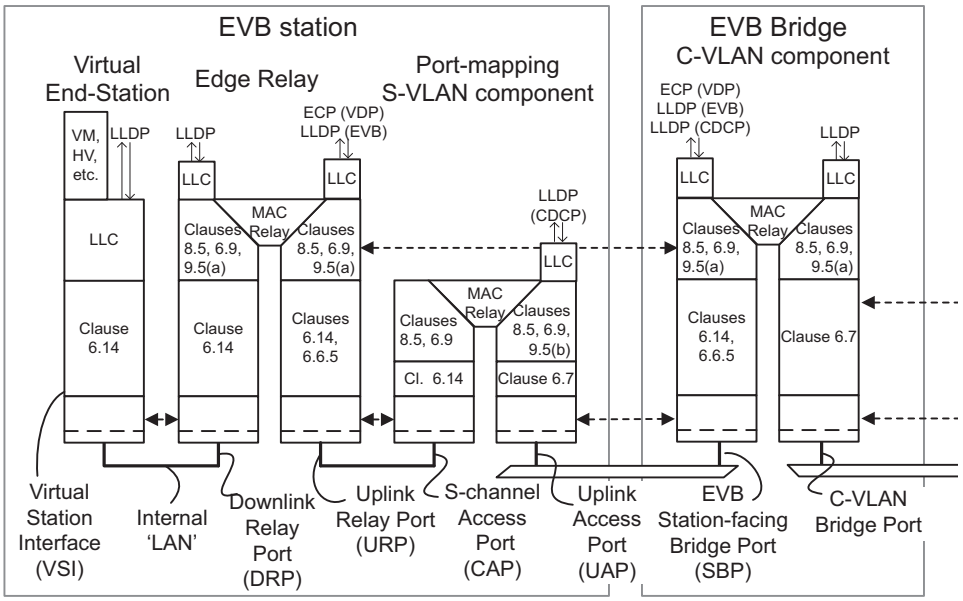


Figure 40-6—EVB architecture without S-channels, with EVB station S-VLAN component

40.4 EVB status parameters

In EVB Bridges and EVB Stations, an **EVBMode** parameter is associated with each port that provides EVB functionality. The parameter represents the EVB status of the port.

The **EVBMode** parameter determines whether EVB functionality is supported, and in what mode. The parameter can take one of the following values:

a) **EVB Bridge.** The port supports the functionality of an EVB Bridge.
b) **EVB station.** The port supports the functionality of an EVB station.
c) **Not Supported.** The port does not support EVB functionality. This value is assumed if the EVB status parameters are not implemented.
d) **NVO3 Mode.** The port supports the revised EVB functionality to be used in an NVO3 Split-NVE scenario.

40.4.1 EVBMode = Not supported

If the value of the **EVBMode** parameter is **Not Supported**, then no further status parameters are available, EVB functionality is not supported, and the operation of the service associated with the port follows the normal forwarding rules for a Bridge.

40.4.2 EVBMode = EVB Bridge

If the value of the **EVBMode** parameter is **EVB Bridge**, then further parameters are available, as follows:

a) **reflectiveRelayCapable.** If this parameter is TRUE, then the active topology enforcement function is capable of performing reflective relay, as specified in 8.6.1; if FALSE, the active topology enforcement function is not capable of performing reflective relay.

   NOTE 1—The value of the reflectiveRelayCapable parameter is an inherent property of the implementation and is not subject to administrative control.

b) **operReflectiveRelayControl**. If this parameter is TRUE, then reflective relay is enabled; if FALSE, reflective relay is disabled.

   NOTE 2—Reflective relay is enabled if a remote EVB station has requested that it be provided (as determined by protocol exchanges between the EVB station and EVB Bridge) and the EVB Bridge is capable of providing it, or disabled if the EVB station has not requested that it be provided or the EVB Bridge is not capable of providing it.

40.4.3 EVBMode = EVB station

If the value of the **EVBMode** parameter is **EVB station**, then further parameters are available, as follows:

a) **adminReflectiveRelayRequest**. This parameter can take one of two values:
   1) **TRUE**. The attached EVB Bridge is requested to enable Reflective relay.
   2) **FALSE**. The attached EVB Bridge is requested to disable Reflective relay.

   NOTE 1—The value of adminReflectiveRelayRequest is used in the EVB TLV exchanges described in D.2.12 to indicate to an attached EVB Bridge that the EVB station needs reflective relay to be provided. A given EVB station is not required to support both possible values of adminReflectiveRelayRequest.

b) **operReflectiveRelayStatus**. This parameter can take one of three values:
   1) **TRUE.** The EVB Bridge has enabled reflective relay.
   2) **FALSE.** The EVB Bridge has disabled reflective relay.
   3) **Unknown.** It is not known whether the EVB Bridge has enabled reflective relay.

   NOTE 2—The value of operReflectiveRelayStatus indicates whether the EVB Bridge has enabled reflective relay, or whether the EVB Bridge status is not currently known, as determined by protocol exchanges between the EVB station and EVB Bridge. The EVB Bridge status can be unknown during initialization or until the protocol exchanges have completed.

40.4.4 EVBMode = NVO3 Mode

If the value of the **EVBMode** parameter is **NVO3 Mode**, then further parameters are available in 40.5.

40.5 EVB Status Parameter for NVO3 Mode Support

In an NVO3 Split-NVE scenario, tNVE is located in a station that may not be an EVB Station and nNVE is located in a bridge or router that may not be an EVB Bridge. Hence tNVE and nNVE will be used to refer to EVB Station and EVB Bridge revised to support NVO3.

The parameters of the EVB TLV provide the required parameter list. EVB TLV (Annex D) and status parameters are amended to support NVO3.

When **EVBMode** is set to **NVO3 Mode**, an **NVERole** parameter is to be further inspected. The parameter represents the NVE role of the port.

40.5.1 NVERole = nNVE

If the value of the **NVERole** parameter is **nNVE**, then further parameters are available, as follows:

a) **reflectiveRelayCapable.** This parameter is FALSE in NVO3 as tNVE has no requirement to support reflective relay.

NOTE 1—The value of the reflectiveRelayCapable parameter is an inherent property of the implementation and is not subject to administrative control.

b) **operReflectiveRelayControl**. If this parameter is TRUE, then reflective relay is enabled; if FALSE, reflective relay is disabled. In an NVO3 scenario, it is always FALSE since tNVE will not request reflective relay to be enabled.

NOTE 2—Reflective relay is enabled if a remote EVB station has requested that it be provided (as determined by protocol exchanges between the EVB station and EVB Bridge) and the EVB Bridge is capable of providing it, or disabled if the EVB station has not requested that it be provided or the EVB Bridge is not capable of providing it.

c) **BGID**. This parameter is set to TRUE, which indicates that the nNVE wishes to control VID assignments and use the GroupID in VDP exchanges.

NOTE 3—GroupID in VDP is equivalent to VNI ID in NVO3, which is a mandatory parameter to be supported. Both bridge and station sides support it.

40.5.2 NVERole = tNVE

If the value of the **EVBMode** parameter is **tNVE**, then further parameters are available, as follows:

a) **adminReflectiveRelayRequest**. This parameter is set to FALSE, which indicates the attached nNVE is requested to disable reflective relay.

b) **operReflectiveRelayStatus**. This parameter can be FALSE or Unknown.

NOTE 1—The value of operReflectiveRelayStatus indicates whether the nNVE has enabled reflective relay, or whether the nNVE status is not currently known, as determined by protocol exchanges between the tNVE and nNVE. The nNVE status can be unknown during initialization or until the protocol exchanges have completed. However The nNVE status cannot be reflective relay enabled.

c) **SGID**. This parameter is set to TRUE, which indicates that the tNVE can support the use of the GroupID.

NOTE 2—GroupID in VDP is equivalent to VNI ID in NVO3, which is a mandatory parameter to be supported. Both bridge and station sides should support it.

41. VSI Discovery and Configuration Protocol (VDP)

VDP associates (registers) a VSI instance with an Station-facing Bridge Port (SBP) of an EVB Bridge. VDP simplifies and automates virtual station configuration by enabling the movement of a VSI instance (and its related VSI Type information) from one virtual station to another or from one EVB Bridge to another. VDP supports VSI discovery and configuration across a channel interconnecting an EVB station and an EVB Bridge. VDP TLVs are exchanged between the station and the Bridge in support of this protocol.

This clause defines the VDP TLV structure and state machines.

When VDP is used between EVB Station and EVB Bridge, VDP uses ECP (Clause 43) as a transport protocol for VDP TLV exchanges. When ECP is used as a transport protocol for VDP, ECP uses the Nearest Customer Bridge group MAC address (Table 8-1) as the destination address for ECPDUs. Three VDP TLVs are defined as follows:

a) The VSI manager ID TLV (41.1). There is a single instance of this TLV in any ECPDU that carries VDP, and it appears as the first TLV in the ECPDU.
b) The VDP association TLV (41.2). One or more of these TLVs can appear in any ECPDU, following the VSI manager ID TLV.
c) The organizationally defined TLV (41.3).

NOTE 1—If there are multiple VSI managers, then their TLVs are transmitted in separate ECPDUs.

NOTE 2—Beyond the requirement stated, that the VSI manager ID TLV appears as the first TLV in ECPDUs carrying VDP, there are no further constraints placed upon how an implementation chooses to pack VDP TLVs into an ECPDU.

NOTE 3—VDP TLVs are not LLDP TLVs, and the TLV type values used in VDP TLVs are assigned from a distinct number space from those used in LLDP TLVs.

When VDP is used between tNVE and nNVE in an NVO3 Split-NVE scenario, VDP may use ECP (Clause 43) as a transport protocol for VDP TLV exchanges. When ECP is used as a transport protocol for VDP in NVO3, ECP uses a specific unicast MAC address or the Nearest Customer Bridge group MAC address (Table 8-1) as the destination address for ECPDUs. The VDP TLVs used between a tNVE and nNVE are as follows:

d) The VDP association TLV (41.2). One or more of these TLVs can appear in any ECPDU or other transport protocol.
e) The organizationally defined TLV (41.3).

41.1 VSI manager ID TLV definition

Figure 41-1 illustrates the format of the VSI manager ID TLV.

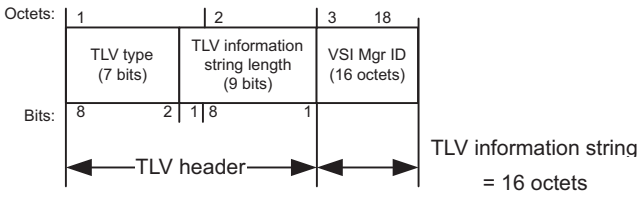


Figure 41-1—VSI manager ID TLV

The VSI manager ID TLV field definitions are contained in 41.1.1 through 41.1.3.

41.1.1 TLV type

The TLV type field takes the value shown in Table 41-1 for VSI manager ID.

Table 41-1—VDP TLV types

TLV type	Value
Pre-Associate	0x01
Pre-Associate with resource reservation	0x02
Associate	0x03
De-associate	0x04
VSI manager ID	0x05
Organizationally defined TLV	0x7F
Reserved for future standardization	0x00, 0x06–0x7E

41.1.2 TLV information string length

This field contains the length of the TLV information string, which is 16 octets.

41.1.3 VSI Manager ID

Identifies the database that should be accessed to get the VSI Type. The value 0 means that the station does not know what VSI Manager ID to use, indicating that the Bridge should select a default value. Any other value is interpreted as an IPv6 address, as defined in IETF RFC 4291.

41.2 VDP association TLV definitions

Figure 41-2 illustrates the format of the VDP association TLV.

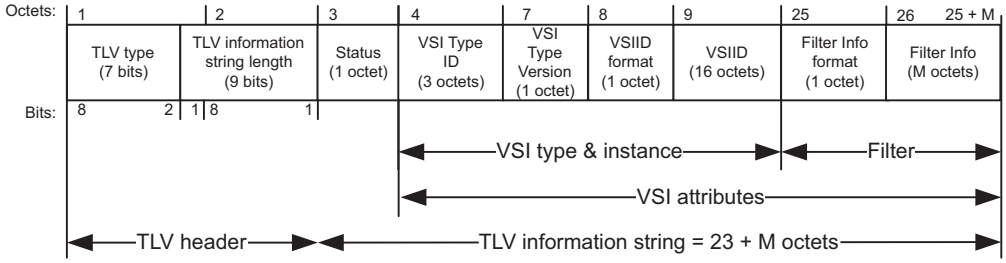


Figure 41-2—VDP association TLV

The VDP association TLV field definitions are contained in 41.2.1 through 41.2.9. The semantics of the VDP association TLV types are defined in 41.2.10.

When the VDP association TLV is sent as a response, the Status field indicates the outcome of the requested operation, and the remaining fields are populated using the information provided in the request or information provided by the EVB Bridge.

41.2.1 TLV type

The TLV type field identifies the type of the VDP association TLV, and can take any of the values shown in Table 41-1 for pre-associate, pre-associate with resource reservation, associate, or de-associate.

41.2.2 TLV information string length

This field contains the length of the TLV information string, calculated as 23 + M octets, where M is the number of octets in the filter info field (41.2.9).

41.2.3 Status

The Status field contains a 4-bit error type, encoded in bits 1–4, and four individual Boolean flags, encoded in bits 5–8.

For all requests, the error type field is reserved for future standardization; it is transmitted as 0x0 and is ignored on receipt.

For all requests, the Boolean flags are interpreted as shown in Table 41-2.

Table 41-2—Flag values in VDP requests

Name	Bit position	Interpretation
M-bit	Bit 5	Indicates that the user of the VSI (e.g., the virtual station) is migrating (M-bit = 1) or provides no guidance on the migration of the user of the VSI (M-bit = 0). The M-bit is used as an indicator relative to the VSI to which the user is migrating.
S-bit	Bit 6	Indicates that the VSI user (e.g., the virtual station) is suspended (S-bit = 1) or provides no guidance about whether the user of the VSI is suspended (S-bit = 0). A keep-alive Associate request with S-bit = 1 can be sent when the VSI user is suspended. The S-bit is used as an indicator relative to the VSI that the user is migrating from.
Req/Ack	Bit 7	Set to 0 to indicate that the TLV contains a request.
N-bit	Bit 8	Indicates that the user of the VSI is NOT migrating (N-bit = 1) or provides no guidance on the migration of the user of the VSI (N-bit = 0).

NOTE—The M-bit is restored to 0 when migration has stopped, either because the migration has succeeded, or it has failed. The S-bit is restored to 0 when the VSI user is no longer suspended.

NOTE 2—Interpretation of M and N bits is described in the following table:

M bit	N bit	Interpretation
0	0	No guidance on the migration of the user of the VSI
0	1	User of the VSI (e.g., the virtual station) is NOT migrating
1	0	User of the VSI (e.g., the virtual station) is migrating
1	1	Reserved

For all responses, the value of the error type indicates the outcome of the request, as shown in Table 41-3, and the Boolean flags are interpreted as shown in Table 41-4.

Table 41-3—Error types in VDP responses

Name	Value	Interpretation
Success	0x0	The VDP Request was successfully completed by the Bridge.
Invalid Format	0x1	The VDP TLV format is invalid.
Insufficient Resources	0x2	The Bridge does not have enough resources to complete the VDP operation successfully.
Unable to contact VSI manager	0x3	The Bridge was unable to contact the VSI manager.
Other failure	0x4	The operation failed for some other reason.
Invalid VID, GroupID, or MAC address	0x5	The operation failed because the VID, GroupID, or MAC address was invalid.
Reserved	0x6–0xF	Reserved for future standardization.
NOTE—"Success" is only interpreted as success by the state machines if all of the flag bits (Table 41-4) are zero.		

Table 41-4—Flag values in VDP responses

Name	Bit position	Interpretation
Hard error	Bit 5	Set to 1 to indicate that the operation failed, and if the same operation is re-tried, it is likely to fail in the same way.
Keep	Bit 6	Set to 1 to indicate that the command was rejected and the state prior to the requested command has been kept.
Req/Ack	Bit 7	Set to 1 to indicate that the TLV contains a response.
Reserved	Bit 8	Reserved for future standardization.

41.2.4 VSI Type ID (VTID)

The VTID is an integer value used to identify a VSI Type.

NOTE—One VTID could describe the VSI Type configuration of multiple VSIs. A VTID is only unique per VSI manager ID.

41.2.5 VSI Type Version

The VSI Type Version is an integer identifier that allows a VSI Manager Database to contain multiple versions of a given VSI Type.

41.2.6 VSIID format

The VSIID format field defines the format of the VSIID field that follows it (41.2.7). The possible values of VSIID format are as shown in Table 41-5.

Table 41-5—VSIID format values

Name	Description	Value
IPv4	An IPv4 address, encoded as specified in IETF RFC 4291.	0x01
IPv6	An IPv6 address, encoded as specified in IETF RFC 4291.	0x02
MAC	An IEEE 802 MAC address (6 octets), with 10 leading octets containing all zeros.	0x03
Local	The interpretation of the VSIID is locally defined.	0x04
UUID	A Universally Unique Identifier (UUID) as specified in IETF RFC 4122.	0x05
Reserved	Reserved for future standardization.	0x00, 0x06 through 0xFF

41.2.7 VSIID

The VSIID is an identifier for the VSI instance. A VSIID is generated when a VSI instance is created. The VSIID remains constant during virtual station migration. The format of the VSIID is determined by the VSIID format field (41.2.6). In cases where the format uses an identifier value that has fewer than 16 octets, the VSIID field is packed out to 16 octets with leading octets containing zeros.

41.2.8 Filter Info format

The Filter Info format field determines the format of the Filter Info field (41.2.9). The Filter Info formats defined by this standard are shown in Table 41-6.

Table 41-6—Filter Info format values

Format	Value
VID (41.2.9.1)	0x01
MAC/VID (41.2.9.2)	0x02
GroupID/VID (41.2.9.3)	0x03
GroupID/MAC/VID (41.2.9.4)	0x04
GroupID/VID/IPv4 (41.2.9.5)	0x05
GroupID/MAC/VID/IPv4 (41.2.9.6)	0x06
GroupID/VID/IPv6 (41.2.9.7)	0x07
GroupID/MAC/VID/IPv6 (41.2.9.8)	0x08
Reserved for future standardization	0x00, 0x09 through 0xFF

41.2.9 Filter Info field

The Filter Info field contains information from which a filter can be constructed. The filter is a set of VID values or a set of MAC/VID values. The MAC address in a MAC/VID value is an individual MAC address. The filter is applied to traffic transiting ports that do not have direct knowledge of the associated VSI, such as an EVB SBP, in order to identify the traffic associated with a particular VSI. This allows such ports to apply a VSI Type to the traffic of an individual VSI. Other devices that have direct knowledge of the traffic associated with a VSI, for example devices that form a 1:1 relationship between a port and VSI, simply provide this information via management interfaces.

The Filter Info field can also contain information that is not part of the filter. In particular, the Filter Info field can contain GroupID values. Like the VID, the GroupID identifies a VLAN. When the number of VLANs in the network is less than 4095, each VLAN can be assigned a VID value that is global within the network. When the number of VLANs in the network exceeds 4094, a globally-scoped VID can no longer be used to uniquely identify each VLAN. Instead, overlapping VIDs may be used in different regions of the network, and a per-region mapping between the global VLAN and the region-specific VID is maintained. In this case, the VLAN is uniquely and globally identified by a GroupID.

When VLANs are identified by GroupID, the station has knowledge of the GroupID but it does not, in general, know the corresponding VID to be used by traffic associated with the VLAN. The Bridge is aware of, or can obtain knowledge of, the VID associated with the specified GroupID. Thus, the station can send GroupID values to the Bridge via the Filter Info field of the VDP Request. The Bridge can map GroupID values to local VID values. The VID is included in the filter constructed by the Bridge and is returned with its corresponding GroupID to the station via the VDP Response.

In the NVO3 Split-NVE scenario, the VNI ID is carried in the lower 3 octets of the GroupID. The upper octet of the GroupID should be all zeros.

NOTE 1—The mechanism by which the EVB Bridge determines the GroupID to local VID associations is outside the scope of this standard.

Additionally, the Filter Info field of a VDP TLV in a VDP Response can specify a Priority Code Point (PCP) value associated with any, or all, of the VID values carried by that VDP Response. The PCP value, if specified, is used by the EVB station as the default PCP value associated with the VSI and VID. The Filter Info field contains a PCP Significant (PS) bit associated with each PCP field, indicating whether the PCP field carries a PCP value (binary 1) or does not carry a PCP value (binary 0). If the PCP field carries a PCP value, then the EVB station can adopt that value as the default PCP value associated with the VSI and VID. When sending data frames associated with a given VSI and VID, the EVB station can determine the PCP value associated with each frame by using an algorithm local to the EVB station. For example, the PCP value can be based on the identity of an application associated with the frame as determined by examining higher layer information. For any given frame, it is possible that the algorithm does not provide a specific value of PCP. In such cases, the PCP field is assigned the value of the default PCP associated with the VSI and VID.

NOTE 2—Specification of a PCP value in the VDP Response does not imply that all frames sent by the EVB station, associated with the VSI and VID, carry the specified PCP. It implies only that, if the EVB station has no other information regarding the PCP value that should appear in that particular frame, then the specified default PCP value is used.

41.2.9.1 VID Filter Info format

The VID Filter Info format specifies that the Format Info field contains a set of VID values to be associated with the VSI instance (41.2.7). Figure 41-3 illustrates the VID Filter Info format.

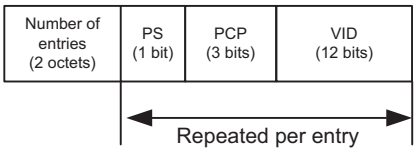


Figure 41-3—VID Filter Info format

The number of VID values in the sequence is specified by the Number of entries field.

The VID field can specify the null VID (see Table 9-2). When the null VID is specified, it is the only VID specified in the Filter Info field (i.e., the Number of entries field is assigned the value 0x0001). Use of the null VID indicates that the set of VID values associated with the VSI is supplied by the Bridge. The Bridge can obtain VID values from the VSI Type whose identity is specified by the VSI Type information in the VDP Request. The set of VID values is returned to the station via the VDP Response.

NOTE—In the case that more than one VID is assigned, the policy that determines how the VIDs are used is outside the scope of this standard.

The Filter Info field can specify the wildcard VID (see Table 9-2). When the wildcard VID is specified, it is the only VID specified in the Filter Info field (i.e., the Number of entries field is assigned the value 0x0001). Use of the wildcard VID value indicates that the VSI Type specified by the VDP Request is designated as the channel VSI Type applied to the EVB SBP associated with the S-channel.

41.2.9.2 MAC/VID Filter Info format

The MAC/VID Filter Info format indicates that the Format Info field specifies a sequence of MAC/VID value pairs to be associated with the VSI instance (41.2.7). Figure 41-4 illustrates the MAC/VID Filter Info format of the Filter Info field.

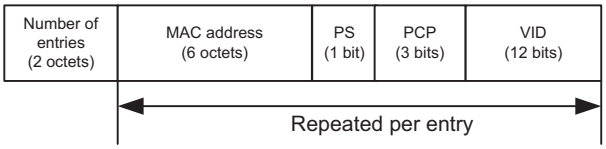


Figure 41-4—MAC/VID filter format

The number of MAC/VID pair values is specified by the field Number of Filter Info entries. Each MAC/VID pair value carries a 6-octet individual MAC address and a 2-octet VID value.

The Filter Info field can specify the null VID for any entry. Use of the null VID indicates that the VID value is supplied by the Bridge.

41.2.9.3 GroupID/VID Filter Info format

The GroupID/VID Filter Info format indicates that the Format Info field specifies a sequence of GroupID/VID pairs to be associated with the VSI instance (41.2.7).

Figure 41-5 illustrates the GroupID/VID Filter Info format of the Filter Info field.

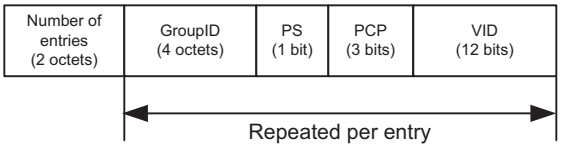


Figure 41-5—GroupID/VID filter format

The number of GroupID/VID pairs is specified by the Number of entries field.

The null VID (see Table 9-2) can be used in a GroupID/VID pair when the GroupID/VID filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.9.4 GroupID/MAC/VID Filter Info format

The GroupID/MAC/VID Filter Info format indicates that the Filter Info field specifies a sequence of GroupID/MAC/VID triples to be associated with the VSI instance (41.2.7). Figure 41-6 illustrates the GroupID/MAC/VID Filter Info format of the Filter Info field.

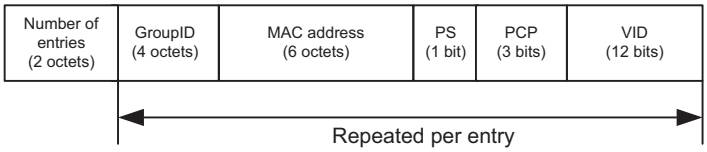


Figure 41-6—GroupID/MAC/VID filter format

The number of GroupID/MAC/VID triples is specified by the value of the Number of entries field. The null VID (see Table 9-2) can be used in a GroupID/MAC/VID triple when the GroupID/MAC/VID filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.9.5 GroupID/VID/IPv4 Filter Info format

The GroupID/VID/IPv4 Filter Info format indicates that the Format Info field specifies a sequence of GroupID/VID/IPv4 triples to be associated with the VSI instance (41.2.7).

Figure 41-7 illustrates the GroupID/VID/IPv4 Filter Info format of the Filter Info field.

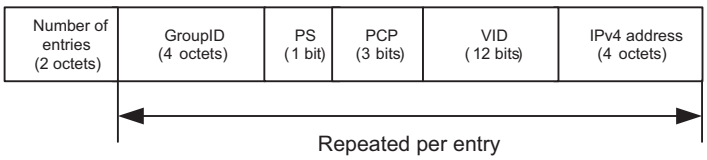


Figure 41-7—GroupID/VID/IPv4 filter format

The number of GroupID/VID/IPv4 triples is specified by the Number of entries field.

The null VID (see Table 9-2) can be used in a GroupID/VID/IPv4 triple when the GroupID/VID/IPv4 filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.9.6 GroupID/MAC/VID/IPv4 Filter Info format

The GroupID/MAC/VID/IPv4 Filter Info format indicates that the Format Info field specifies a sequence of GroupID/MAC/VID/IPv4 values to be associated with the VSI instance (41.2.7).

Figure 41-8 illustrates the GroupID/MAC/VID/IPv4 Filter Info format of the Filter Info field.

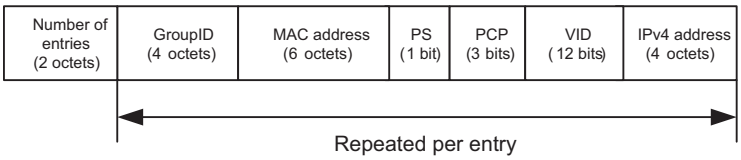


Figure 41-8—GroupID/MAC/VID/IPv4 filter format

The number of GroupID/MAC/VID/IPv4 values is specified by the Number of entries field. The null VID (see Table 9-2) can be used in a GroupID/MAC/VID/IPv4 value when the GroupID/MAC/VID/IPv4 filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.9.7 GroupID/VID/IPv6 Filter Info format

The GroupID/VID/IPv6 Filter Info format indicates that the Format Info field specifies a sequence of GroupID/VID/IPv6 triples to be associated with the VSI instance (41.2.7).

Figure 41-9 illustrates the GroupID/VID/IPv6 Filter Info format of the Filter Info field.

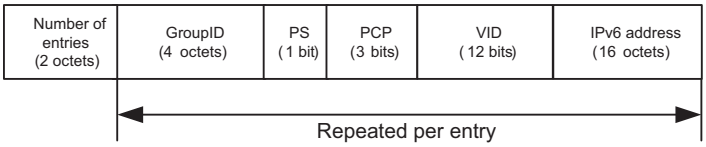


Figure 41-9—GroupID/VID/IPv6 filter format

The number of GroupID/VID/IPv6 triples is specified by the Number of entries field.

The null VID (see Table 9-2) can be used in a GroupID/VID/IPv6 triple when the GroupID/VID/IPv6 filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.9.8 GroupID/MAC/VID/IPv6 Filter Info format

The GroupID/MAC/VID/IPv6 Filter Info format indicates that the Format Info field specifies a sequence of GroupID/MAC/VID/IPv6 values to be associated with the VSI instance (41.2.7).

Figure 41-10 illustrates the GroupID/MAC/VID/IPv6 Filter Info format of the Filter Info field.

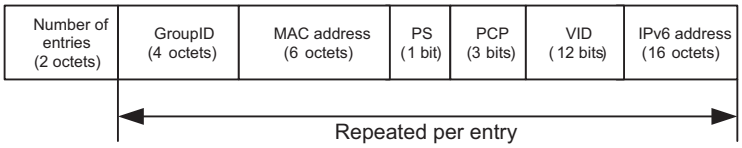


Figure 41-10—GroupID/MAC/VID/IPv6 filter format

The number of GroupID/MAC/VID/IPv6 values is specified by the Number of entries field. The null VID (see Table 9-2) can be used in a GroupID/MAC/VID/IPv6 value when the GroupID/MAC/VID/IPv6 filter format is specified in the VDP Request. In this case, the Bridge is expected to supply the corresponding local VID value in the VDP Response. For this purpose, the Bridge maintains, or has access to, the mapping between GroupID and local VID.

41.2.10 VDP TLV type and status semantics

The following subclauses define the semantics associated with each VDP TLV type.

41.2.10.1 Pre-Associate

The Pre-Associate TLV type is used to pre-associate a VSI instance with a Bridge Port. The Bridge validates the request (see below) and returns a failure Status in case of errors. Successful pre-association does not imply that the VSI Type will be applied to any traffic flowing through the VSI. The pre-associate enables faster response to an associate by allowing the Bridge to obtain the VSI Type prior to an association.

The station can send a Pre-Associate TLV to roll back the station and bridge from associated to pre-associate status.

NOTE—If the VSI Type changes without a corresponding change to its version, then inconsistent behavior can result.

41.2.10.2 Pre-Associate with Resource Reservation

Pre-Associate with Resource Reservation involves the same steps as Pre-Associate (41.2.10.1), but on successful pre-association also reserves resources in the Bridge to prepare for a subsequent Associate request.

The station can send Pre-Associate with a Resource Reservation TLV to roll back the station and bridge from associated to pre-associate with Resource Reservation status.

41.2.10.3 Associate

The Associate TLV Type creates and activates an association between a VSI instance and a Bridge Port. The Bridge allocates any required Bridge resources for the referenced VSI. The Bridge activates the configuration for the VTID. This association is then applied to the traffic flow to/from the VSI instance.

NOTE—The mechanism used by a Bridge to determine the required resources associated with a VTID is outside the scope of this standard.

For a given VSIID, a station may issue an Associate without having previously issued a Pre-Associate or Pre-Associate with Resource Reservation. During normal operations a VSI instance is associated on only one port. During network transitions (e.g., virtual station migration) a VSI instance might be associated with more than one port.

If a Pre-Associate or a Pre-Associate with Resource Reservation had previously been received for a given VSI instance, the Bridge establishes the association and allocates resources based only on the information contained in the Associate TLV. Any resources that had been reserved in order to satisfy a previous Pre-Associate with Resource Reservation, and that are not required in order to establish the association as specified in the Associate, are released.

41.2.10.4 De-Associate

The de-associate TLV Type is used to remove an association between a VSI instance and a Bridge Port. Pre-Associated and Associated VSIs can be de-associated. De-associate releases any resources that were reserved as a result of prior Associate or Pre-Associate operations for that VSI instance.

A de-associate can be initiated either by the station or the Bridge. In the latter case, the Bridge sends a de-associate TLV as if it was a response to a request from the station.

NOTE 1—A Bridge could, for example, issue a de-associate as a consequence of changes in the Bridge's status or configuration.

NOTE 2—The result of the above semantics is that a de-associate can be initiated at any time and by either party.

41.3 Organizationally defined TLV definitions

Figure 41-11 illustrates the format of the organizationally defined TLV.

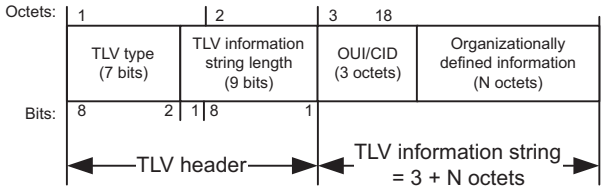


Figure 41-11—Organizationally defined TLV

The organizationally defined TLV field definitions are contained in 41.3.3 and 41.3.4.

41.3.1 TLV type

The TLV type field takes the value shown in Table 41-1 for the organizationally defined TLV.

41.3.2 TLV information string length

This field contains the length of the TLV information string, which is 3 + N octets, where N is the number of octets in the organizationally defined information field (41.3.4).

41.3.3 Organizationally unique identifier (OUI) or Company ID (CID)

Identifies the organization that is responsible for defining the content of the organizationally defined information field (41.3.4). The value of the OUI/CID field is an OUI (see IEEE Std 802) or a CID assigned to that organization by the IEEE registration authority.

41.3.4 Organizationally defined information

The content and interpretation of this field is specified by the organization that owns the OUI or CID value contained in the OUI/CID field (41.3.3).

41.4 Validation rules for VDP TLVs

The following rules apply to the validation of received ECPDUs that carry VDP TLVs:

a) If the first TLV in the ECPDU is not a VSI manager ID TLV (41.1), then the entire ECPDU is discarded without further processing.
b) If the ECPDU contains a TLV of a type that is not recognized by the implementation, then that TLV is discarded and is ignored by the VDP state machines.
c) If a TLV extends past the physical end of the ECPDU, then that TLV is discarded.

41.5 VDP state machines

The station VDP state machine is defined in 41.5.3. A station that supports VDP shall support one instance of the station VDP state machine for each active VSI.

The Bridge VDP state machine is defined in 41.5.2. A Bridge that supports VDP shall support one instance of the Bridge VDP state machine for each active VSI.

41.5.1 State machine conventions

The notational conventions used in the specification of VDP are as stated in Annex E.

41.5.2 Bridge VDP state machine

The Bridge VDP state machine shall implement the function defined in Figure 41-12 and the attendant definitions in 41.5.4 through 41.5.7.

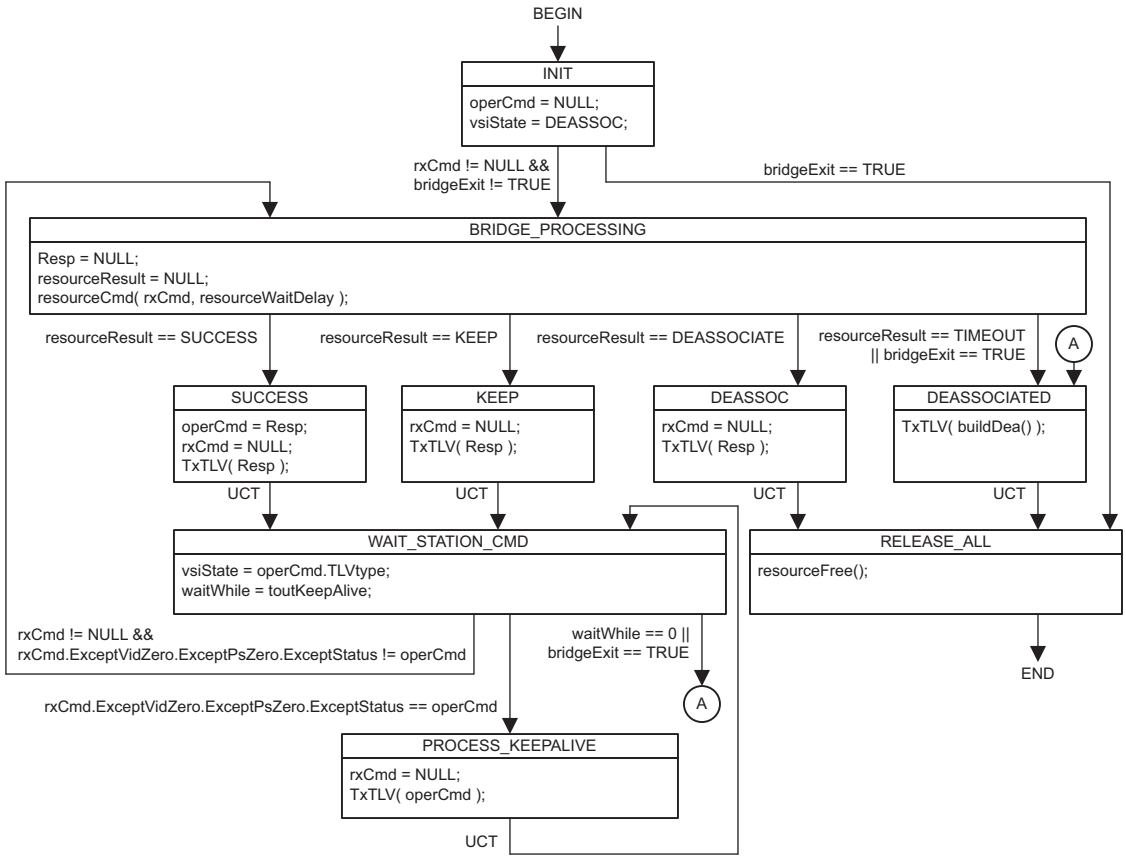
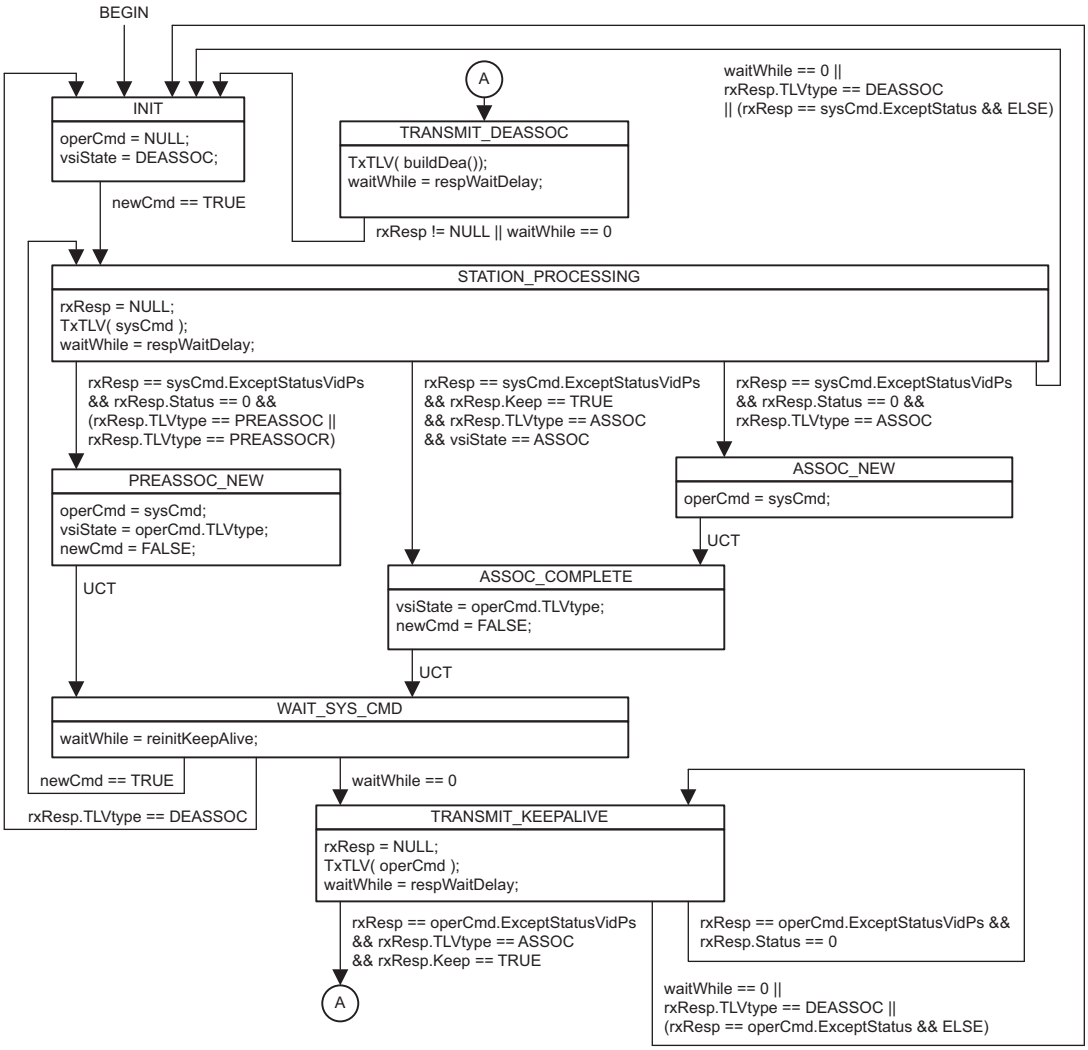


Figure 41-12—Bridge VDP state machine

41.5.3 Station VDP state machine

The station VDP state machine shall implement the function defined in Figure 41-13 and the attendant definitions in 41.5.4 through 41.5.7.



NOTE - The ".Except" notation used in some exit conditions is described in 41.5.6.
In this state machine, "ExceptStatus.ExceptVidZero.ExceptPsZero" has been abbreviated to "ExceptStatusVidPs".

Figure 41-13—Station VDP state machine

41.5.4 VDP state machine timers

A set of timers is used by the VDP state machines; these operate as countdown timers (i.e., they expire when their value reaches zero). These timers are 32-bit countdown timers. They:

a) Have a resolution of ten microseconds, with a tolerance of ± 20%.
b) Are started by loading an initial integer value, n, where $0 < n \leq 2^{31}$.
c) Are decremented by one per timer tick, as long as $n > 0$; the interval between timer ticks is the same as the timer resolution.
d) Represent the remaining time in the period.

NOTE—Where timers are used in the VDP state machines to initiate keep-alive messages, it is recommended that a small random component is added to the timer interval in order to avoid the possibility that timers associated with different VSIs become synchronized.

41.5.4.1 waitWhile

An instance of the waitWhile timer exists for each instance of the station VDP state machine (41.5.3) and for each instance of the Bridge VDP state machine (41.5.2).

41.5.5 VDP state machine variables and parameters

41.5.5.1 bridgeExit

A Boolean signal from the Bridge. When TRUE, this variable indicates that the Bridge VDP state machine should exit.

41.5.5.2 newCmd

This variable is set to TRUE by the system to indicate to the state machine that there is a command ready to be transmitted. The state machine sets newCmd FALSE when that command has been processed and is ready to process a further command.

41.5.5.3 NULL

A null value. If NULL is assigned to a TLV variable, it indicates that the variable contains no TLV.

41.5.5.4 operCmd

The command TLV (the TLV that carried the current operating command—associate, pre-associate, or de-associate), at the station or Bridge, or NULL if there is no current operating command.

41.5.5.5 reinitKeepAlive

The value used to initialize the waitWhile timer (41.5.4.1) by the station VDP state machine in order to determine when to transmit a keep alive message. This value is derived from the value of the management variable urpVdpOperReinitKeepAlive (12.26.5), which is type timer exp, by using urpVdpOperReinitKeepAlive as an exponent of 2. The variable urpVdpOperReinitKeepAlive is the larger of the values proposed by the station and Bridge.

The default value used by the station for urpVdpOperReinitKeepAlive is an exponent value of 20, representing a timer interval of about 10.5 s.

41.5.5.6 resourceCmdResult

This variable is used to record the result of a resourceCmd() procedure call (41.5.7.2). The possible result values are as follows:

a) Success
b) timeOut
c) Fail (insufficient resources)
d) Fail (invalid format)
e) Fail (other)

41.5.5.7 resourceWaitDelay

The value used to initialize the waitWhile timer (41.5.4.1) by the Bridge VDP state machine when the state machine is waiting for a response. This value is derived from the values of the management variable sbpVdpOperRsrcWaitDelay (12.26.2), which is type timer exp, by using sbpVdpOperRsrcWaitDelay as an exponent of 2. The variable sbpVdpOperRsrcWaitDelay is the larger of the values proposed by the EVB station and EVB Bridge.

The default value used by the station and Bridge for sbpVdpOperRsrcWaitDelay is an exponent value of 20, representing a timer interval of about 10.5 s.

41.5.5.8 Resp

A response TLV returned from the procedure resourceCmd() (41.5.7.2). Resp can be set to NULL prior to issuing resourceCmd(). The variable is always non-NULL when resourceCmd() completes.

41.5.5.9 respWaitDelay

The value used to initialize the waitWhile timer (41.5.4.1) by the station VDP state machine when the state machine is waiting for a response. This value is derived from the values of the management variables urpVdpOperRsrcWaitDelay (12.26.5), ecpOperAckTimerInit (12.27) and ecpOperMaxRetries (12.27). The value is expressed in units of VDP timer tics of 10 usec by the following equation:

$$\text{respWaitDelay} = 1.5 \times (2^{\text{urpVdpOperRsrcWaitDelay}} + (2 + 2 \times \text{maxRetries}+1) \times \text{ackTimerInit})$$

NOTE 1—The factor of 1.5 allows for a 20% tolerance in the timer values.

where maxRetries is the ECP state machine variable that is ecpVdpOperMaxRetries and ackTimerInit is the ECP state machine variable that is 2ecpOperAckTimerInit. The values of urpVdpOperRscWaitDelay, ecpOperAckTimerInit, and ecpOperMaxRetries that are used are the larger of the values proposed by the station and Bridge.

The default value used by the station and Bridge is about 17.4 s. The default value for urpVdpOperRscWaitDelay is an exponent of 20 representing a timer interval of about 10.5 s and for ecpOperAckTimerInit is an exponent of 14 representing a timer interval of about 164 ms. The default value of the ECP state machine variable ackTimerInit is 16,384 ECP/VDP timer tics. The default value for ecpOperMaxRetries and the ECP state machine variable maxRetries is 3.

NOTE 2—The factor of 1.5 allows for a 20% tolerance in the timer values.

41.5.5.10 rxCmd

The last received command TLV, or NULL if no command TLV has been received. The rxCmd variable is updated only if it is NULL.

41.5.5.11 rxResp

The last received response TLV. The rxResp variable contains the last received Resp TLV at the station or NULL. RxResp is NULL if no TLVs have been received or if the variable has been cleared by the state machine.

NOTE—It is possible to have a race condition when clearing rxResp since it can be updated asynchronously if the Bridge issues an unsolicited DEASSOC command. If the race condition occurs, the de-associate will occur as a result of the station timer expiring.

41.5.5.12 sysCmd

A command TLV from the system or hypervisor, or NULL if there is no pending command. The VDP state machine is ready to accept a new command when the value of sysCmd is NULL.

41.5.5.13 toutKeepAlive

The value used to initialize the waitWhile timer (41.5.4.1) by the Bridge VDP state machine in order to determine when to expect to receive a keep alive message. This variable is derived from the values of the management variables sbpVdpOperReinitKeepAlive (12.26.2), ecpOperAckTimerInit (12.27), and ecpOperMaxRetries (12.27). The value is expressed in units of VDP timer tics of 10 usec by the following equation:

$$\text{toutKeepAlive} = 1.5 \times (2^{\text{sbpVdpOperReinitKeepAlive}} + (2 + 2 \times \text{maxRetries} + 1) \times \text{ackTimerInit})$$

NOTE—The factor of 1.5 allows for a 20% tolerance in the timer values.

Where maxRetries is the ECP state machine variable that is ecpVdpOperMaxRetries and ackTimerInit is the ECP state machine variable that is $2^{\text{ecpOperAckTimerInit}}$. The values of sbpVdpOperReinitKeepAlive, ecpOperAckTimerInit, and ecpOperMaxRetries that are used are the larger of the values proposed by the EVB station and EVB Bridge.

The default value used by the station and Bridge is about 17.4 s. The default for sbpVdpOperReinitKeepAlive is an exponent of 20 representing a timer interval of about 10.5 s and for ecpOperAckTimerInit is an exponent of 14 representing a timer interval of about 164 ms. The default value of the ECP state machine variable ackTimerInit is 16,384 ECP/VDP timer tics. The default value for ecpOperMaxRetries and the ECP state machine variable maxRetries is 3.

41.5.5.14 vsiState

The current association state of the VDP state machine. This variable may take the values DEASSOC (de-associated), PREASSOC (pre-associated), PREASSOCR (pre-associated with resource reservation), or ASSOC (associated).

41.5.6 Command-Response TLV field references in state machines

The state machines can make use of the value of individual fields within the value of a TLV by using the following notation:

Tlv-variable-name.Field-name

In practice, only the following two Field-names are used in the state machines:

a) TLVtype, which references the TLV type field of the TLV (41.2.1)
b) Keep, which references the Keep bit of the Status field in the TLV (41.2.3)

So, for example, a reference in the state diagram to sysCmd.Keep is a reference to the Keep bit of the Status field of the TLV value contained in the sysCmd variable.

The state machines also make use of the ability to compare TLV values for equality or inequality while ignoring a specific field, using the following notation:

Tlv-variable-name.ExceptField-name

This is interpreted as meaning “The value of the TLV contained in the Tlv-variable-name variable, ignoring the value of Field-Name in the comparison.”

The reserved Field-name “VidZero” is used to specify that if any VID in the Filter Info field (41.2.9.1) contains zero, then that VID is ignored in the comparison. The reserved Field-name “PsZero” is used to specify that if PS in the Filter Info field contains zero, then the PS and PCP are both ignored in the comparison.

Multiple fields can be excepted by concatenating ExceptField-name items with a separating period.

The value of the Flag bits (Table 41-2 and Table 41-4) are always ignored in field comparison operations.

41.5.7 VDP state machine procedures

41.5.7.1 buildDea()

The buildDea() procedure builds a DEASSOCIATE TLV for the VSI as the return parameter.

41.5.7.2 resourceCmd(rxCmd, delay)

This procedure makes a resource request from the Bridge, waits for a response, builds a response TLV and places it in the variable Resp. The response values reflect the requested resource action (PREASSOC, ASSOC, or DEASSOC), conditioned by return variable resourceResult, which is set to NULL before calling the resourceCmd procedure and set to one of the following values by the procedure:

a) SUCCESS
b) KEEP
c) DEASSOCIATE
d) TIMEOUT

The response constructed by the procedure in the Resp variable can be PREASSOC, ASSOC, or DEASSOC with a Status, keep indicator and hard error indicator. For a successful completion the procedure will copy the rxCmd parameter into the Resp variable. If the Bridge is selecting VIDs based on GroupIDs, then the procedure also replaces zero VIDs with valid VIDs.

The delay parameter specifies how long the procedure should wait for a response. If the delay is exceeded, no response is received, and the VSI is not associated, then the procedure returns a value of TIMEOUT. If the delay is exceeded, no response is received and the VSI is associated, then the procedure returns a value of KEEP along with a Resp equal to the rxCmd parameter. If the delay is not exceeded, then the procedure returns SUCCESS, KEEP, or DEASSOCIATE depending on the response received along with the rxCmd in the Resp and the Status set as follows:

e) **DEASSOC**:

The procedure returns DEASSOCIATE along with Resp.Status set to Success.

f) **PREASSOC**:
   1) If the request can be satisfied, the procedure returns SUCCESS along with Resp.Status set to Success.
   2) If the request cannot be satisfied, the procedure returns DEASSOCIATE along with Resp.Status set to a code other than Success and the Resp.hard set to TRUE if a retry will not change the situation or FALSE if a retry might change the situation.

g) **PREASSOCR**:
   1) If the request can be satisfied, and the resources requested are available and reserved for this VSI, the procedure returns SUCCESS along with the Resp.Status set to Success.
   2) If the request cannot be satisfied, or the resources are unavailable or not reserved for this VSI, the procedure returns DEASSOCIATE along with the Resp.Status code other than Success and the Resp.hard set to TRUE if a retry will not change the situation or FALSE if a retry might change the situation.

h) **ASSOC**:
   1) If the request can be satisfied, and the resources requested are available and enabled for this VSI, the procedure returns SUCCESS along with the Resp.Status set to Success.
   2) If the request cannot be satisfied, or the resources are unavailable or not reserved for this VSI, and the VSI is not currently Associated, the procedure returns DEASSOCIATE along with the Resp.Status code other than Success and the Resp.hard set to TRUE if a retry will not change the situation or FALSE if a retry might change the situation.
   3) If the request cannot be satisfied, or the resources are unavailable or not reserved for this VSI, and the VSI is currently Associated, the procedure returns KEEP along with the Resp.Status code other than Success and the Resp.hard set to TRUE if a retry will not change the situation or FALSE if a retry might change the situation.

NOTE—A de-associate can happen at any time, initiated by either party to an association.

41.5.7.3 resourceFree()

The resourceFree() procedure frees all resources associated with this VSI.

41.5.7.4 TxTlv(tlv)

The TxTlv() procedure causes the TLV passed in the tlv parameter to be transmitted.

42. S-Channel Discovery and Configuration Protocol (CDCP)

This clause provides an overview, detailed semantics, and state machines for CDCP.

42.1 CDCP discovery and configuration

CDCP is used to configure S-channels (see 40.2). S-channels are implemented in stations and Bridges using a Port-mapping S-VLAN component (22.6.4). Figure 40-1 illustrates the use of S-channels.

When the Port-mapping S-VLAN components used to create S-channels exist, they can exchange un-S-tagged frames that are assigned to S-VID 1 and are considered to be assigned to the default S-channel, which has an S-channel Identifier (SCID) of 1. The default S-channel is always un-S-tagged even when S-channels are enabled.

NOTE 1—SCIDs are locally assigned identifiers.

The S-channel configuration is determined by the Bridge's capabilities and by requests made using CDCP described in this clause. The station requests S-channels using CDCP. CDCP in turn uses an LLDP TLV exchange to coordinate the creation and deletion of S-channels. The LLDP database used by CDCP is addressed using the Nearest non-TPMR Bridge address. The Port-mapping S-VLAN component filters both the Nearest Bridge and the Nearest non-TPMR Bridge addresses on all ports and passes the Nearest Customer Bridge address.

The SCID value 1 and S-VID value 1 are always reserved for the exclusive use as the un-S-tagged default S-channel. CDCP reports the default S-channel in the CDCP TLV as the first SCID, S-VID pair (i.e., <1,1>). The Bridge shall not assign this S-VID except to the default S-channel.

NOTE 2—For the default S-channel, any QoS information that is necessary is extracted from the PCP bits of the C-tag.

42.2 CDCP state machine overview

CDCP requires each side of the configuration be assigned a role as a Bridge or a station. This is done by setting the AdminRole variable. In most cases the station or Bridge role will not be settable, though the protocol allows for systems that can take either role. For CDCP to configure an S-channel, one side takes the station role and the other side takes the Bridge role. If both sides of the LAN have equipment configured as stations or as Bridges the protocol will not configure S-channels.

NOTE—The role adopted by a given system can be fixed if the system is only capable of operating in a given role.

The CDCP state machine (Figure 42-1) operates on data contained in LLDP MIBs that is updated as a result of the reception of CDCP TLVs, exchanged using LLDP operating on the Nearest non-TMPR Bridge address. The structure of CDCP TLVs is defined in D.2.13.

The configuration proceeds by the Bridge providing the best match it can to the station's requested channels and configuration. The station makes the resource request, the Bridge responds with its best matching resources, the station then goes operational and reports its running configuration to the Bridge, and finally the Bridge goes operational with the running configuration of the station.

In the event the station wishes to change its configuration it alters the request in its CDCP TLV and then follows the same process as previously stated. If the 'B' loses its ability to support the current configuration it can alter the current configuration in its CDCP TLV at which time the station drops down to the resources supplied by the Bridge.

42.3 CDCP configuration state machine

The notational conventions used in the specification of CDCP are as stated in Annex E.

In an implementation that supports the station role, the CDCP configuration state machine shall implement the function specified by the state diagram in Figure 42-1 and the attendant definitions in 42.4 and 42.5.

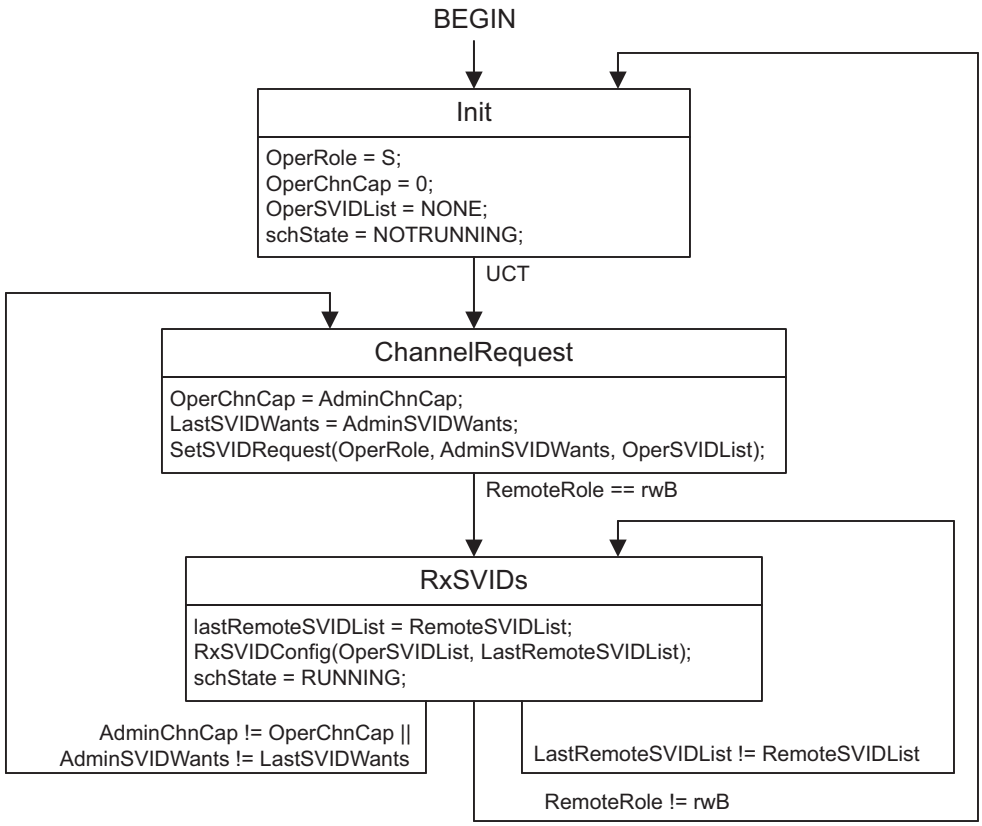


Figure 42-1—CDCP state machine—Station role

In an implementation that supports the Bridge role, the CDCP configuration state machine shall implement the function specified by the state diagram in Figure 42-2 and the attendant definitions in 42.4 and 42.5.

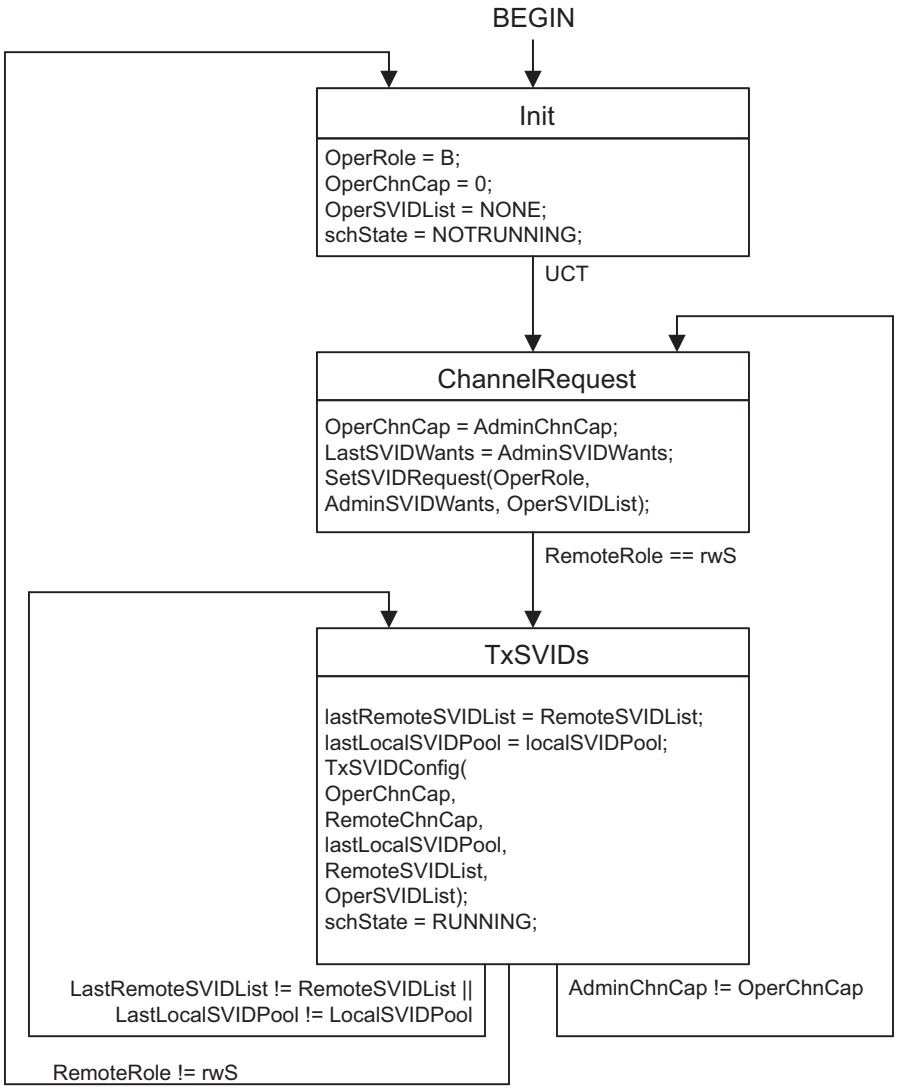


Figure 42-2—CDCP state machine—Bridge role

42.4 CDCP configuration variables

42.4.1 AdminChnCap

The administratively configured value for the Number of Channels supported parameter. This value is included as the ChnCap parameter in the CDCP TLV.

42.4.2 AdminRole

The administratively configured value for the local port's role parameter. The value of AdminRole is not reflected in the CDCP TLV. The AdminRole can take the value S or B; the value determines which of the CDCP state machines is instantiated. If AdminRole is S, the Station role state machine (Figure 42-1) is instantiated. If AdminRole is B, the Bridge role state machine (Figure 42-2) is instantiated. S indicates the sender is unwilling to accept S-channels configuration (mode, number of channels supported, channel index) from its neighbor and that the sender is willing to accept S-VID assignments from the neighbor. Stations usually take the S role. B indicates the sender is willing to accept S-channels configuration (mode, number of channels supported, channel index) from its neighbor and that the sender is willing do the best it can to fill the S-VID requests from the neighbor. Bridges usually take the B role.

42.4.3 AdminSVIDWants

The administratively configured value for (SCID, S-VID) pairs wanted by a station; it is not used by a Bridge. The first value is always the pair (1, 1) for the default S-channel assignment. The S-channel numbers may be any valid number in the range 0–167. A 0 S-channel number indicates reserved space in the TLV. If the S-VID value is 0 it means the station is requesting any available S-VID. S-VID value 1 is reserved for exclusive use for the default S-channel S-VID. No other values of the SVID are permitted. The AdminSVIDWants parameter is used to form the (SCID, S-VID) pairs in the CDCP TLV. This list is formed from the EVB station's S-channel interface table (12.26.4) and is used to build the EVB Bridge's S-channel interface table.

42.4.4 LastLocalSVIDPool

A temporary copy of the LocalSVIDPool.

42.4.5 LastRemoteSVIDList

Temporary local copy of the RemoteSVIDList. This variable is not included in the CDCP TLV. The LastRemoteSVIDList has the same syntax as RemoteSVIDList.

42.4.6 LastSVIDWants

A local temporary copy of the AdminSVIDWants.

42.4.7 LocalSVIDPool

The set of S-VIDs and Bridge Ports available for S-channel assignment. These are determined by both administrative resource assignments and by resource availability. The OperSVIDList for a B role is drawn from the LocalSVIDPool.

42.4.8 OperChnCap

The current value for the ChnCap parameter. This value is included as the ChnCap parameter in the local CDCP TLV. The range for this variable is 1–167.

42.4.9 OperRole

The current operational value of the Role parameter in the local port. This value is included as the Role parameter in the CDCP TLV and may take values S or B as described for AdminRole.

42.4.10 OperSVIDList

The current value for (SCID, S-VID) assignments. This is the list of (SCID, S-VID) pairs included in the local CDCP TLV. The total size of the list cannot exceed 167 pairs. The list always includes the default S-channel pair (1,1).The valid range for each S-channel of this list is from 1–167. The valid range for each S-VID in the list is from 0 to 0xffe. For the S role a S-VID of 0 indicates a request for a channel. For the B role an S-VID of 0 indicates a non-configured channel.

42.4.11 RemoteChnCap

The current value for the ChnCap parameter. This value is included as the ChnCap parameter in the remote CDCP TLV. NULL means no remote CDCP TLV exists in the local LLDP database. The range for this variable is 1–167.

42.4.12 RemoteRole

Indicates the value in the remote CDCP TLV role field. rrNull indicates either the TLV was not present in the last LLDPDU or that no LLDPDUs have been received. rwS and rwB indicate that the Role field was set in the CDCP TLV received and that it had a value of S or B, respectively, as described for the AdminRole variable.

42.4.13 RemoteSVIDList

The current value for (SCID, S-VID) assignments. This is the list of (SCID, S-VID) pairs included in the remote CDCP TLV. NULL means no remote CDCP TLV exists in the local LLDP database. If the list is empty but the CDCP TLV is present, its value is NONE. The total size of the list cannot exceed 167 pairs. The valid range for each S-channel of this list is from 1–167. The valid range for each S-VID in the list is from 0 to 0xffe. When the S-VID is value is 0 the S-VID is not configured. For the S role, a S-VID of 0 indicates a request for a channel. For the B role, an S-VID of 0 indicates a non-configured channel. The RemoteSVIDList is reflected within the EVB Bridge in the S-channel interface table (12.26.4).

42.4.14 schState

The current running state of the S-channel. The values for this variable are NOTRUNNING or RUNNING. This variable can be read using the management functionality defined in Clause 12.

42.5 CDCP configuration procedures

42.5.1 SetSVIDRequest (OperRole, AdminSVIDWants, OperSVIDList)

This function creates the OperSVIDList placed in the Local LLDP database, as follows:

a) If the OperRole for the equipment is B, then the OperSVIDList remains unchanged.
b) If the OperRole for the equipment is S, the function compares the AdminSVIDWants with the OperSVIDList and amends the OperSVIDList, as follows:
    1) All active S-channels in the OperSVIDList that are in the AdminSVIDWants are kept active, and in addition, any channels not currently in the OperSVIDList are requested by including them in the OperSVIDList along with a 0 S-VID number. The OperSVIDList S-channel order is changed to match the AdminSVIDWants.
    2) Any S-channels in the OperSVIDList that are not in AdminSVIDWants are made inactive and are removed from the OperSVIDList.

42.5.2 RxSVIDConfig (OperSVIDList, LastRemoteSVIDList)

This function creates the OperSVIDList placed in the Local LLDP database for an S role port.

The function compares the AdminSVIDWants with the LastRemoteSVIDList. For each AdminSVIDWants S-channel with an S-VID assignment in the LastRemoteSVIDList, a (SCID, S-VID) pair is generated in the OperSVIDList. For each AdminSVIDWants S-channel without an S-VID assignment in the LastRemoteSVIDList, a (SCID,0) pair is generated in the OperSVIDList. The OperSVIDList S-channel order is set to match the AdminSVIDWants.

42.5.3 TxSVIDConfig (OperChnCap, RemoteChnCap, LastLocalSVIDPool, RemoteSVIDList, OperSVIDList)

This function creates the OperSVIDList placed in the Local LLDP database for a B role port.

First the function takes the smaller of the OperChnCap and RemoteChnCap and truncates the RemoteSVIDList to the smaller of the two.

A new OperSVIDList is created as follows:

a) For each S-channel in the RemoteSVIDList with a (SCID, S-VID) pair in the OperSVIDList, the (SCID, S-VID) remains unchanged unless the S-VID is no longer part of the LastLocalSVIDPool. If the S-VID is no longer in the pool, a new one is selected if available. If no S-VID is available, the (SCID, S-VID) pair will be deleted from the OperSVIDList.
b) For each S-channel in the OperSVIDList without a (SCID, SVID) pair in the RemoteSVIDList, the (SCID, SVID) pair will be deleted from the OperSVIDList.
c) For a (SCID, SVID) pair in the remote list, where the S-VID is zero, an S-VID is assigned if it is available and the pair is inserted in the OperSVIDList. If an S-VID is not available, the pair is not inserted in the OperSVIDList.
d) For a (SCID, SVID) pair in the remote list, where the S-VID is nonzero, there is no effect on the OperSVIDList.

43. Edge Control Protocol (ECP)

This clause provides an overview, detailed semantics, and state machines for ECP.

43.1 ECP operation

Figure 43-1 depicts, at a high level, ECP operation. In step 1, the upper layer protocol (ULP) passes an outgoing ULP Data Unit (ULPDU) to ECP by invoking a transmit request procedure. In step 2, the ULPDU, which for some ULPs (e.g., VDP) may contain a set of ULP TLVs, is transmitted and an ECP low-level acknowledgment (ACK) timer is set. The frame is not yet deleted from the transmit buffer until an ACK (L-ACK in the diagram) is received for that ECPDU. In step 3, the arriving ECP frame is received into a receive buffer, where it is held until it is removed by an ECP indication procedure that passes the ULP Data Unit to the associated upper-level protocol. In step 4, when the receive buffer is emptied, a L-ACK is sent to the sender. In step 5, if the L-ACK is received before the L-ACK timer expires, then the transmit buffer is cleared and ECP can process another ULPDU through the ECP procedure. However, if the L-ACK timer expires before the L-ACK is received, then the frame in the transmit buffer is re-sent and the L-ACK timer is re-initialized. This timeout and re-sending can occur up to a maximum number of retries determined by the value of the *maxRetries* parameter of the transmit state machine. If this number of retries is reached and there is still no response, then the transmit buffer is cleared, a failure counter is incremented, and the transmit state machine is then ready to process another ULPDU. There is no indication to the ULP that a transmission failure has occurred; it is the ULP's responsibility both to detect the failure condition and to recover from it in an appropriate way.

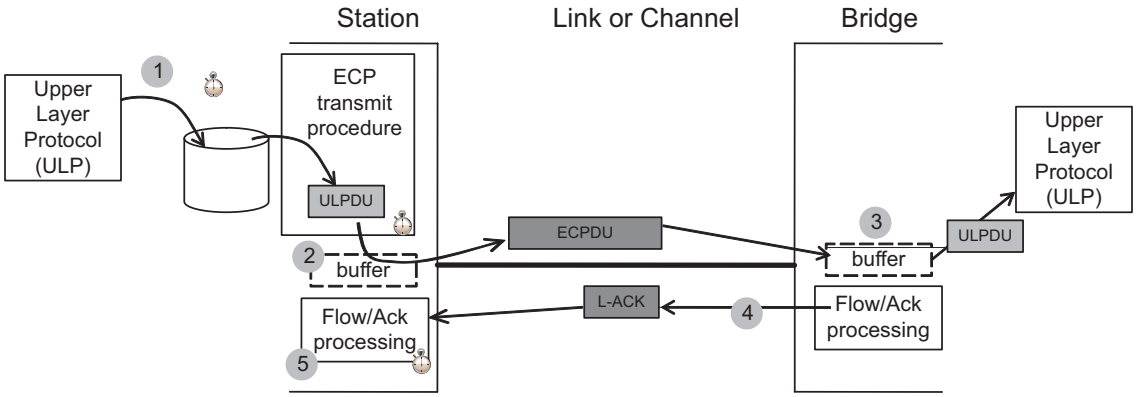


Figure 43-1—Example ECP exchange

ECP is intended to operate between two peers over an IEEE 802 LAN. ECP delivers the following service characteristics:

a) Reliable delivery of ULPDUs, resilient against frame loss. The value of the *maxRetries* parameter determines the number of sequential lost frames that the protocol can sustain.
b) Delivery of ULPDUs to the recipient ULP in the order that they were transmitted by the sending ULP.
c) Delivery of a single copy of each ULPDU to the recipient.
d) Flow control that provides protection against buffer overrun on the receive side.

43.2 Edge Control Sublayer Service (ECSS)

Two service primitives model the hand-off of data units between the ULP and ECP: ECP_UNITDATA.request and ECP_UNITDATA.indication.

ECP_UNITDATA.request (ulptype, ulpdu)

The ECP_UNITDATA.request primitive is invoked by the ULP to notify ECP that a ULPDU is ready to be transmitted. The **ulpdu** parameter is the ULPDU that the ULP wishes to transmit. The **ulptype** parameter identifies the type of the ULP (see 43.3.3).

NOTE—For example, for VDP the ULPDU consists of a set of VDP TLVs passed to ECP for transmission. The maximum size of the ULPDU, and therefore the set of TLVs that it can contain, is determined by the maximum SDU size supported by the underlying MAC (see 6.5.8).

ECP_UNITDATA.indication (ulptype, ulpdu)

The ECP_UNITDATA.indication is invoked by ECP to indicate a ULPDU has been received and is available for ULP processing. The **ulpdu** parameter is the ULPDU that has been received. The **ulptype** parameter identifies the type of the ULP, as indicated in the received ECPDU (see 43.3.3).

43.3 ECP state machines

43.3.1 State machine conventions

The notational conventions used in the specification of ECP are as stated in Annex E.

43.3.2 Overview

There are two state machines used by each ECP instance: the ECP transmit state machine (43.3.4) and the ECP receive state machine (43.3.5). A Bridge Port that supports ECP shall support one instance of the ECP transmit state machine and one instance of the ECP receive state machine.

Initialization of the transmit and receive state machines occurs when portEnabled (43.3.7.5) is FALSE, or when a BEGIN global event occurs. The transmit state machine transmits an ECPDU in response to an ECP_UNITDATA.request from the ULP that indicates there is a PDU ready to be transmitted. The PDU is transmitted with a sequence number that is used by the (remote) receive state machine in a responding ACK ECPDU. If no ACK with the correct sequence number is received within a defined time period, and if the maximum number of retries has not been reached, the transmit state machine retransmits the ECPDU. If the maximum number of retries is exceeded, or if an ACK is received that matches the last sequence number sent, then the transmit state machine increments the sequence number and waits for the next ECP_UNITDATA.request.

NOTE—The sequence number for the first ECPDU transmitted after a state machine initialization (which occurs when BEGIN is TRUE or portEnabled [43.3.7.5] is FALSE) is an implementation choice; for example, it could be a pre-determined number, a random number, or it could continue the sequence from the last sequence number used.

When the first ECPDU is received following initialization, the receive state machine initializes its local record of the last sequence number received to be one less than the sequence number in the received ECPDU. This record of the last sequence number received allows the state machine to detect whether the received ECPDU has been received already (current and last sequence numbers match) or this is a new ECPDU (current and last sequence numbers differ). In both cases, the receive state machine sends an ACK ECPDU, using the current sequence number. In the case that the received ECPDU is new, the last received sequence number is updated to reflect the sequence number of the received ECPDU, and an ECP_UNITDATA.indication is sent to the ULP to pass the contents of the ECPDU to the service user.

43.3.3 Edge Control Protocol Data Unit (ECPDU)

This subclause specifies the format of a ECPDU, along with the header that is added to and removed from ECP frames by the ECP function. The ECP header allows each ECPDU from the sender to be identified through a sequence number, which the receiver acknowledges by sending a ECP Acknowledgment frame. The format of the ECPDU is illustrated in Figure 43-2.

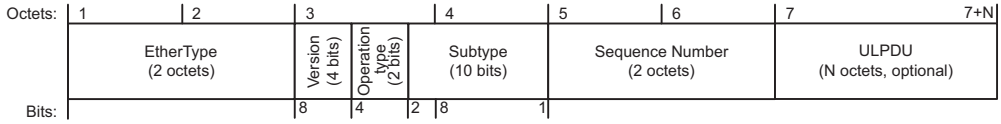


Figure 43-2—ECPDU structure

The destination address of the Ethernet frame that contains a ECPDU is specified by the ULP. The address used is either an individual MAC address or one of the reserved addresses specified in Table 8-1.

The source address shall be the individual MAC address of the sending station or port.

The fields of the ECPDU are defined in the following subclauses.

43.3.3.1 EtherType

A 16-bit field that contains the EtherType assigned for use by ECP (89-40).

43.3.3.2 Version

A 4-bit field that identifies the protocol version. The version shall be 0x01.

43.3.3.3 Operation type

A 2-bit field that identifies the operation type as follows:

a) ECP request (0x0)
b) ECP acknowledgment (0x1)

43.3.3.4 Subtype

A 10-bit field that defines the ULP type included in the PDU. For ACKs the subtype is ignored at the station. The subtype used by VDP is as shown in Table 43-1.

Table 43-1—ECP subtypes

Use	Reference	Subtype
VDP	Clause 41	0x0001
Port Extender Control and StatusProtocol (PE CSP)	IEEE Std 802.1BR	0x0002
Link-local Registration Protocol (LRP)	IEEE Std 802.1CS	0x0003
Reserved for future standardization	—	All other values

43.3.3.5 Sequence Number

A 2-octet field that identifies the sequential order of the PDU, with respect to other ECPDUs. The starting sequence number can start anywhere for the first ECPDU, but the sequence number for each subsequent new request ECPDU is incremented by 1 modulo 65536.

NOTE—The sequence numbers used by each instance of the ECP transmit state machine are independent of each other.

43.3.3.6 ULPDU

This field contains an upper layer protocol data unit (ULPDU) if the operation type in the Mode field is ECP request; the field is absent if the operation type is ECP acknowledgment.

43.3.4 ECP transmit state machine

The ECP transmit state machine shall implement the function specified by the state diagram in Figure 43-3 and the attendant definitions in 43.3.6 through 43.3.8.

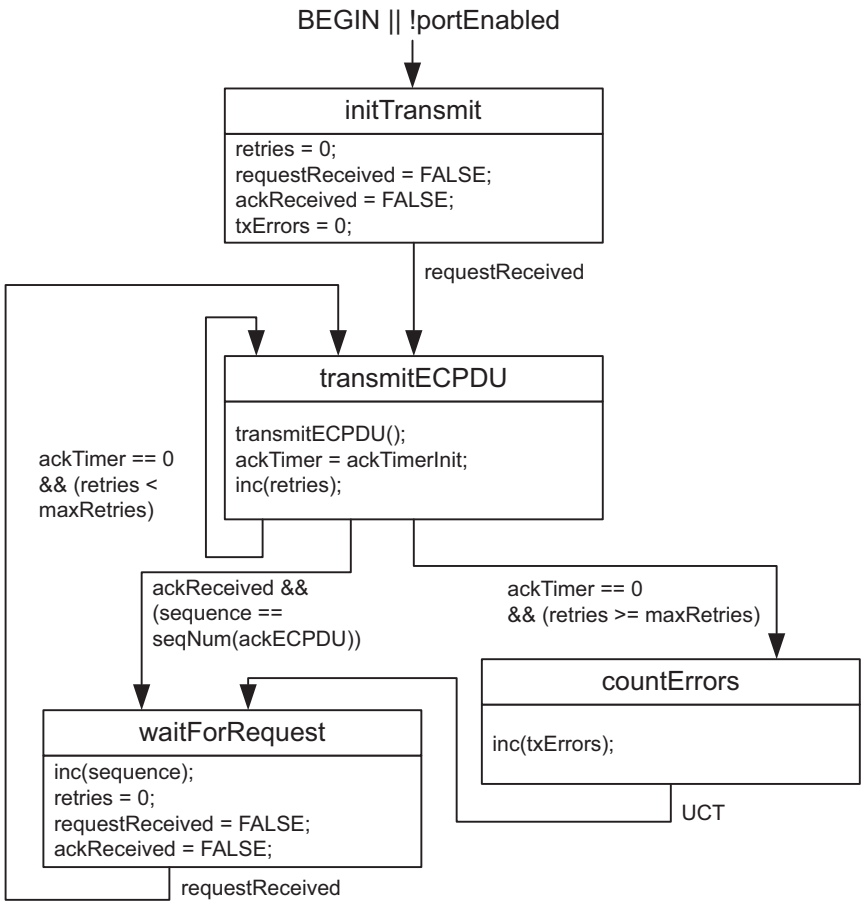


Figure 43-3—ECP transmit state machine

43.3.5 ECP receive state machine

The ECP receive state machine shall implement the function specified by the state diagram in Figure 43-4 and the attendant definitions in 43.3.6 through 43.3.8.

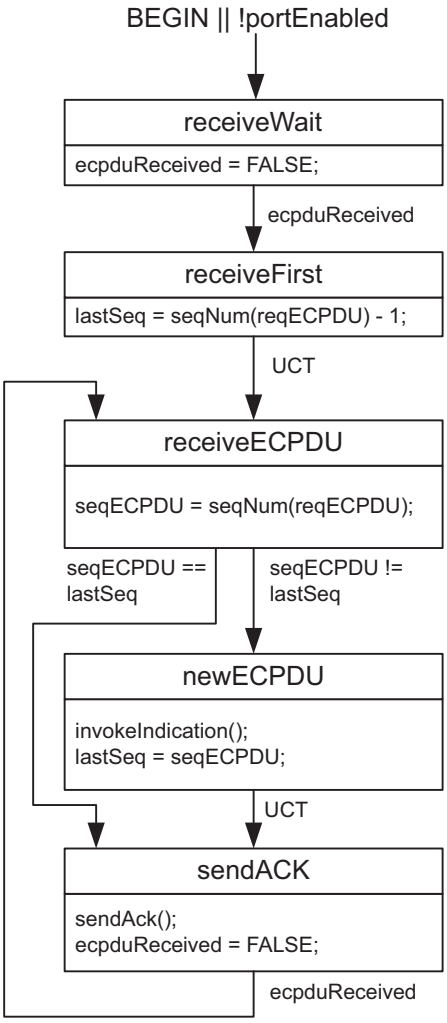


Figure 43-4—ECP receive state machine

43.3.6 ECP state machine timers

A set of timers is used by the ECP state machines; these operate as countdown timers (i.e., they expire when their value reaches zero). These timers are based on the Timer Exp data type (12.3). They:

a) Have a resolution of ten microseconds, with a tolerance of ± 20%.
b) Are started by loading an initial integer value, n, where $0 < n \leq 2^{31}$.
c) Are decremented by one per timer tick, as long as $n > 0$; the interval between timer ticks is the same as the timer resolution.
d) Represent the remaining time in the period.

43.3.6.1 ackTimer

The ackTimer is used to determine how long the transmit state machine will wait for an acknowledgment PDU to be received before it either retries a transmission or aborts a transmission due to too many retries. This timer is initialized using the value of ackTimerInit determined as stated in D.2.12.6.

43.3.7 ECP state machine variables and parameters

43.3.7.1 ackReceived

This Boolean variable is set to TRUE when an ECPDU is received with a MODE field indicating that the PDU is an ACK. The variable is set FALSE by the ECP transmit state machine once the ACK has been processed.

43.3.7.2 ecpduReceived

This Boolean variable is set to TRUE when an ECPDU is received with a MODE field indicating that the PDU is a request. The variable is set FALSE by the ECP receive state machine once the request has been processed and the ACK has been sent.

43.3.7.3 lastSeq

This integer variable is used to record the previous received sequence number.

43.3.7.4 maxRetries

This integer variable defines the maximum number of times that the ECP transmit state machine will retry a transmission if no ACK is received. The default value of maxRetries is 3; this variable can be changed by management as documented in 12.26.2. The value is derived from ecpOperMaxRetries (Table 12-31).

43.3.7.5 portEnabled

This Boolean variable is set to the value of the MAC_Operational parameter (IEEE Std 802.1AC) for the Port.

43.3.7.6 requestReceived

This Boolean variable is set to TRUE when a ULP issues an ECP_UNITDATA.request primitive. The variable is set FALSE by the state machine once the request has been processed.

43.3.7.7 retries

This integer variable counts the number of transmission retries that have been made for the current ECPDU.

43.3.7.8 seqECPDU

This integer variable is used to record the sequence number contained in the most recent received request ECPDU.

43.3.7.9 sequence

This integer variable is used to record the current sequence number that is used in transmitted request ECPDUs.

43.3.7.10 txErrors

This integer variable is used to count the number of times that the ECP transmit state machine has retransmitted an ECPDU.

43.3.8 ECP state machine procedures

43.3.8.1 inc(counter)

This procedure increments the counter variable by 1 modulo 65 536.

43.3.8.2 transmitECPDU()

This procedure causes an ECPDU to be transmitted, using the PDU structure defined in 43.3.3. The sequence number field is set to the least significant 16 bits of the current sequence number contained in the sequence variable (43.3.7.9). The mode field is set to ECP request. The ULPDU field is set to the value of the ulpdu parameter of the request primitive. The subtype field is set to the value of the ulptype parameter of the request primitive.

43.3.8.3 invokeIndication()

This procedure causes an ECP_UNITDATA.indication primitive to be invoked in order to pass the contents of an incoming ECPDU to the ECP service user. The ulptype parameter carries the value of the ULP type carried in the ECPDU. The ulpdu parameter carries the value of the ULPDU field of the ECPDU.

43.3.8.4 sendAck()

This procedure causes an ECPDU to be transmitted, using the PDU structure defined in 43.3.3. The sequence number field is set to the least significant 16 bits of the sequence number contained in the seqECPDU variable (43.3.7.8). The mode field is set to ECP acknowledgment. The ULPDU field is absent. The subtype field is set to the value of the ulptype parameter of the received request ECPDU.

43.3.8.5 seqNum(pdu-type)

This procedure returns an integer value equal to the value of the most recently received request ECPDU (pdu-type = reqECPDU) or acknowledgment ECPDU (pdu-type = ackECPDU).

44. Equal Cost Multiple Paths (ECMP)

SPB supports two approaches to spreading traffic load. The first approach, ECT VLANs, spreads traffic by assigning each service instance to a VLAN configured to use one of the supported SPT Sets. This approach is applicable to both SPBV and SPBM. Each Base VID is assigned to an ECT-ALGORITHM (tie-breaker) that defines the SPT Set for that VLAN, and different ECT Algorithms may thus be used to select different shortest paths in the SPT Region. In case of a PBBN, each I-SID is assigned to a Base VID. This approach can spread traffic load while maintaining traffic path congruence in each VLAN.

The second approach, ECMP, spreads traffic by employing multiple equal cost paths with a single VID. This approach is applicable only to SPBM. Unicast frame filtering dynamically selects a next hop from the set of equal cost next hops for the frame's destination MAC address. Multicast frame filtering is controlled by selecting a multicast routing mode and a tie-break mask for each backbone service instance and advertising that selection in ISIS-SPB. Multicast filtering entries for the backbone service instance are generated by calculations that select a multicast tree from the set of Equal Cost Trees (ECTs) in the SPT Region based on the advertised multicast mode and tie-break mask.

44.1 SPBM ECMP

44.1.1 ECMP Operation

SPBM ECMP provides a mechanism to spread traffic load across a set of equal cost shortest paths in an SPT Region using a single VID. Rather than using one equal cost tie-breaking function to create a single SPT for all individual addresses, ECMP uses a hash function to spread individual address forwarding over a set of equal cost forwarding ports.

If flow filtering (44.2) is not supported, the ECMP ECT Algorithm selects one port from the set of equal cost forwarding ports for each individual address (44.1.2) and creates a Dynamic Filtering Entry for the address indicating the selected port.

If flow filtering (44.2) is supported, a set of equal cost forwarding ports may be recorded in the FDB in a Dynamic Filtering Entry (8.8.3). During unicast frame filtering the MAC Relay Entity selects one forwarding port from the applicable set using a dynamic port selection process (44.2.3).

The individual address forwarding port selection processes, both with and without flow filtering, are designed to:

a) Spread traffic (i.e., make varied choices) for different flows traversing the SPT Region, and
b) Maintain frame ordering for each flow by making the same choice for all frames belonging to any single flow.

ECMP is supported by Dynamic Filtering Entries in the FDB and, optionally, the flow filtering tag (F-TAG, 44.2.1) that carries Flow Hash and TTL information. The flow hash serves both to distinguish frames belonging to different flows and to identify frames that belong to (or may belong to) the same flow. The flow hash is used as input to the dynamic port selection process to support the design goals noted above. The TTL is used to mitigate traffic loops, if they happen to occur (44.2.4).

While unicast frames are spread across equal cost paths, multicast frames cannot be treated this way. Instead multicast traffic load is spread by assigning a multicast mode and tie-breaker to each group address. This selection enables the use of varied SPTs for each group address or set of group addresses. The default ECMP ECT Algorithm selects a source rooted SPT for each node that may transmit multicast traffic. This default source rooted SPT is used for all group addresses assigned to that node. Finer grained control of multicast load spreading is done by selecting a multicast mode and tie-break mask for a particular I-SID. This

selection governs the multicast routing used for that I-SID's assigned group address. The selectable multicast modes include the following:

c) Source rooted SPT
d) Shared tree
e) Head-end replication

Up to 16 source rooted SPTs can be supported per node by using one of 16 different tie-break masks in calculating the SPT. During SPT calculation the tie-break mask is used to select one from the set of equal cost parents (neighbor nodes closer to the root) for each node (28.9). The default multicast treatment is equivalent to using a tie-break mask of zero. An I-SID on a CBP can be assigned to a specific SPT by configuring the Tie-Break Mask for that I-SID [item h) in 12.25.6.1.2 and item h) in 28.12.10].

To reduce the amount of multicast forwarding state required, shared (spanning) trees are supported. Up to 16 shared trees can be configured using the 16 tie-break masks. For shared trees the tie-break mask is used both to select a shared tree root Bridge and to select from the set of equal cost parents for each node in the tree. The shared tree root for a given tie-break mask is determined by selecting the best (least) masked Bridge ID (i.e., the Bridge ID value masked using the tie-break mask). The SPT calculation from the shared tree root also uses the tie-break mask to select between equal cost parents (again selecting the least masked Bridge ID). Each I-SID on a CBP can be assigned to a shared tree by setting a shared tree transmit indicator bit and configuring the tie-break mask to identify the shared tree (28.12.10). All CBPs for a given I-SID that transmit on a shared tree use the same group address (Figure 27-6), and share the forwarding state for this address in the FDB.

It is possible to avoid using group addresses altogether and handle multicast frames by head-end replication. An I-SID on a CBP using head-end replication sends a unicast frame to each destination instead of sending a group addressed frame. If an I-SID is using head-end replication it is configured to indicate no multicast transmission from that CBP. In this case no group address forwarding state will be installed for that I-SID's assigned address at that CBP (28.9). An I-SID using head-end replication at a CBP should nevertheless indicate that it wishes to receive multicast frames since other CBPs supporting the same I-SID may still use multicast.

NOTE—ISIS-SPB does not check for the use of the same tree type for all endpoints of an I-SID, but use of different tree types within a single I-SID is not recommended.

44.1.2 ECMP ECT Algorithm

The content of FDB entries for individual addresses in ECMP depends on whether flow filtering (44.2) is supported by a Bridge.

If flow filtering is not supported or the ECT-ALGORITHM value indicates no flow filtering (Table 44-1), then for each individual address the ECMP ECT Algorithm selects one port from the set of equal cost forwarding ports using a form of the FNV non-cryptographic hash algorithm and creates a Dynamic Filtering Entry (8.8.3) indicating that port as forwarding. The forwarding port is selected by the following process:

For a set of *k* equal cost forwarding Ports, let P be an ordered list of the forwarding Ports sorted from greatest to least neighbor SPB System Identifier and Pi be the ith Port in P. Thus P0 is the Port whose neighbor has the greatest SPB System Identifier and Pk–1 is the Port whose neighbor has the least SPB System Identifier. The following algorithm is used to select a value for i for the individual MAC address, thus selecting Port Pi to be the forwarding port:

a) Set a 32-bit variable *bestHash32* to 0xFFFFFFFF.
b) Set *i* to 0 (zero).

c) For each *n* in 0..*k*–1, (in order) perform the following steps:
   1) Set a 32-bit variable *hash32* to 0x811C9DC5.
   2) For each octet O_j (extended to 32 bits with leading 0's) in the Bridge's SPB System Identifier (8.13.8), starting with the least significant octet (octet 5) and progressing to the most significant octet (octet 0), set *hash32* to ((*hash32* XOR O_j) × 0x01000193).
   3) For each octet O_j (extended to 32 bits with leading 0's) in the neighbor SPB System Identifier for Port P_n, starting with the least significant octet (octet 5) and progressing to the most significant octet (octet 0), set *hash32* to ((*hash32* XOR O_j) × 0x01000193).
   4) For each octet O_j (extended to 32 bits with leading 0's) in the individual MAC address, starting with the least significant octet (octet 5) and progressing to the most significant octet (octet 0), set *hash32* to ((*hash32* XOR O_j) × 0x01000193).
   5) If *hash32* < *bestHash32*, set *i* to *n* and set *bestHash32* to *hash32*.

If flow filtering (44.2) is supported and the ECT-ALGORITHM value indicates flow filtering (Table 44-1), ISIS-SPB configures the Flow Filtering Control Table (44.2.2) for each port on which the ECMP SPBM VID is registered (27.13). For CBPs the Base VID is configured with both Flow Filtering and Flow Hash Generation enabled. For PNPs the Base VID is configured with Flow Filtering enabled and Flow Hash Generation disabled. For each individual address the ECMP ECT Algorithm calculates a Port Map specifying forwarding for a set of equal cost hops to that address and creates a corresponding Dynamic Filtering Entry (8.8.3). These Dynamic Filtering Entries are used in the dynamic selection of forwarding ports by the flow filtering process (44.2.3).

For each I-SID on a CBP transmitting multicast frames, the ECMP ECT Algorithm may calculate a source rooted SPT. If equal cost paths are found to any node on the tree, the path whose parent node (neighbor node toward the root) has the least Bridge Identifier is selected. A group MAC Address Registration Entry (8.8.4) is created for the I-SID's source rooted tree SPBM group MAC address (Figure 27-3) if the node performing the calculation is located between the source node and any multicast receiver(s) for the I-SID. The group MAC Registration Entry indicates forwarding for each port that leads to at least one multicast receiver for the I-SID on the calculated SPT (except the port from the source).

The ECMP ECT Algorithm supports two additional parameters that control multicast forwarding state calculation. First, a Tie-Break Mask value may be specified for an I-SID on a CBP [item i) in 28.12.10 and item h) in 12.25.6.1.2]. When a nonzero Tie-Break Mask is advertised, a 64-bit mask (formed by repeating the 4-bit Tie-Break Mask value in each nibble) is applied to (XORed with) each Bridge Identifier before selecting the lowest value as described in the SPT calculation in the paragraph above. Thus the default behavior described above is equivalent to using a Tie-Break Mask of zero. This parameter enables up to 16 different SPTs to be calculated from a given source node. Each I-SID on a CBP may be assigned independently to one of these 16 source trees.

The second parameter controlling multicast forwarding state calculation is the shared tree indicator. An I-SID on a CBP may be configured to use a shared tree instead of a source-specific SPT [item h) in 28.12.10 and item g) in 12.25.6.1.2]. There may be up to 16 shared trees, corresponding to the 16 Tie-Break Mask values. Each shared tree is calculated by selecting a root Bridge using the least masked Bridge Identifier. If a node advertises a Bridge Priority for the given Tie-Break Mask (28.12.6.1) the advertised value is used instead of the normal Bridge Priority in forming its Bridge Identifier (before masking). In calculating the SPT from the selected root, the same Tie-Break Mask is used to form masked Bridge Identifiers (using the normal Bridge Priority), and the least value of masked Bridge Identifier is used to choose between equal cost parents for any node. If an I-SID on a CBP is configured to use a shared tree, the group address used in the group MAC Address Registration Entry is constructed using the Tie-Break Mask and the I-SID (27.15, Figure 27-6). In this case the ECMP ECT Algorithm creates a group MAC Address Registration Entry if the node performing the calculation is between the CBP and any multicast receivers on the SPT calculated from the selected root node. The Port Map indicates forwarding for all Ports that lead from a multicast transmitter to at least one multicast receiver for the I-SID.

If an I-SID on a CBP does not indicate transmission of multicast frames (e.g., head-end replication is to be used instead), then no group MAC Address Registration Entry is configured for multicast from that CBP for that I-SID.

Table 44-1 shows the ECT-ALGORITHM values for the ECMP ECT Algorithm.

Table 44-1—ECMP ECT-ALGORITHM values

ECT-ALGORITHM	ECMP behavior
00-80-C2-11	ECMP without flow filtering
00-80-C2-12	ECMP with flow filtering

44.1.3 Loop prevention for ECMP

Loop prevention for unicast ECMP operates as specified in Clause 13 with the extension of allowing multiple Root Ports in case of multiple equal cost paths in order to support the per frame tie-breaking of ECMP. The ECMP connectivity to a destination bridge comprises the shortest paths destined to that bridge when the topology is Agreed in the meaning of the Agreement Protocol. If a bridge is not the destination bridge, then the one or more ports that ISIS-SPB has calculated as respectively providing a shortest path to the destination is a Root Port in the ECMP connectivity. Each port, other than a Root Port, is a Designated Port if ISIS-SPB has calculated that the port provides a shortest path for frames forwarded from the attached bridge to the destination in the ECMP connectivity. With these extensions to the definitions of Port Roles, Clause 13 specifications apply to ECMP as well.

NOTE 1—Despite allowing more than one Root Port for an SPT Bridge, a single Root Port is enforced on a per-frame basis as ECMP operation ensures that a frame is forwarded through only one of the Root Ports towards the destination.

Loop prevention for the shared trees used for ECMP multicast operates as specified by Clause 13 for shared spanning trees except for that instead of a Spanning Tree Protocol Entity (STPE), it is ISIS-SPB that configures the per-tree Port States and Roles based on its calculations and the operation of the Agreement Protocol; furthermore, the Learning Process (8.7) neither creates nor deletes Dynamic Filtering Entries.

NOTE 2—The per-tree Port States and Roles do not belong to an MSTI having a distinct MSTID because an ECMP B-VID is assigned to the SPBM MSTI. The Port States and Roles are associated with a single SPT used as a shared spanning tree supporting bidirectional forwarding (not as a unidirectional tree as for SPB).

44.2 Support for Flow Filtering

Flow filtering support enables Bridges to distinguish frames belonging to different client flows and to use this information in the forwarding process. Information related to client flows may be used at the boundary of an SPT Domain to generate a flow hash value. The flow hash, carried in an F-TAG, serves to distinguish frames belonging to different flows and can be used in the forwarding process to distribute frames over equal cost paths. This provides for finer granularity load spreading while maintaining frame order for each client flow.

Flow filtering behavior is controlled by ISIS-SPB. To allow Bridges that support flow filtering to be used alongside Bridges that do not support flow filtering, ISIS-SPB requires that all Bridges at the SPT Domain boundary that advertise I-SIDs for an ECMP Base VID using flow filtering support F-TAG processing. Bridges that do not advertise I-SIDs for that Base VID are not required to support flow filtering. Therefore,

network operators are able to upgrade selected bridges to support flow filtering and use flow filtering for selected VIDs without requiring the simultaneous upgrade of all bridges in the SPT Domain.

NOTE—Support for F-TAG processing is indicated in I-SID advertisements and so is only available via ISIS-SPB once I-SIDs are assigned to the Base-VID. A "dummy" ISID configuration can be used to discover via ISIS-SPB whether F-TAG processing is supported on a Bridge.

This clause specifies the following:

a) A flow filtering tag (F-TAG) that carries a flow hash value (44.2.1).
b) F-TAG processing on Bridge Ports (44.2.2).
c) A forwarding process using the flow hash to select one forwarding port from a set of equal cost options (44.2.3).
d) TTL loop mitigation (44.2.4).
e) CFM for ECMP with flow filtering (44.2.5).
f) Operation of bridged LANs with selective support for flow filtering (44.2.6).

44.2.1 Flow filtering tag (F-TAG)

An F-TAG is specified to carry additional information in support of flow filtering functions. The F-TAG comprises a Tag Protocol Identifier (TPID) (EtherType) and Tag Control Information (TCI).

Table 44-2—F-TAG EtherType

Tag Type	Name	Value
Flow Filtering Tag	IEEE 802.1Q Flow Filtering Tag EtherType	89-4B

The F-TAG TCI field (Figure 44-1) is 4 octets in length and encodes priority, drop_eligible, TTL, and flow hash information for a service primitive.

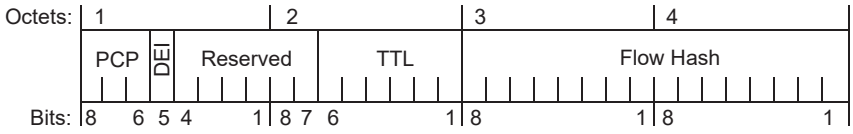


Figure 44-1—Flow Filtering TCI format

The F-TAG TCI contains the following fields:

a) *PCP (Priority Code Point)*—This 3-bit field encodes the priority and drop_eligible parameters of the service request primitive associated with this frame using the same encoding as specified for VLAN tags in 6.9.3.
b) *DEI (Drop Eligible Indicator*)—This 1-bit field carries the drop_eligible parameter of the service request primitive associated with this frame.
c) *Reserved*—This 6-bit field may be used for future format variations. The Reserved field contains a value of zero when the tag is encoded and is ignored when the tag is decoded.
d) *TTL (Time To Live)*—This 6-bit field holds a counter value that is decremented each time the F-TAG is read (44.2.2.1) and provides a mechanism to limit the number of network hops a frame may take.
e) *Flow Hash*—This 16-bit field carries a flow hash value used in the dynamic port selection process for ECMP (8.8.3).

44.2.2 F-TAG processing

This standard specifies flow filtering behavior for SPBM ECMP (44.2). To support this behavior, a flow hash may be conveyed in a mac_service_data_unit using an F-TAG (44.2.1). This clause specifies a Support for Flow Filtering shim that produces and processes F-TAG information. The shim has two EISS SAPs—a lower EISS toward a LAN and an upper EISS toward the MAC Relay Entity.

At the boundary of a flow filtering SPT Domain, for example, at CBPs, the flow hash is generated for EM_UNITDATA.indication primitives. At intermediate ports, for example, PNPs, the F-TAG is generated using the flow hash in EM_UNITDATA.request primitives or processed to retrieve the flow hash value from EM_UNITDATA.indication primitives. The F-TAG also includes a TTL field, used for loop mitigation, and PCP and DEI fields that are processed by this shim.

Flow filtering support is governed by a Flow Filtering Control Table for each port containing an entry for each VID with the following fields:

a) Flow Filtering (enabled/disabled). This field indicates whether flow filtering behavior is enabled on the port for the VID. The default value is disabled.
b) Flow Hash Generation (enabled/disabled). This field indicates whether flow hash generation is enabled on the port for the VID. The default value is disabled.
c) TTL Value (1..63). This field is the initial TTL value for frames entering the flow filtering SPT Domain [item d) in 12.16.5.5.2]. The default value is 8.

The Flow Filtering Control Table is provisioned by ISIS-SPB (44.1.2). For flow filtering, a CBP will have both the Flow Filtering field and the Flow Hash Generation field set to enabled and the TTL Value field set to provide the initial time_to_live value for indication primitives. For flow filtering, a PNP will have the Flow Filtering field set to enabled and the Flow Hash Generation field set to disabled. The TTL Value field (initial TTL value) is not used on a PNP.

NOTE—Based on the description above, for flow filtering, the condition “Flow Hash Generation field indicates enabled” is equivalent to indicating a CBP, and the condition “Flow Hash Generation field indicates disabled” is equivalent to indicating a PNP.

44.2.2.1 Data indications

On receipt of an EM_UNITDATA.indication primitive from the lower EISS on a PNP, the received frame shall be discarded if:

a) For the vlan_identifier in the Flow Filtering Control Table, the Flow Filtering field indicates enabled, and the initial octets of the mac_service_data_unit do not contain a valid F-TAG; or
b) The value in the TTL field in the F-TAG is 0.

NOTE 1—A frame received with a TTL value of 0 will be discarded, i.e., not relayed, even if it is addressed to another port on the receiving Bridge.

Otherwise, an EM_UNITDATA.indication primitive is invoked at the upper EISS with parameter values determined from the received primitive based on the Flow Filtering Control Table for the received vlan_identifier as follows:

c) If the Flow Filtering field indicates disabled, the invoked primitive is identical to the received primitive.
d) If the Flow Filtering field indicates enabled, the **destination_address**, **source_address**, **vlan_identifier**, and **connection_identifier** in the invoked primitive are identical to those parameters in the received primitive.
e) If the Flow Filtering field indicates enabled and the Flow Hash Generation field indicates disabled, the **mac_service_data_unit** in the invoked primitive is created by removing the F-TAG from the

received **mac_service_data_unit**; otherwise, the **mac_service_data_unit** in the invoked primitive is identical to the received primitive.

The value of the **flow_hash** and **time_to_live** parameters are determined as follows:

f) If the Flow Hash Generation field indicates enabled, the value of flow_hash is generated from the received primitive (using a process selected by the implementation). time_to_live is set to the TTL Value from the Flow Filtering Control Table for the received vlan_identifier.

NOTE 2—Procedures for calculating the flow hash are not covered by this standard. The procedure is typically a protocol-dependent hash of the client protocol header being carried within the mac_service_data_unit.

NOTE 3—There is often a compromise between the speed of a hash calculation and the quality of value spreading. This standard makes no assurances regarding the quality of the distribution of flow_hash values.

g) If the Flow Hash Generation field indicates disabled, the value of flow_hash is taken from the Flow Hash field in the received F-TAG, and time_to_live is set to the TTL value in the received F-TAG decremented by 1.

The value of the **drop_eligible** and **priority** parameters are determined as follows:

h) If the **mac_service_data_unit** was tagged with an F-TAG, the value of the drop_eligible parameter and the received priority value are decoded as described in 6.9.3, using the PCP and DEI values from the F-TAG. Otherwise,

i) The received priority value and the drop_eligible parameter value are the values in the EM_UNITDATA.indication.

j) The value of the priority parameter is then regenerated from the received priority, as specified in 6.9.4.

44.2.2.2 Data requests

On invocation of an EM_UNITDATA.request primitive at the upper EISS, an EM_UNITDATA.request primitive is invoked at the lower EISS, with parameter values determined based on the Flow Filtering Control Table for the received vlan_identifier.

If the Flow Filtering field indicates disabled or the Flow Hash Generation field indicates enabled, the invoked primitive is identical to the received primitive.

If the Flow Filtering field indicates enabled and the Flow Hash Generation field indicates disabled, all parameters in the invoked primitive match those in the received primitive except the mac_service_data_unit. The mac_service_data_unit in the invoked primitive is formed by inserting an F-TAG as the initial octets to the received mac_service_data_unit. The values of the **flow_hash**, **time_to_live**, **priority**, and **drop_eligible** parameters are used to determine the contents of the F-TAG, in accordance with 44.2.1.

44.2.3 Forwarding process extension for flow filtering

Frame filtering (8.6.3) reduces the set of potential transmission ports in accordance with applicable FDB entries. When flow filtering is enabled, the ISIS-SPB control plane creates Dynamic Filtering Entries with multiple forwarding Ports in the Port Map when there are multiple equal cost hops to a given individual address. Frame filtering must select only one of these forwarding ports on which to transmit each frame with a matching destination_address and VID.

Selection of one Port from a set indicated by the Port Map shall be performed using a form of the FNV non-cryptographic hash algorithm as follows:

For a Port Map specifying k potential forwarding Ports, let **P** be an ordered list of potential forwarding Ports sorted from greatest to least neighbor SPB System Identifier and P_i be the ith Port in **P**. Thus P_0 is the Port

whose neighbor has the greatest SPB System Identifier, and P_{k-1} is the Port whose neighbor has the least SPB System Identifier. The following dynamic port selection process is used to select a value for *i*, thus selecting Port P_i to be the transmission port:

a) Set a 32-bit variable *hash32* to 0x811C9DC.
b) For each octet O_j (extended to 32 bits with leading 0's) in the Bridge's SPB System Identifier (8.13.8), starting with the least significant octet (octet 5) and progressing to the most significant octet (octet 0), set *hash32* to ((*hash32* XOR O_j) × 0x01000193).
c) For each octet O_j (extended to 32 bits with leading 0's) in the flow_hash parameter, starting with the least significant octet (octet 4 of Figure 44-1) and progressing to the most significant octet (octet 3 of Figure 44-1), set *hash32* to ((*hash32* XOR O_j) × 0x01000193).
d) Set a 16-bit variable *hash16* to ((*hash32* and 0x0000FFFF) XOR (*hash32* / 0x00010000)).
e) Set *i* to (*hash16* mod *k*), selecting Port P_i.

44.2.4 TTL Loop mitigation

The F-TAG contains a TTL field whose value is decremented each time a frame is forwarded by an SPT Bridge supporting flow filtering [item g) in 44.2.2]. A frame is filtered (discarded) if it is received with a TTL value of 0. This mechanism mitigates the impact of looping frames by limiting the number of hops these frames may travel in the network. This method of loop mitigation protects network resources by ensuring frames are forwarded at most a fixed number of times.

NOTE—The TTL carried in the F-TAG is decremented for all frames; however, the Flow Hash is applicable only to unicast frames. The Flow Hash has no effect on the filtering of group addressed frames.

44.2.5 CFM for ECMP with flow filtering

CFM as specified in Clause 18 through Clause 22 provides capabilities useful in detecting, isolating, and reporting connectivity faults. SPBM MAs (27.18) can be used with an ECMP VID and provide most of the necessary CFM functionality. One additional MA type is specified for ECMP, the ECMP path MA, because an SPBM path MA can test only one path between a pair of endpoints.

An ECMP path MA is used to continuously test multiple paths between two endpoints. This type of MA has only two MEPs at two SPT Region boundary ports. The MA is identified by a TE-SID comprising an ESP in each direction between the two endpoints. An ECMP path MEP cycles through a set of flow hash values intended to direct the CCM frames along (and thus test) different paths to the other MEP in the MA. Each flow hash is used in multiple consecutive CCM frames so that a fault on a particular path will be detected and reported back via an RDI signal. This standard does not specify the mechanisms that would be necessary to support Loopback and Linktrace on an ECMP path MA since full Loopback and Linktrace coverage can be provided by an SPBM VID MA. Therefore, there are no MHFs associated with an ECMP path MA.

44.2.5.1 ECMP path MEP placement in a Bridge Port

Since ECMP path MEPs must only see traffic from one other endpoint, these MEPs need to be further differentiated by the TESI Multiplex Entity (6.19). This locates an ECMP path MEP so that it receives CCMs only from the other MEP in its MA. Figure 44-2 shows an example of ECMP path MEPs on a CBP.

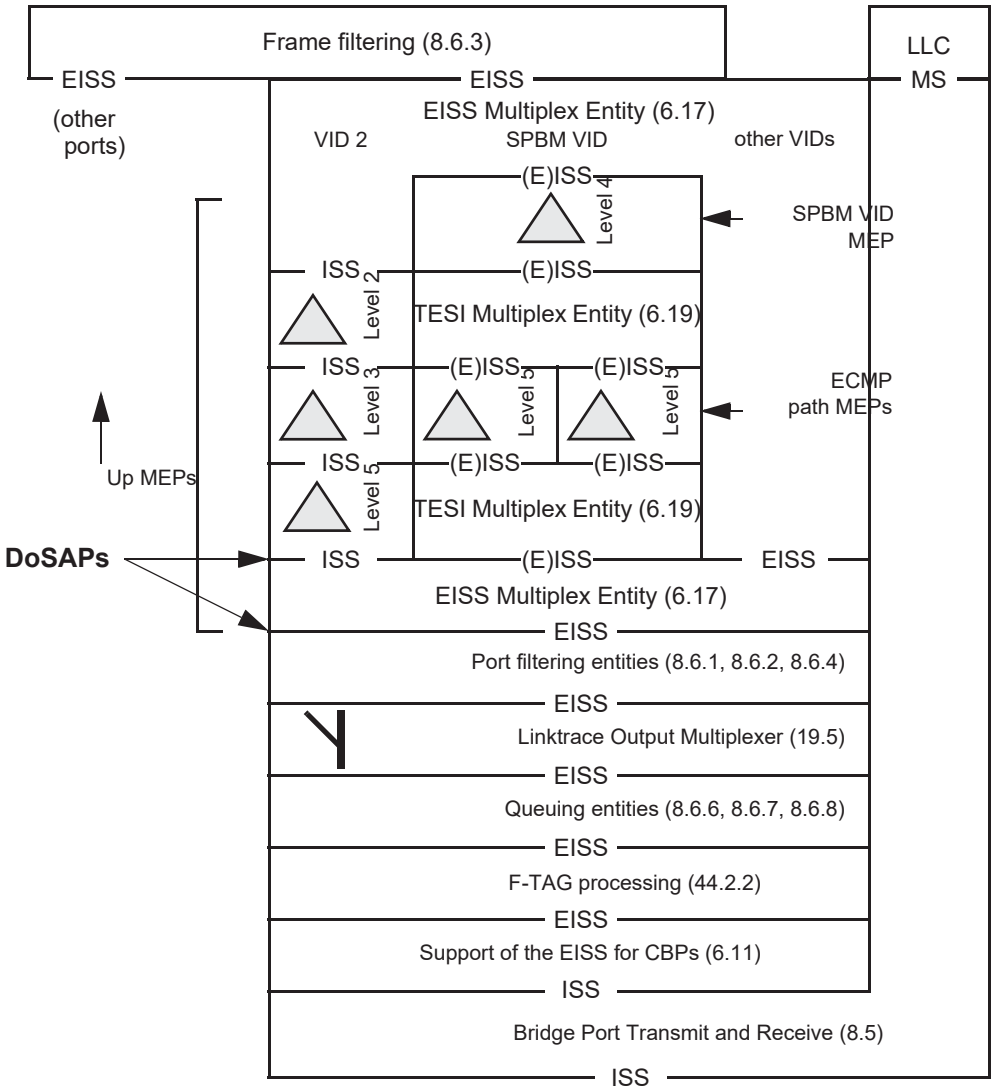


Figure 44-2—SPBM VID MEP and ECMP path MEP placement in a CBP

44.2.5.2 Continuity Check protocol in an ECMP path MA

The Continuity Check protocol is described in 20.1 and the corresponding state machines in Clause 20. The modifications required to realize ECMP path MAs include the following:

a) The MEP Continuity Check Initiator state machine adds three variables for controlling ECMP path testing (20.10.4, 20.10.5, 20.10.6) and shares two of these with the Remote MEP state machine (Figure 20-1).

b) The destination_address parameter is set to the individual MAC address of the other MEP in the MA [item a) in 20.11.1].

c) The flow_hash parameter is set to one of the values to be tested, and the time_to_live parameter is set as specified in item e) in 20.11.1.

d) The MEP Continuity Check initiator state machine is modified to support a cycle of path tests for an ECMP path MEP (20.12).

e) The Remote MEP state machine is modified to track a cycle of path test RDI values and report rMEPlastRDI as set if any RDI has been seen in the last path test cycle for an ECMP path MEP (20.19.2, 20.20).

NOTE—In an ECMP path MEP testing a set of paths, the RDI signal reflects back the state of far end CCM reception. Using the current CCM sending cycle position (pathN), the CCM sending rate, and the path round trip delay, one can calculate roughly the position in the sending cycle corresponding to a received RDI. This approach makes minimal changes to the CCM state machines at the CCM sending MEP and no changes at the CCM receiving MEP. It is subject to some ambiguity based on differences in path delay, the sending rate, and cycle length. In the case of ambiguous results, further testing would be required to identify a faulty path.

SPBM MAs may also implement the following enhancements to the Continuity Check protocol:

f) The procedure MEPprocessEqualCCM() on ECMP path MEPs does not include the check of the MAID on received CCMs [item b) in 20.17.1].

All other Continuity Check processes are the same as those for a VID-based MA.

44.2.6 Operation with selective support for flow filtering

When adding new capabilities to a network, it is desirable to make changes incrementally rather than perform a wholesale upgrade (e.g., incur a “flag day” event). Flow filtering is optional functionality that can be used with selected Base-VIDs while not adversely affecting other services in the network. However, flow filtering changes frame encoding (i.e., adds new header information in an F-TAG) and therefore requires that a Base-VID using ECMP with flow filtering have all its boundary points capable of processing the F-TAG. To enable incremental incorporation of flow filtering, ISIS-SPB requires F-TAG support for any Bridges with a CBP associated with a Base VID using ECMP with flow filtering while allowing other Bridges in the SPT region to operate without flow filtering support.

When the ECMP ECT-ALGORITHM value indicates support for flow filtering (Table 28-1), an I-SID cannot be configured to use a Base VID using ECMP with flow filtering unless the Bridge supports flow filtering (12.16.5.2). Requiring all Bridges advertising service instances using ECMP with flow filtering to support F-TAG processing provides for proper handling of F-tagged frames at the boundary of the SPT Domain.

Within the SPT Domain, it is possible to use Bridges that support the ECMP ECT Algorithm but do not support flow filtering (i.e., do not recognize F-TAGs). In this case, the ECMP ECT Algorithm (28.9) selects one port from the set of equal cost forwarding ports for each individual address and creates a Dynamic Filtering Entry for the address indicating the selected port.

NOTE—Bridges that do not support flow filtering should not change PCP and DEI values for frames carrying F-TAGs as this may not provide the desired behavior. If the PCP and DEI values are changed in the VLAN tag only, the PCP and DEI values carried in the F-TAG will be reasserted when the F-TAG is next processed.

These ECMP behaviors enable incremental upgrade of edge bridges to support flow filtering and selective use of this capability with I-SIDs registered only at these upgraded edge bridges. ECMP operation with selective support for flow filtering enables incremental introduction of flow filtering capabilities into an existing network and earlier introduction of flow filtering support for selected services.

45. Path Control and Reservation (PCR)

This clause specifies IS-IS extensions to provide the following:

a) Establishment of explicit trees for frame forwarding in an SPT Region (45.1),
b) Use of IS-IS to communicate bandwidth assignments made by the Path Computation Element (PCE) (45.2), and
c) Redundancy with the establishment of the corresponding trees (45.3).

The Path Control and Reservation (PCR) IS-IS extensions specified in this clause are compatible with ISIS-SPB specified in Clause 27 and Clause 28. Furthermore, IS-IS with PCR extensions (ISIS-PCR) relies on the SPB architecture and terminology; and ISIS-PCR also leverages some of the ISIS-SPB sub-TLVs (see, e.g., 5.5) as specified by this clause. This specification considers only point-to-point links for PCR although IS-IS also supports shared media LANs.

NOTE 1—ISIS-PCR does not require the implementation of the full ISIS-SPB protocol; but in addition to IS-IS, ISIS-PCR requires the support of the ISIS-SPB sub-TLVs listed in 5.5 (also listed as PCR-2–PCR-5 in A.43), whose use is specified by this clause. Nonetheless, if an SPT Bridge supports both ISIS-SPB and ISIS-PCR, then both of them are implemented by the same IS-IS Higher Layer Entity.

A VID can be associated with an explicit tree, i.e., with an explicit active topology within an SPT Region. The Base VID of the VLAN is then associated with explicit path control mode of IS-IS operation, i.e., ISIS-PCR. A VID can be associated with multiple explicit trees if the considerations explained in 45.1.4 are taken into account. VIDs controlled by ISIS-PCR do not participate in ECMP operation (Clause 44).

NOTE 2—A VLAN can provide a point-to-point, point-to-multipoint, or multipoint-to-point service using the multipoint-to-multipoint connectivity provided by an active topology. Similarly the Transmit and Receive IS-IS sub-TLV flags (28.12.10) of Edge Bridges allow an I-SID to use a multipoint-to-multipoint VLAN to provide point-to-point, point-to-multipoint, or multipoint-to-point service.

Path Computation Element (PCE) entities are external to the IS-IS protocol and fully or partially determine and describe each explicit tree to be established by ISIS-PCR throughout an SPT Region. There can be multiple PCEs in a region; nevertheless, any given explicit tree is under the control of one PCE. Explicit trees can be used, for example, for placing selected traffic on a precisely defined route, usually off the shortest path tree.

ISIS-PCR is able to record and communicate bandwidth assignments if instructed to do so by a PCE. ISIS-PCR can be used for bandwidth assignments only if MSRP is not used in the SPT Region. If ISIS-PCR communicates bandwidth assignments, then the tree descriptor assembled by the PCE also includes the details of the bandwidth assignment to be recorded by the Bridges. This mode of operation is expected to be used to divert traffic aggregates off their shortest path route, in order to avoid potential congestion on the default shortest path.

The redundancy provided by a physical topology can be leveraged by various resiliency schemes. A PCE can be used for the computation, and ISIS-PCR can be used for the establishment of the trees required for a given resiliency solution.

45.1 Explicit trees

This subclause specifies IS-IS extensions that provide explicit forwarding trees for data frames. An explicit tree is determined by a Path Computation Element (PCE) and is not required to follow the shortest path. PCE is defined by IETF RFC 4655 [B34]. A PCE is an entity that is capable of computing a topology for forwarding based on a network topology, its corresponding attributes, and potential constraints. A PCE explicitly describes a forwarding tree as specified in 45.1.9. Either a single PCE or multiple PCEs determine explicit trees for a region. Even if there are multiple PCEs in a region, each explicit tree is determined by only one PCE, which is referred to as the owner PCE of the tree. PCEs and ISIS-PCR can be used in combination with ISIS-SPB shortest path routing.

A PCE is a higher layer entity in an SPT Bridge or an end station. The PCE interacts with the active topology control protocol, i.e., with ISIS-PCR. The collaboration with ISIS-PCR can be provided by a Path Control Agent (PCA) on behalf of a PCE. Either the PCE or the corresponding PCA is part of the IS-IS Domain. If the PCE is not part of the IS-IS Domain, then the PCE has to be associated with a PCA that resides either in an SPT Bridge or in an end station directly connected to at least one Bridge of the SPT Region. The PCE or its PCA establishes IS-IS adjacency (45.1.7) in order to receive all the LSPs transmitted by the Bridges in the region. The PCE, either on its own or via its PCA, can control the establishment of explicit trees in that region by injecting an LSP conveying an explicit tree and thus instruct ISIS-PCR to set up the explicit tree determined by the PCE. Each PCE, whether located in a Bridge or end station, has access to the link state topology and resource information common throughout the region. If instructed to do so by a PCE, ISIS-PCR can also record and communicate bandwidth assignments, which can be applied only if MSRP is not used in the region. Different PCE and PCA locations are illustrated in Figure 45-1 and Figure 45-2.

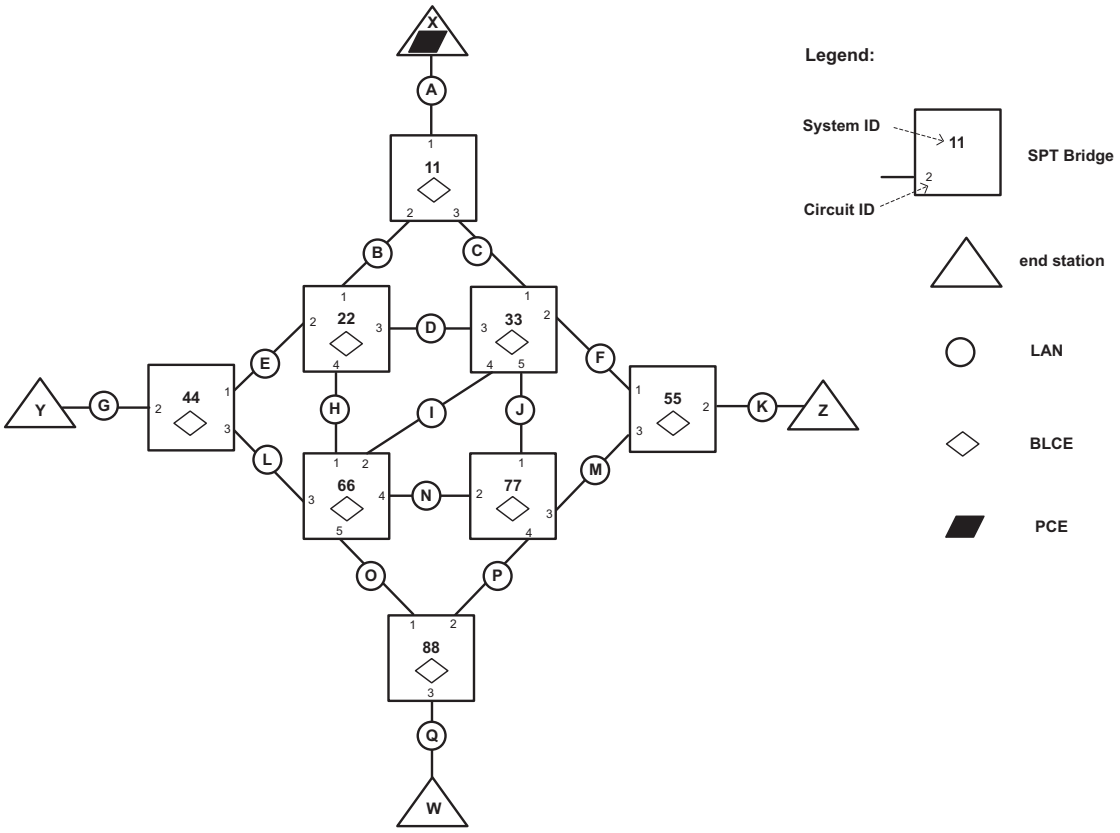


Figure 45-1—An SPT Region controlled by a single PCE

NOTE 1—The operation details of the PCE are not specified by this standard. If the PCE is part of the IS-IS Domain, then the PCE uses IS-IS PDUs to communicate with the IS-IS Domain, and the PCE has a live IS-IS LSDB (i.e., the PCE implements the PCA functions, too). A PCE can instead communicate with the IS-IS Domain via a PCA, e.g., to retrieve the Link State Database (LSDB) or instruct the creation of an explicit tree. However, the means of communication between the PCE and the PCA is not specified by this standard. A PCE could operate on a network topology retrieved by other means, e.g., configuration, instead of retrieving it from a live IS-IS LSDB; which operation mode is not specified by this standard. Having no live LSDB, the PCE instructs its PCA to flood the LSP conveying the appropriate Topology sub-TLV.

ISIS-PCR implements Software Defined Networking (SDN) through hosting the PCE in an external agent, e.g., an SDN Controller. In this case IS-IS is the protocol used to control the Bridges by the SDN Controller; the explicit trees are programmed in the Bridges via IS-IS.

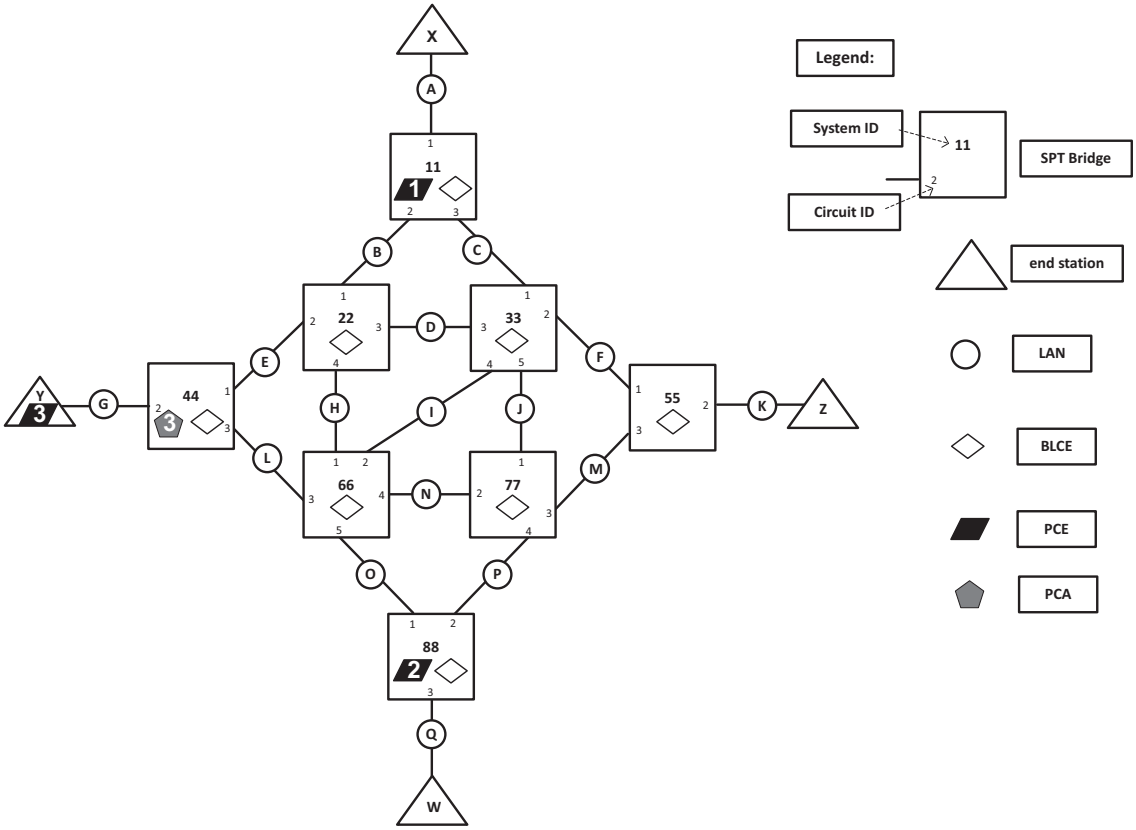


Figure 45-2—An SPT Region controlled by multiple PCEs

Figure 45-1 shows a region controlled by a single PCE residing in end station X connected to SPT Bridge 11. The PCE has IS-IS adjacency established with SPT Bridge 11, i.e., the PCE is part of the IS-IS Domain.

The IS-IS Domain coincides with the SPT Region in Figure 45-1 and Figure 45-2; they comprise SPT Bridges 11, 44, 55, and 88 (Edge Bridges) and SPT Bridges 22, 33, 66, and 77 (Core Bridges). As shown in the figures, each SPT Bridge implements a Bridge Local Computation Engine (BLCE).

Figure 45-2 shows a region controlled by multiple PCEs. Some of the SPT Bridges implement a PCE in addition to their BLCE; PCE 1 and PCE 2 reside in SPT Bridge 11 and SPT Bridge 88, respectively. PCE 3 resides in End Station Y. PCE 3 is not part of the IS-IS Domain; PCE 3 uses PCA 3 to instruct ISIS-PCR for the establishment of explicit trees and to retrieve link state data from the domain.

An Explicit Tree (ET) is an undirected loop-free topology, whose use is under the control of the owner PCE by means of associating VIDs and MAC addresses with it. As it is undirected, the ET contains no assumptions about the direction of any flows that use it; it can be used in either direction as specified by the VIDs and MAC addresses associated with it. It is the responsibility of the PCE to ensure reverse path congruency (3.213) and unicast multicast congruency (3.285) if that is required, e.g., making an explicit tree symmetric (3.264) by setting it up so that it is used in both directions between a pair of Bridges.

An explicit tree is either strict or loose. A strict explicit tree specifies all Bridges and paths it comprises. A loose tree specifies only the Bridges that have a special role in the tree, e.g., an Edge Bridge, and no path or path segment is specified between the Bridges, which are therefore loose hops even if Edge Bridges are adjacent neighbors. The special role of a hop can be an Edge Bridge, a root, a leaf, a Bridge to be avoided, or

a transit hop in the case of a tree with a single leaf. The path for a loose hop is determined by the BLCE of the SPT Bridges. The shortest path is used for a loose hop unless specified otherwise by the descriptor (45.1.9) of the tree or by the corresponding ECT Algorithm (45.1.2).

NOTE 2—PCE and BLCE are architecturally different entities. A BLCE is implemented in each SPT Bridge, where the BLCE implements the SPF algorithm at the minimum and can also implement more complex path computation algorithms, e.g., for determining constrained or redundant trees. For instance, the BLCE of SPT Bridges supporting ISIS-SPB at least implements an all pairs shortest path algorithm in addition to SPF. Forwarding trees are computed by the BLCEs unless they are explicitly given. Conversely, a PCE can implement more complex computation algorithms, and its main task is to determine explicit trees even if the PCE resides in a Bridge.

NOTE 3—If shortest paths are used for loose hops, then there is no need for any computation in addition to SPB as ISIS-SPB performs all pairs shortest path computation.

A loose explicit tree is constrained if the tree descriptor includes one or more constraints, e.g., the administrative group to which the links of the tree have to belong. The BLCE of the SPT Bridges then performs constrained routing (CR) to determine a loose hop instead of shortest path routing. CR relies on distributed link state operation similarly to shortest path routing. CR essentially performs shortest path routing on the topology that contains only the links meeting the constraint(s); therefore, the applied path computation algorithm is also referred to as Constrained Shortest Path First (CSPF).

NOTE 4—If a tree is a strict explicit tree, then it is fully specified; therefore, no constraint is included in the tree descriptor (45.1.9) as no further computation is needed.

An explicit tree is specified by a Topology sub-TLV (45.1.9). The Topology sub-TLV associates one or more VIDs with an explicit tree. The Topology sub-TLV includes two or more Hop sub-TLVs (45.1.10), and a hop is specified by an IS-IS System ID. A strict tree is decomposed to branches, and each branch is specified by an ordered list of Hop sub-TLVs. A loose tree is not fully specified, but the Topology sub-TLV conveys some of its hops. The Hop sub-TLV of a loose hop can include a delay constraint [item h) in 45.1.10]. A Topology sub-TLV can also include further sub-TLVs to constrain (45.1.11, 45.1.12) loose hops. The Bridges involved in an explicit tree store the corresponding Topology sub-TLVs in their Explicit Tree Database (ETDB).

Explicit trees are propagated and set up by ISIS-PCR in an SPT Region. The PCE or its PCA assembles the Topology sub-TLVs (45.1.9) and then instructs ISIS-PCR to establish the tree. If the PCE resides in an SPT Bridge, then the PCE entity passes the Topology sub-TLV (45.1.9) to the ISIS-PCR entity, which shall then flood an LSP including the Topology sub-TLV throughout the SPT Domain. If the PCE resides in an end station, then either the PCE or its PCA adds the Topology sub-TLV (45.1.9) into an LSP, which is flooded throughout the SPT Domain. The Topology sub-TLV is flooded by the same techniques used for the SPB LSPs. The SPT Bridges then shall process the Topology sub-TLV (45.1.9) upon reception. If the Topology sub-TLV specifies one or more loose trees, then the path for the loose hops is determined by the BLCE of the SPT Bridges. The SPT Bridges then install the appropriate FDB entries (45.1.6) for frame forwarding along the tree described by the Topology sub-TLV (45.1.9) or the trees computed based on the Topology sub-TLV. Dynamic Filtering Entries are maintained by ISIS-PCR for the VID, MAC address tuples associated with an ET.

NOTE 5—Due to the LSP aging of IS-IS, the Topology sub-TLVs (45.1.9) have to be refreshed similar to other IS-IS TLVs in order to keep the integrity of the LSDB. The corresponding Dynamic Filtering Entries are also refreshed when a Topology sub-TLV is refreshed. Refreshing Topology sub-TLVs is the task of the entity being part of the IS-IS Domain, i.e., either the PCE or the PCA.

The owner PCE can withdraw an explicit tree by sending an updated LSP that does not include the Topology sub-TLV. If a Topology sub-TLV is removed from an LSP (or has been changed), so that (previous) Topology sub-TLV is no longer present (or has been changed) in the LSDB, then that (previous) Topology sub-TLV is implicitly withdrawn. ISIS-PCR then removes (or updates) the explicit tree.

ISIS-PCR provides precedence order among Topology sub-TLVs as specified in 45.2.3 if it is needed in a region with multiple PCEs.

45.1.1 Tree structures

Two types of tree structures can be used for explicit trees, as follows:

— Ad-hoc trees
— Template trees

Ad-hoc explicit trees do not follow any template; they can comprise any path. A particular explicit tree is defined, and a VID is assigned to the explicit tree. The administratively straightforward way to do this is to use a bidirectional VID for the explicit tree. This approach constructs a shared bidirectional (*,G) tree joining all members of a group.

NOTE 1—A single common (*,G) spanning tree can be constructed this way.

Alternatively, explicit trees can follow templates. It can be helpful to define a tree rooted on every Bridge, where each tree spans every Bridge of a domain and the complete set of trees, one rooted on each Bridge of a domain, are constructed consistently, so that collectively they form a single forwarding plane offering any-to-any connectivity within that domain. Such trees are used as a source rooted tree for multicast traffic emitted from a Bridge, and they are also used as a destination rooted tree for unicast traffic being sent to their Bridge. There is a fundamental constraint that has to be obeyed for all such structures individually in that plane. They have to be simply connected trees, with only one path from any point in the network domain to the root of the tree. If paths to the root cross at any point, or merge and subsequently diverge, a unicast forwarding inconsistency or an unwanted multicast frame replication point is created.

This connectivity style (i.e., a tree per Bridge per plane) is, for example, enforced by construction by Shortest Path Bridging. In SPB, a Base VID is associated with one of the standard symmetric ECT Algorithms (28.8), which identifies a plane. In SPBM, the individual trees within each Base VID are defined by the MAC address of the root Bridge; in SPBV each Bridge is allocated an individual SPVID to define its tree.

Any preferred algorithm can be used when performing explicit routing, and the required constraint can be replicated by maintaining the simply connected tree construct. Thus the template-tree-based approach constructs one or more explicitly routed forwarding planes with tree sets, one tree rooted on each Bridge within each plane.

In the case of a learning VLAN, a unidirectional VID can be assigned to each tree (similarly to the unidirectional SPVID model), so that each tree is independent and identifies its root Bridge. Shared VLAN Learning (3.238) takes place among the VIDs associated with the same explicit tree set, where reverse congruence (3.213) has to be enforced by the function that computes the explicit trees on a particular forwarding plane (Base VID).

In the case of a non-learning VLAN, the MAC of the root Bridge identifies the tree, and a single Base VID identifies the entire forwarding plane.

Care has to be taken when constructing multicast trees with multiple sources if the template tree approach is used. Source-specific multicast (S,G) has to be applied if multiple sources participate in a single multicast group. A separate source rooted tree is constructed for every source of the group, and the complete multicast structure is the superposition of all these separate source rooted trees. The multicast traffic of the different sources has to be distinguished either by a VID (as in SPBV) or by a source-specific Group MAC address (as in SPBM, see 27.15).

NOTE 2—There is no requirement here that the initial template construction actually generates spanning trees. If Bridges only initially require connectivity to a subset of the SPT Bridges of a region, only the relevant part of the template need initially be constructed. This leaves freedom to add hitherto unconnected Bridges by extension of trees using a preferred route at a later stage.

45.1.2 Explicit ECT Algorithms

Five explicit path control modes are specified by this standard; each of them is identified by a distinct ECT-ALGORITHM. Table 45-1 summarizes the ECT Algorithms that can be used for explicit trees. The ECT-ALGORITHMs specified by this standard for explicit trees are formed using OUI=00-80-C2 and Index values 0x17, 0x18, 0x19, and the range from 0x21 to 0x40. SPT Bridges that support PCR shall support the Strict Tree ECT Algorithm (00-80-C2-17) and may support the other ECT Algorithms of Table 45-1. VLANs under explicit path control are associated with one of the ECT Algorithms as specified by 45.1.3.

NOTE 1—The ECT-ALGORITHM is in fact the identifier of the method and the algorithm used to determine the active topology. Although the active topology specified by this clause is not an Equal Cost Tree, the terminology and the ECT Algorithm framework of Clause 27 and Clause 28 is kept. The Opaque ECT concept (28.6) is also supported for explicit path control, which can be used for further algorithms.

Table 45-1—ECT-ALGORITHM values for explicit trees

ECT-ALGORITHM	Algorithm Name	Behavior
00-80-C2-17	Strict Tree (ST ECT Algorithm)	A single strict explicit tree. No restoration or update is performed by IS-IS on its own; only the PCE can initiate the update of a strict ET.
00-80-C2-21 ... 00-80-C2-30	Loose Tree (LT ECT Algorithm)	A single loose explicit tree. The loose hops are computed by the BLCE of SPT Bridges applying constrained or shortest path routing. The loose hops are restored by IS-IS upon a topology change if loop-free paths are available. The Bridge Priority Mask to be used in the case of constrained or shortest paths is specified by Table 45-2.
00-80-C2-31 ... 00-80-C2-40	Loose Tree Set (LTS ECT Algorithm)	A set of loose explicit trees. The set comprises an individual tree for each Edge Bridge included in the descriptor of the explicit tree, i.e., they are template trees. Each tree is computed by the BLCE of SPT Bridges applying constrained routing. These trees are restored by IS-IS upon a topology change. The Bridge Priority Mask to be used in the case of constrained or shortest paths is specified by Table 45-2.
00-80-C2-18	Maximally Redundant Trees (MRT ECT Algorithm)	Maximally Redundant Trees (MRTs) are loose trees for each MRT Root, which are computed together with the corresponding GADAG by the BLCE of SPT Bridges and cautiously restored by ISIS-PCR. If the topology view is identical throughout the SPT Domain, then IS-IS restores these trees one by one, only one of each redundant set at a time (45.3.3).
00-80-C2-19	Maximally Redundant Trees with GADAG (MRTG ECT Algorithm)	Maximally Redundant Trees (MRTs) are loose trees for each MRT Root, which are computed by the BLCE of SPT Bridges based on the GADAG received from the single GADAG Computer. MRTs are cautiously restored by ISIS-PCR upon reception of a new GADAG from the GADAG Computer. IS-IS restores these trees one by one, only one of each redundant set at a time (45.3.4).

The Strict Tree (ST) ECT Algorithm is used for a strict explicit tree. A strict ET is static as no other entity can update it but the tree owner PCE. In the case of a topology change, it is the task of the owner PCE to detect the topology change, e.g., based on the changes in the LSDB, and to update the strict trees if needed. In other words, the owner PCE computes the new tree, assembles its descriptor, and then instructs ISIS-PCR to install it. The use of VIDs for strict trees is described in 45.1.4, and redundant strict trees are explained in 45.3.2.

The Loose Tree (LT) ECT Algorithm is used for a single loose explicit tree. The path for loose hops is determined by the BLCE of the SPT Bridges; therefore, the Topology sub-TLV (45.1.9) specifying the tree

has to indicate which hop is the root of the tree. The loose hops are maintained by IS-IS, i.e., restored upon a topology change if a loop-free path is available. If the tree computed by the BLCE visits the same Bridge twice (implying that a loop or hairpin has been created), then that loop or hairpin has to be pruned from the tree even if it contains a hop specified by the Topology sub-TLV. Constrained routing can be applied for the loose hops based on the attributes listed in 45.1.8. If a Bridge is not to be included is also a constraint, which can be specified by the Exclude flag [item c6) in 45.1.10] of a Hop sub-TLV (45.1.10) conveyed by the Topology sub-TLV specifying the tree.

The Loose Tree Set (LTS) ECT Algorithm is used if connectivity among the Edge Bridges specified by the Topology sub-TLV (45.1.9) is to be provided by a set of loose trees so that one tree is rooted at each Edge Bridge, i.e., the loose trees are template trees (45.1.1). The BLCEs of the SPT Bridges compute the loose trees, which are maintained by IS-IS, i.e., restored upon a topology change. Avoiding some bridges in these trees is a constraint, which can be specified by the Exclude flag [item c6) in 45.1.10]. Further constraints can be specified by the Topology sub-TLV based on the attributes listed in 45.1.8.

NOTE 2—A Loose Tree Set is similar to a Shortest Path Tree Set with the following differences: The trees of an LTS span only the Edge Bridges specified by the Topology sub-TLV; they do not span the entire SPT Region. Furthermore, constrained routing is applied instead of shortest path routing.

Table 45-2—Bridge Priority Masking for the LT and LTS ECT Algorithms

ECT-ALGORITHM (LT ECT Algorithm)	ECT-ALGORITHM (LTS ECT Algorithm)	Algorithm MASK
00-80-C2-21	00-80-C2-31	0x00
00-80-C2-22	00-80-C2-32	0xFF
00-80-C2-23	00-80-C2-33	0x88
00-80-C2-24	00-80-C2-34	0x77
00-80-C2-25	00-80-C2-35	0x44
00-80-C2-26	00-80-C2-36	0x33
00-80-C2-27	00-80-C2-37	0xCC
00-80-C2-28	00-80-C2-38	0xBB
00-80-C2-29	00-80-C2-39	0x22
00-80-C2-2A	00-80-C2-3A	0x11
00-80-C2-2B	00-80-C2-3B	0x66
00-80-C2-2C	00-80-C2-3C	0x55
00-80-C2-2D	00-80-C2-3D	0xAA
00-80-C2-2E	00-80-C2-3E	0x99
00-80-C2-2F	00-80-C2-3F	0xDD
00-80-C2-30	00-80-C2-40	0xEE

In the case of the LT and LTS ECT Algorithms, the symmetric shortest path tie-breaking specified in 28.5, 28.6, 28.7, and 28.8 is used during shortest path computation to manipulate the lexicographic ordering of hops on a path after pruning the topology according to the constraints. The Bridge Priority Masks for the LT and LTS ECT Algorithms are shown in Table 45-2. The mask identification method specified for the

Symmetric ECT Algorithms is used. The IEEE 802.1 OUI (00-80-C2) is used, Index values 0x21 through 0x30 are used for the LT ECT Algorithm, and Index values 0x31 through 0x40 are used for the LTS ECT Algorithm as shown in Table 45-2.

The Maximally Redundant Trees (MRT) ECT Algorithm or the Maximally Redundant Trees with Generalized Almost Directed Acyclic Graph (GADAG) (MRTG) ECT Algorithm is used if maximally redundant loose explicit trees have to be maintained together. The use of the MRT ECT Algorithm and the MRTG ECT Algorithm is described in 45.3.3 and 45.3.4, respectively.

ISIS-PCR uses the link metrics specified by the SPB Link Metric sub-TLVs (28.12.7) if the LT, the LTS, the MRT, or the MRTG ECT Algorithm is used. The SPB Link Metric sub-TLV is used as specified in 28.12.7; therefore, the maximum metric value is used in cases where the metrics advertised by adjacent Bridges for a given link are different.

A topology change can cause the need for recomputing and updating multiple loose trees. If constrained routing based on available bandwidth (45.1.12) is used for multiple loose trees, then there can be a race hazard for the same resources if they are updated at the same time. Furthermore, the computation order can influence the trees. Therefore, ISIS-PCR applies the tie-breaking method specified in 45.2.3 in order to determine the computation order among the loose trees based on their descriptor Topology sub-TLV. If a Topology sub-TLV specifies multiple loose trees, e.g., LTS or MRTs, then the computation order of these trees follows the ascending order of the IS-IS System ID of the Bridges rooting the trees.

45.1.3 ISIS-PCR VLAN configuration

A VLAN provided by an explicit tree controlled by IS-IS is associated with IS-IS by means of allocating the VLAN's Base VID to the appropriate MSTID, i.e., either to the SPBM-MSTID or to the SPBV-MSTID. The explicit path control mode is then selected by associating the Base VID with the corresponding explicit ECT Algorithm.

The Base VID of VLANs controlled by IS-IS is allocated either to the SPBM-MSTID (0xFFC) or to the SPBV-MSTID (0xFFD) as specified in 27.4, which also applies to VLANs under explicit path control via IS-IS. If multiple VIDs belong to a VLAN under explicit path control, then each VID has to be allocated to the same MSTID; otherwise, the explicit trees do not get installed for the VLAN.

The exact active topology enforcement method applied for the VLAN is determined by the ECT Algorithm (28.8) with which the VLAN is associated. Explicit path control mode is configured by means of associating the Base VID with one of the ECT Algorithms specified in 45.1.2. The association of the VLAN with the ECT Algorithm shall be provided by the SPB Base VLAN-Identifiers sub-TLV (28.12.4).

Each VID belongs only to one PCE, which is the owner PCE that has full control on the use of the VID. The VIDs of a PCE are to be configured at the PCE. If multiple PCEs try to use the same VID, then ISIS-PCR provides the precedence as specified in 45.2.3.

An IS-IS controlled VLAN is a non-learning VLAN if the VLAN's Base VID is allocated to the SPBM-MSTID (0xFFC). MAC addresses are distributed explicitly for non-learning VIDs by IS-IS. The M flag is set in the SPB Instance sub-TLV (28.12.5) for non-learning VLANs. If a non-learning VLAN is associated with a symmetric ECT Algorithm (28.8), then the VLAN is under SPBM control as specified by Clause 27 and Clause 28 even if the VLAN is not a B-VLAN. If a non-learning VLAN is associated with one of the explicit ECT Algorithms (45.1.2), then it is under explicit path control as specified by this clause.

An IS-IS controlled VLAN is a learning VLAN if the VLAN's Base VID is allocated to the SPBV-MSTID (0xFFD). If a learning VLAN is supported by multiple VIDs, then Shared VLAN Learning (3.238) takes place among the VLAN's VIDs associated with the same shortest path or explicit tree set. The M flag is cleared in the SPB Instance sub-TLV (28.12.5) for learning VLANs. If a learning VLAN is associated with a

symmetric ECT Algorithm (28.8), then the VLAN is under SPBV control as specified by Clause 27 and Clause 28; correspondingly, SPVIDs can be auto-allocated to SPTs from the pool of SPVIDs, i.e., from the VIDs allocated to the SPVID-Pool-MSTID (0xFFF) as specified by 27.4. If a learning VLAN is associated with one of the explicit ECT Algorithms (45.1.2), then it is under explicit path control as specified by this clause; and each VID of the VLAN is allocated to the SPBV-MSTID (0xFFD), i.e., none of the VLAN's VIDs is allocated automatically. When a VLAN is under explicit path control, it is the responsibility of the PCE to provide reverse congruent paths (3.213) so that Shared VLAN Learning (3.238) operates correctly.

NOTE 1—The learning VIDs used for explicit trees are not allocated to the SPVID-Pool-MSTID. Therefore, they are not taken from the SPVID pool; they are not Shortest Path VIDs even if conveyed by an SPVID field of an IS-IS sub-TLV. To emphasize, a learning VID is an SPVID only if it is taken from the SPVID pool.

The Topology sub-TLV (45.1.9) conveys only the VLAN's Base-VID for each ECT Algorithm. Further VIDs, if any, are associated with the VLAN and its Base VID by ISIS-SPB sub-TLVs as specified below.

If the ST ECT Algorithm (Table 45-1) is used for either a learning or a non-learning VLAN, then the VLAN is supported only by its Base VID. The VLAN's Base VID shall be associated with the ST ECT Algorithm in the SPB Base VLAN-Identifiers sub-TLV (28.12.4) and in the SPB Instance sub-TLV (28.12.5).

If the LT ECT Algorithm (Table 45-1) is used for either a learning or a non-learning VLAN, then the VLAN is supported only by its Base VID, which is associated with the LT ECT Algorithm in the SPB Base VLAN-Identifiers sub-TLV (28.12.4) and in the SPB Instance sub-TLV (28.12.5).

If the LTS ECT Algorithm (Table 45-1) is used for a non-learning VLAN, then the VLAN is supported only by its Base VID, which is associated with the LTS ECT Algorithm in the SPB Base VLAN-Identifiers sub-TLV (28.12.4) and in the SPB Instance sub-TLV (28.12.5).

NOTE 2—The use of the LTS ECT Algorithm for a non-learning VLAN is similar to SPBM (Clause 27 and Clause 28) operations, but constrained trees are used instead of SPTs. One VID is sufficient for the support of a set of constrained trees, which is specified as a set of loose explicit trees.

However, if the LTS ECT Algorithm (Table 45-1) is used for a learning VLAN, then the VLAN is supported by multiple VIDs because each tree of an LTS is required to have its own VID. The VLAN's Base-VID is associated with the LTS ECT Algorithm in the SPB Base VLAN-Identifiers sub-TLV (28.12.4) and in the SPB Instance sub-TLV (28.12.5). In addition to the Base VID, as many VIDs are needed to support the VLAN as the number of transmitter Edge Bridges specified by the Topology sub-TLV (45.1.9). The individual VID of a transmitter Edge Bridge is configured to support the VLAN at the given SPT Bridge. The VID to be used for the loose tree of a transmitter Edge Bridge is conveyed by the SPVID field of the VLAN ID Tuple of the corresponding Base VID in the SPB Instance sub-TLV (28.12.5) of the given Edge Bridge. The A flag of the given VLAN ID Tuple is cleared to indicate that auto-allocation is not used for the SPVID parameter. If no VID is configured for the loose tree in the SPB Instance sub-TLV of a transmitter Edge Bridge, then ISIS-PCR does not install the loose tree for that Edge Bridge. If the same local VID value is configured at multiple Bridges, then ISIS-PCR does not install the loose tree for either Bridge, and the conflict has to be resolved by operator action. Although the field is called SPVID, the VID it conveys is not a Shortest Path VID but a loose tree VID as indicated by the ECT Algorithm field of the given VLAN ID Tuple and by the VID to MSTID allocation.

NOTE 3—The use of the LTS ECT Algorithm for a learning VLAN is similar to SPBV (Clause 27 and Clause 28) operations, but with loose trees, i.e., constrained trees are used instead of SPTs. Therefore, each Bridge rooting a loose tree has to have its own VID for the support of a learning VLAN on that tree. The SPB Instance sub-TLV is used to bind the VIDs of the individual root Bridges to the Base VID; the SPVID parameter conveys the VID to be used for the loose tree rooted at the given Bridge. The VID is not a Shortest Path VID because it is used for a loose explicit tree as indicated by the ECT Algorithm parameter and by the VID to MSTID allocation.

If the MRT ECT Algorithm (Table 45-1, 45.3.3) or the MRTG ECT Algorithm (Table 45-1, 45.3.4) is used for a VLAN, then a distinct VID is required for the two MRTs: MRT-Blue and MRT-Red. In the case of a non-learning VLAN, a single VID is used for MRT-Blue of all MRT Roots, and another VID is used for all MRT-Reds. Two VIDs support a non-learning VLAN if the MRTs protect each other, whereas the VID of

the SPT Set is also needed as the third VID if the MRTs protect SPTs. The MRT VIDs are also allocated to the SPBM-MSTID (0xFFC) in the case of a non-learning VLAN. However, each MRT Root has to be configured with its own unique VID-pair for its MRT-Blue and MRT-Red in the case of a learning VLAN, and all the MRT VIDs are allocated to the SPBV-MSTID (0xFFD). Independent VLAN Learning (3.95) is applied among the VIDs associated with MRTs. Twice as many MRT VIDs support a learning VLAN as MRT Roots, which are all the VIDs that are needed if the MRTs protect each other. The Shortest Path VIDs (real SPVIDs) of the SPTs are also needed in addition to the MRT VIDs for the support of a learning VLAN if the MRTs protect SPTs. As the two MRT algorithms differ only in GADAG handling, the VLAN configuration is the same for these two ECT Algorithms once the appropriate ECT-ALGORITHM value is used in the ECT Algorithm field of the IS-IS sub-TLVs. The VLAN's Base VID is associated with the MRT ECT Algorithm or with the MRTG ECT Algorithm in the SPB Base VLAN identifier sub-TLV (28.12.4).

The SPB Instance sub-TLV (28.12.5) provides the VIDs for MRT-Blue and MRT-Red and also associates them with the VLAN. The same VID values are used in the corresponding SPVID fields in the SPB Instance sub-TLV of all MRT Roots in the case of a non-learning VLAN; whereas the VID values in the SPVID fields are unique for each MRT Root in the case of a learning VLAN. The SPB Instance sub-TLV also specifies whether the MRTs are used to protect each other or whether they protect an SPT.

The SPB Instance sub-TLV (28.12.5) conveys three VLAN ID Tuples for the VLAN. The ECT Algorithm parameter of the second and the third VLAN ID Tuple is either the MRT ECT Algorithm or the MRTG ECT Algorithm, accordingly. If the MRTs are used to protect SPTs, then the ECT Algorithm parameter of the first VLAN ID Tuple specifies the ECT Algorithm to be used for shortest path computation, e.g., one of the standard symmetric ECT Algorithms (Table 45-1). The first VLAN ID Tuple also specifies the VID to be used for the shortest paths, which is the Base VID for a non-learning VLAN or the Shortest Path VID (allocated to the SPVID-Pool-MSTID) conveyed by the SPVID parameter for a learning VLAN. If the MRTs are used to protect each other, then the ECT Algorithm parameter of the first VLAN ID Tuple is the same as that of the second and the third VLAN ID Tuple. The second and the third VLAN ID Tuples associate the MRT VIDs with the Base VID. The SPVID parameter of the second VLAN ID Tuple provides the VID for MRT-Blue. The SPVID parameter of the third VLAN ID Tuple provides the VID for MRT-Red. In other words, the SPVID parameters of the second and third VLAN ID tuples convey the MRT VIDs, not Shortest Path VIDs. If ISIS-PCR detects that the same local MRT VID value is configured at multiple Bridges, then ISIS-PCR does not install the MRT for either Bridge, and the conflict has to be resolved by operator action.

If the MRTs are used to protect SPTs, then the MRT VIDs differ from the Base VID and also differ from Shortest Path VID conveyed by the SPVID parameter of a learning VLAN's first VLAN ID Tuple. In the case of non-learning VLANs, if the MRTs are used to protect each other, then the VLAN's Base VID is used as the VID for MRT-Blue; consequently, the SPVID parameter of the VLAN's second VLAN ID Tuple conveys the VLAN's Base VID. If the MRTs of a learning VLAN are used to protect each other, then no Shortest Path VID is required for the VLAN; therefore, the SPVID parameter of the VLAN's first VLAN ID Tuple is not used but ignored. The use of the SPB instance sub-TLV for the MRT and MRTG ECT Algorithms is illustrated in Figure 45-3.

NOTE 4—The SPVID parameter conveys only a Shortest Path VID if the ECT Algorithm parameter of the given VLAN ID Tuple identifies shortest path operations and the VID is allocated to the SPVID-Pool-MSTID. The SPVID parameter is not a Shortest Path VID if the ECT Algorithm parameter identifies explicit path control, i.e., taken from Table 45-1, which is also indicated by the fact that the VID is not allocated to the SPVID-Pool-MSTID.

An I-SID of a PBBN shall be associated with an explicit tree by the SPBM Service Identifier and Unicast Address sub-TLV (28.12.10) by means of associating the I-SID with a Base VID that is allocated to one of the explicit ECT Algorithms of Table 45-1.

	Parameter	Value			
		non-learning VLAN		*learning VLAN*	
		MRTs protect SPT	*MRTs protect each other*	*MRTs protect SPT*	*MRTs protect each other*
	Type	1			
	Length	43			
	CIST Root Identifier	CIST Root Identifier (imported from RSTP or MSTP)			
	CIST External Root Path Cost	CIST External Root Path Cost (imported from RSTP or MSTP)			
	Bridge Priority	Bridge Priority			
	reserved	0			
	V	1 or 0			
	SPSourceID	SPSourceID or 0			
	Number of Trees	3			
VLAN ID Tuple 1	U	1			
	M	1	1	0	0
	A	0	0	1 or 0	0
	reserved	0			
	ECT Algorithm	Symmetric ECT Alg.	MRT or MRTG	Symmetric ECT Alg.	MRT or MRTG
	Base VID	Base VID			
	SPVID	–	–	SPVID	–
VLAN ID Tuple 2	U	1			
	M	1	1	0	0
	A	0			
	reserved	0			
	ECT Algorithm	MRT or MRTG			
	Base VID	Base VID			
	SPVID	MRT-Blue domain VID	MRT-Blue domain VID = Base VID	MRT-Blue local VID	MRT-Blue local VID
VLAN ID Tuple 3	U	1			
	M	1	1	0	0
	A	0			
	reserved	0			
	ECT Algorithm	MRT or MRTG			
	Base VID	Base VID			
	SPVID	MRT-Red domain VID	MRT-Red domain VID	MRT-Red local VID	MRT-Red local VID

Figure 45-3—The use of the SPB Instance sub-TLV for MRT

45.1.4 Use of VIDs for strict explicit trees

The use of a distinct VID for each explicit tree does not scale in some cases. A more flexible and scalable method of VID assignment is available for explicit trees. This subclause explains the rules to be observed and suggests two schemes for the use of VIDs for strict explicit trees, i.e., for VIDs associated with the ST ECT Algorithm (Table 45-1). Nonetheless, ensuring that VIDs associated with strict explicit trees actually follow these rules in order to provide unambiguous and loop-free frame forwarding is the responsibility of the network administrator and the owner PCE controlling the VID; this standard provides no method for policing this. As each VID belongs to a single owner PCE, a VID can be used only for multiple explicit trees that are controlled by the same PCE.

NOTE 1—Use of VIDs associated with MRTs is explained in 45.3.3.

Ensuring unambiguous filtering entries and providing forwarding to the appropriate destination are the fundamental requirements to be met when assigning VIDs with explicit trees.

For unicast frames, there has to be a single egress port for each Individual MAC, VID tuple in each SPT Bridge. In other words, different explicit trees associated with the same bidirectional VID within an SPT Domain are not allowed to have any SPT Bridges in common when MAC learning is being used. Unidirectional VIDs or bidirectional non-learning VIDs associated with different explicit trees to a particular destination can have common SPT Bridges along the merged segments of those explicit trees as long as every such tree uses a single egress port for each unicast destination in every Bridge.

NOTE 2—A VID can be unidirectional by means of asymmetric use, e.g., as explained in F.1.3 or like an SPVID (3.248). Also, a bidirectional non-learning VID is in fact used in unidirectional fashion with respect to any given destination MAC address.

For multicast frames, it has to be ensured that each member of the multicast group receives only a single copy of a particular frame, even if there are multiple potential sources within a group.

Congruency (3.213), if required, has to be enforced by the PCE. In the case of unidirectional VIDs, the same path has to be used for both directions between a source and destination pair in order to provide reverse path congruency, essential when MAC learning is employed. Unicast and multicast traffic have to be placed on the same tree in order to provide unicast multicast congruency.

The tree structures explained in 45.1.1 can be applied for strict explicit trees, and VIDs can be used on top of these strict trees as follows.

An ad-hoc explicit tree (45.1.1) with a bidirectional VID provides a shared bidirectional (*,G) tree joining all members of a group. This structure minimizes VID consumption (as a local instance-by-instance optimization) compared to cases when each member has its own VID. On the other hand, there is the constraint that trees using the same VID are not allowed to touch or cross; hence the number of explicit trees is limited by the available VID space.

The template tree (45.1.1) approach constructs one or more explicitly routed forwarding planes with tree sets, one tree rooted on each Bridge within each plane. In the case of learning VIDs, each tree is associated with a unidirectional VID, and Shared VLAN Learning (3.238) takes place among the VIDs of a tree set. In the case of non-learning VIDs, the MAC of the root Bridge identifies the tree; therefore, one VID (the Base VID) is enough for an entire plane. Furthermore, source-specific multicast (S,G) has to be applied if multiple sources participate in a single multicast group as explained in 45.1.1. The desired connectivity can be then laid for VIDs associated with strict template trees with the complete assurance that the required simply connected tree constraint is obeyed.

The efficiency of the template trees approach can be improved substantially in terms of the usage of local VIDs if Edge Bridges “inherit” the tree and VID rooted at their directly connected Core Bridge. This is possible because a loop or forwarding ambiguity cannot be created in a single Ethernet hop; to guarantee this, multi-homed Edge Bridges have to be always configured as non-transit Bridges.

45.1.5 MAC addresses and ISIS-PCR

Propagation of MAC address information by IS-IS is required for explicit trees in order to create Dynamic Filtering Entries for VID, MAC tuples, except for learning VIDs. The SPBV MAC Address sub-TLV (28.12.9) shall be used for the advertisement of both Individual and Group MAC Addresses for S-VLANs and C-VLANs associated with explicit trees. The VLAN's VID is conveyed by Octets 3 and 4 of the SPBV MAC Address sub-TLV. This local VID (if required) and the VLAN's Base VID are allocated either to the SPBV-MSTID (for learning VIDs) or to the SPBM-MSTID (for non-learning VIDs); furthermore, the Base VID is allocated to one of the explicit ECT Algorithms (Table 45-1) as explained in 45.1.2 in more detail.

NOTE 1—Multiple SPBV MAC Address sub-TLVs are used if different MAC addresses are mapped to different VIDs at an SPT Bridge, i.e., MAC addresses associated with an SPT Bridge are not bound together.

The SPBM Service Identifier and Unicast Address sub-TLV (28.12.10) shall be used to associate Individual addresses with an I-SID; Octets 3 through 8 of the sub-TLV convey an Individual B-MAC address. Thus, the SPT Bridges populate their FDB with the Individual MAC addresses according to their T/R flags for the B-VLANs allocated to the SPBM-MSTID and associated with explicit path control.

Either a Group MAC address associated with an I-SID is source specific, or it is the Backbone Service Instance Group address (26.4). If Octets 3 through 8 of any SPBM Service Identifier and Unicast Address sub-TLV convey the null value throughout the SPT Domain, then the Backbone Service Instance Group address corresponding to the given I-SID is to be used for all multicast sources in (*,G) mode on one simple explicit tree. If no SPBM Service Identifier and Unicast Address sub-TLV with null value in its B-MAC address field is present in the SPT Domain, then the source-specific group addressing specified in 27.15 has to be applied, exactly as used for SPBM. In the source-specific case, the SPB Instance sub-TLV (28.12.5) shall be used to propagate the SPSourceID (27.10) of the Bridges that are Edge Bridges of the explicit tree and can be a source of the multicast traffic. In order to avoid forwarding anomalies, source-specific group addressing has to be used if there are multiple multicast sources for a given I-SID using the same B-VID and the template tree model (45.1.4) is followed, i.e., multiple trees are used.

NOTE 2—Multiple SPBM Service Identifier and Unicast Address sub-TLVs are used if different MAC addresses are mapped to different I-SIDs at an SPT Bridge, i.e., MAC addresses associated with an SPT Bridge are not bound together.

45.1.6 Filtering Database entries for explicit trees

The Topology sub-TLV (45.1.9) provides the information needed for ISIS-PCR to create the appropriate Dynamic VLAN Registration Entries, i.e., it provides the explicit tree, the VIDs associated with the tree, and the direction of the directed VIDs.

The per Bridge association of a MAC address with a VID is provided by the SPBV MAC Address sub-TLV (28.12.9) as described in 45.1.5. Based on the Topology sub-TLVs and SPBV MAC Address sub-TLVs, ISIS-PCR can create the VID, MAC tuple Dynamic Filtering Entries for VLANs associated with explicit trees.

The association of a B-VID with an explicit tree is provided by the Topology sub-TLV (45.1.9), and the per Bridge association of an I-SID to a B-VID is provided by the SPBM Service Identifier and Unicast Address sub-TLV (28.12.10), which also provides the association of a B-MAC to an I-SID as described in 45.1.5. The SPBM Service Identifier and Unicast Address sub-TLVs also make it clear whether source-specific group addressing is to be used. If that is the case, then the SPB Instance sub-TLVs (28.12.5) provide the SPSourceIDs (27.10) that are needed for the creation of the automatically generated Group MAC addresses of the I-SID as described in 45.1.5. Based on these sub-TLVs, ISIS-PCR can create the B-VID, B-MAC tuple Dynamic Filtering Entries for I-SIDs associated with explicit trees.

45.1.7 ISIS-PCR support

ISIS-PCR and PCEs are configured to use one of the Group addresses from Table 8-17 to establish adjacencies and exchange PDUs. ISIS-PCR running on C-VLAN components use the Customer Bridge address. ISIS-PCR running on S-VLAN components use the Provider Bridge address. ISIS-PCR running on B-VLAN components can use the Provider Bridge Address or one of the existing IS-IS addresses.

The use of the ISIS-PCR adjacency between Bridges is contingent on the Bridges inclusion within the same SPT Region and thus requires that they have an MCID and Auxiliary MCID (13.8, 28.12.2) where at least one matches on every adjacency in the Region (8.9.4, 13.8). MCID and Auxiliary MCID enable migration of the MCID definition allowing these Bridges to operate as one SPT Region under certain small changes. The operational set of Base VLANs has to be consistent during migration. The MCID and the Auxiliary MCID are exchanged in IS-IS Hello PDUs, which also include the SPB Base VLAN-Identifiers sub-TLV (28.12.4). ISIS-PCR adjacencies are formed and maintained as specified by 28.2, i.e., in exactly the same way as ISIS-SPB adjacencies. Either a PCE hosted by an end station has a PCA that is part of the IS-IS Domain, or the PCE forms and maintains an ISIS-PCR adjacency between the PCE and the SPT Bridge to which the end station is attached.

Management of explicit trees also requires the following:

a) Management of the PCR objects (12.26)
b) Administrative agreement on the MCID Configuration Name and Revision Level (Clause 28)

NOTE—The addresses used by IS-IS PDUs and the operations with respect to IS-IS adjacencies are the same for ISIS-PCR and ISIS-SPB. This subclause (45.1.7) simply reiterates provisions of Clause 27 and Clause 28 (see 27.2, 28.2).

45.1.8 Attributes for path computation

More attributes than the link metric are needed for PCEs or BLCEs in order to be able to determine paths that meet the requirements. Extended link attributes are specified by the Traffic Engineering (TE) extensions for IS-IS in IETF RFC 5305. The TE information is flooded in LSPs by IS-IS and it is stored in the Traffic Engineering Database (TED). The TED contains the topology and the resource information of the IS-IS Domain.

SPT Bridges may support the Extended IS Reachability TLV (type 22) specified in IETF RFC 5305, which provides the following link attribute IS-IS sub-TLVs:

a) Administrative Group (color, resource class) (sub-TLV type 3)
b) Maximum Link Bandwidth (sub-TLV type 9)
c) Maximum Reservable Link bandwidth (sub-TLV type 10)
d) Unreserved Bandwidth (sub-TLV type 11)
e) Traffic Engineering Default Metric (sub-TLV type 18)

SPT Bridges may support the following IS-IS TE Metric Extension link attribute sub-TLVs specified in IETF RFC 7810:

f) Unidirectional Link Delay (sub-TLV type 33)
g) Min/Max Unidirectional Link Delay (sub-TLV type 34)
h) Unidirectional Delay Variation (sub-TLV type 35)
i) Unidirectional Link Loss (sub-TLV type 36)
j) Unidirectional Residual Bandwidth (sub-TLV type 37)
k) Unidirectional Available Bandwidth (sub-TLV type 38)
l) Unidirectional Utilized Bandwidth (sub-TLV type 39)

The IS-IS TE Metric Extensions sub-TLVs are conveyed by IS-IS Extended IS Reachability TLV (type 22). The bandwidth already allocated determines the Residual Bandwidth and the Available Bandwidth. When they are used in a Bridged Network, reservations performed by MSRP or bandwidth assignments recorded by ISIS-PCR are taken into account to determine these sub-TLVs.

NOTE—The Residual Bandwidth and the Unreserved Bandwidth sub-TLVs can be used concurrently; see IETF RFC 7810.

If Shared Risk Link Group (SRLG) information is to be applied, then the SRLG TLV (type 138) of IETF RFC 5307 may be used as specified here. Figure 45-4 shows the format of the SRLG TLV.

		Octet	Length
	Type (138)	1	1
	Length	2	1
	System ID	3–8	6
	Pseudonode num	9	1
	Flag	10	1 bit
	reserved	10	7 bits
	Link Local Identifier	11–14	4
	Link Remote Identifier	15–18	4
SRLG *1*	Shared Risk Link Group Value	19–22	4
	...		
SRLG *n*	Shared Risk Link Group Value	(4*n*+15)–(4*n*+18)	4

Figure 45-4—Shared Risk Link Group (SRLG) TLV

The SRLG parameters are encoded as follows:

m) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 138.

n) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field, which is the number of SRLG Values multiplied by 4 plus 16 bytes.

o) System ID (48 bits). Octets 3 through 8 convey the 6-byte IS-IS System Identifier of the adjacent neighbor.

p) Pseudonode num (8 bits). Octet 9 conveys the pseudonode number if the neighbor is connected through a shared media.

q) Flag (1 bit). Octet 10 conveys a flag, which is encoded as a bit in a single octet. A flag is set if the bit takes the value 1; otherwise, it is reset. The Flag of Octet 10 indicates whether an IP address is used to identify the link. It is not an IP address in the case of ISIS-PCR, i.e., the link is unnumbered. Therefore, the flag is reset in an SPT Domain, i.e., each bit of Octet 10 takes value 0.

r) reserved (7 bits). Seven bits of Octet 10 are reserved for future use, transmitted as 0, and ignored on receipt.

s) Link Local Identifier (32 bits). Octets 11 through 14 convey the local identifier of the interface, which is an Extended Local Circuit ID as specified by IETF RFC 5303.

t) Link Remote Identifier (32 bits). Octets 15 through 18 convey the identifier of the remote interface, which is a Neighbor Extended Local Circuit ID as specified by IETF RFC 5303.

u) Shared Risk Link Group Value (32 bits). Octets 4*n*+15 through 4*n*+18 convey the value assigned to SRLG *n* to which the link belongs. The same SRLG value is used for all links that share a resource whose failure affects each link of the group. A link can belong to multiple SRLGs; therefore, multiple Shared Risk Link Group Values can be present in the same SRLG TLV.

45.1.9 Topology sub-TLV

The variable-length Topology sub-TLV shall be used to describe an explicit tree. The Topology sub-TLV may be also used for describing a Generalized Almost Directed Acyclic Graph (GADAG) as explained in 45.3.4 in detail. The Topology sub-TLV is carried in an MT-Capability TLV (type 144) in a Link State PDU. A Topology sub-TLV specifying an explicit tree conveys one or more Base VIDs and two or more Hop sub-TLVs (45.1.10) and can convey further sub-TLVs (45.1.11, 45.1.12) to constrain loose hops. The Topology sub-TLV also specifies the algorithm to be used for constrained routing. Figure 45-5 shows the format of the Topology sub-TLV.

		Octet	Length	
	Type (21)	1	1	
	Length	2	1	
	Number of Base VIDs	3	1	
Base VID Tuple *1*	reserved	4	4 bits	0 or 16 bits
	Base VID	4–5	12 bits	
	...			
Base VID Tuple *n*	reserved	(2*n*+2)	4 bits	0 or 16 bits
	Base VID	(2*n*+2)–(2*n*+3)	12 bits	
sub-TLV *1*	sub-TLV			
	...			
sub-TLV *m*	sub-TLV			

Figure 45-5—Topology sub-TLV

The parameters of explicit trees are encoded by the Topology sub-TLV as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 21.

b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field.

c) Number of Base VIDs (8 bits). Octet 3 conveys the number of Base VIDs carried in the Topology sub-TLV. Its minimum value is 1 if the Topology sub-TLV specifies an active topology. Its value can be 0 if the Topology sub-TLV specifies only a GADAG.

d) reserved (4 bits). Four bits of Octet 2n+2 are reserved for future use, transmitted as 0, and ignored on receipt.

e) Base VID (12 bits). Octet 2n+2 and Octet 2n+3 convey the nth Base VID parameter. The Base VID parameter provides the Base VID of the VLAN that is associated with the explicit tree. Multiple Base VIDs can be associated with the same explicit tree.

   Some of the explicit ECT Algorithms (45.1.2) require further VIDs, in addition to the Base VID, which are associated with the VLAN by using the SPB Instance sub-TLV as specified in 45.1.3.

   By default, each Edge Bridge is both transmitter and receiver for all VIDs associated with an explicit tree. Different behavior can be specified in the Hop sub-TLV (45.1.10) of the Edge Bridge.

   If VIDs of a learning VLAN associated with the LTS ECT Algorithm (Table 45-1) are conveyed by the Topology sub-TLV, then the default behavior for each Edge Bridge is that it is the only transmitter on its own VID and a receiver on the VIDs of all the other Edge Bridges. For such a learning VLAN, a per Bridge local VID is announced by a transmitter Edge Bridge via the SPB Instance sub-TLV (28.12.5) as specified in 45.1.3. If no VID is allocated to the Edge Bridge, then it is not a transmitter but only a receiver.

   A Topology sub-TLV specifying a GADAG can have zero Base VID parameters. In this case, the given GADAG has to be applied for each VLAN associated with the MRTG ECT Algorithm.

f) sub TLVs. The rest of the octets convey further sub-TLVs that specify the hops of the topology and can also specify constraints, bandwidth assignment, and timestamp as specified in the following subclauses.

A topology is specified by a list of Hop sub-TLVs (45.1.10), and a hop is specified by an IS-IS System ID. An ill-formed Topology sub-TLV, e.g., specifying an invalid strict tree or having a conflict in its specification, is ignored; no tree is installed but a management report is generated.

The Topology sub-TLV specifies a strict tree by decomposing the tree to branches. Each branch is a point-to-point path specified by an ordered list of hops where the end of each branch is a leaf. Each element of a branch is the direct link between adjacent neighbor Bridges whose Hop sub-TLV is next to each other in the Topology sub-TLV. The first hop of the Topology sub-TLV is the root; hence, the first branch originates from the root. The rest of the branches fork from another branch. The first hop of a branch is a Bridge that is already part of a former branch, and the last hop is a leaf Bridge. Therefore, the hop after a leaf hop is the beginning of a new branch, if any. A hop of a branch is created if and only if the Bridge specified for that hop is directly connected to the preceding Bridge of the same branch. The order of the branches does not matter within the Topology sub-TLV, but the first branch begins with the root. Figure 45-6 shows an example for the specification of a strict tree.

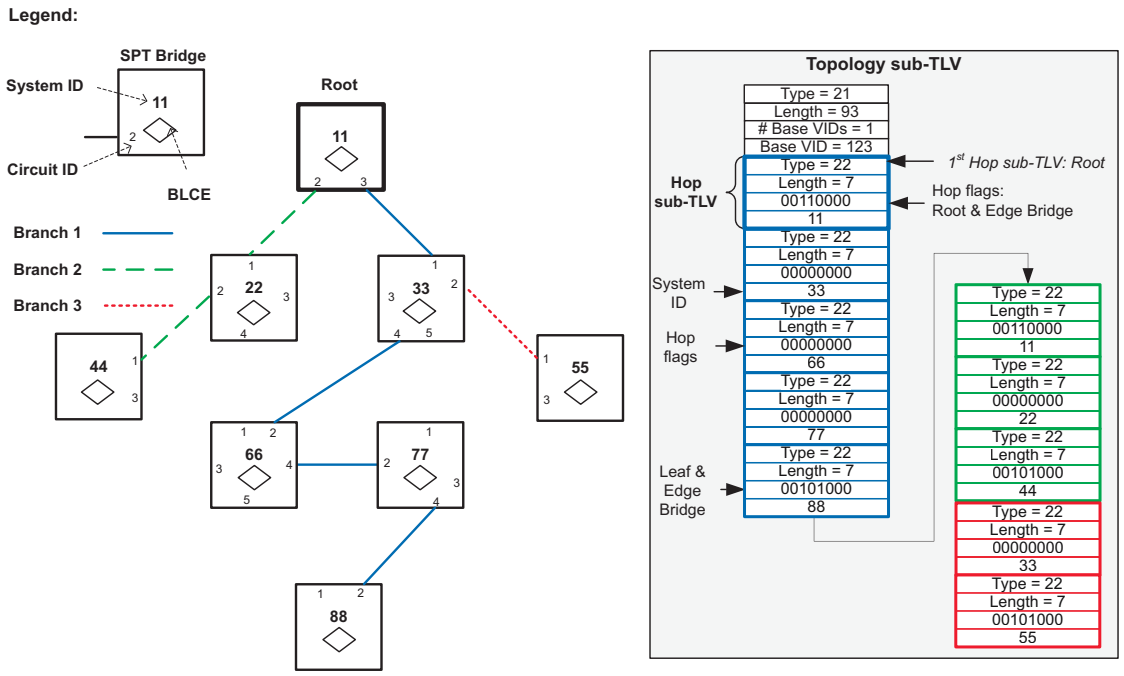


Figure 45-6—A strict tree and its descriptor Topology sub-TLV

The Topology sub-TLV of a loose tree does not provide any path or path segment, but the hops that are to participate. The root is the first hop. The leaves of a single loose tree are also specified. Hop sub-TLVs can be included in a Topology sub-TLV to specify Bridges that have to be avoided. If the Topology sub-TLV specifies only a single leaf, then one or more transit hops can be specified by the Topology sub-TLV to direct the path along a sequence of Bridges, specified by the order of hops. If Bridges whose respective Hop sub-TLVs are adjacent to each other in the Topology sub-TLV but are not topology neighbors, then it is a loose hop. If a Topology sub-TLV conveys one or more loose hops, then that sub-TLV defines a loose explicit tree, and each hop is considered as a loose hop. If a loose tree specified by a Topology sub-TLV would create a loop or hairpin, then the loop is pruned, and the remaining hops are installed. An example for the specification of a single loose tree is shown in Figure 45-7, where Bridge 77 is the root; Bridges 11, 44,

55, and 88 are leaves; and Bridge 22 is excluded from the tree. Bridges 11, 44, 55, and 88 are the Edge Bridges. Bridges 11, 44, 55, 77, and 88 are part of the tree because each of them has its special role as specified by the Topology sub-TLV. Conversely, the role of Bridges 33 and 66 is determined by the BLCE of the SPT Bridges only when the tree is computed after the reception of the Topology sub-TLV.

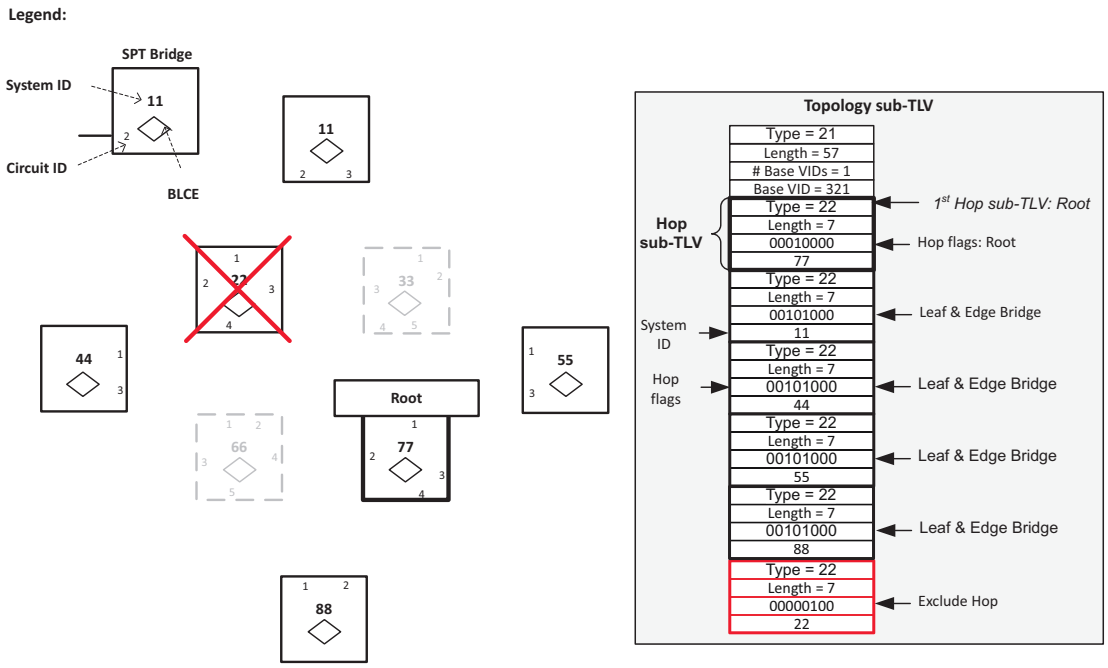


Figure 45-7—Topology sub-TLV of a loose tree

If the Base VIDs of the Topology sub-TLV are associated with the LTS ECT Algorithm or the MRT ECT Algorithm, then the Hop sub-TLVs conveyed by the Topology sub-TLV belong to Edge Bridges or Bridges to be excluded [item c6) in 45.1.10]. The BLCEs compute the loose trees, e.g., MRTs, so that they span the Edge Bridges and are rooted at an Edge Bridge.

The Topology sub-TLV specifies a GADAG if the Base VIDs conveyed by the Topology sub-TLV are associated with the MRTG ECT Algorithm (Table 45-1). The Topology sub-TLV specifies a GADAG by directed ear decomposition. A directed ear is a directed point-to-point path whose end points can coincide, but no other element of the path is repeated in the ear. Each ear is specified by an ordered list of hops, and that order of hops is according to the direction of the arcs in the GADAG. There are no leaves in a GADAG; hence, the Leaf flag is used to ease the parsing of the Topology sub-TLV and to mark the end of a topology block (3.272). The sequence of ears in the Topology sub-TLV is such that the end points of an ear belong to former ears. The GADAG Root is not marked by any flag, but the GADAG Root is the first hop in the Topology sub-TLV; correspondingly the first ear starts and ends with the GADAG Root. MRT Roots are marked by the Root flag, and all other Edge Bridges are leaves of the MRTs. If no MRT Root is specified, then each SPT Root is also an MRT Root. An example GADAG is shown in Figure 45-13 (in 45.3.4).

Each Edge Bridge of an explicit tree is always specified in the Topology sub-TLV by the inclusion of the Hop sub-TLVs corresponding to the Edge Bridges. The Edge Bridges of a tree are identified by setting the Edge Bridge flag [item c3) in 45.1.10] in the appropriate Hop sub-TLVs.

If the explicit tree is loose, then Administrative Group (45.1.11) and Bandwidth Constraint (45.1.12) sub-TLVs can be also conveyed by the Topology sub-TLV. In that case, each path of the tree has to meet the constraints specified by these sub-TLVs.

If ISIS-PCR is used for recording bandwidth assignment, then the Topology sub-TLV conveys the Bandwidth Assignment sub-TLV (45.2.1), and it can also convey a Timestamp sub-TLV (45.2.2). If the assignment of the bandwidth indicated by the Bandwidth Assignment sub-TLV of the Topology sub-TLV would result in overbooking any link of the explicit tree, then bandwidth assignment is not performed, and a management report is generated. If such a Topology sub-TLV describes a new valid explicit tree, then the paths of the tree are installed, but no bandwidth assignment is performed by ISIS-PCR.

NOTE 1—The LSP ID can be also considered as an identifier of an explicit tree if an LSP describes only a single tree, i.e., includes a single Topology sub-TLV.

NOTE 2—Allocation of VIDs to individual Aggregation Links between adjacent IS-IS Systems has to be done by the explicit configuration of conversations in that LAG at the two Systems in accordance with IEEE Std 802.1AX.

45.1.10 Hop sub-TLV

The Hop sub-TLV shall be used to specify a hop of a topology. Each Hop sub-TLV conveys an IS-IS System ID, which specifies a hop. A Hop sub-TLV is conveyed by a Topology sub-TLV (45.1.9). A strict explicit tree is decomposed to branches where each branch is a point-to-point path specified by an ordered list of Hop sub-TLVs as specified in 45.1.9 and illustrated in Figure 45-6. A hop of a branch is created if and only if the Bridge specified for that hop is directly connected to the preceding Bridge in the path. In other words, a point-to-point LAN is identified by the two Bridges it interconnects; and the LAN is part of the strict tree if and only if the Hop sub-TLVs of the two Bridges are next to each other in the Topology sub-TLV. A Hop sub-TLV can convey a Circuit ID in order to distinguish multiple links between adjacent neighbor Bridges. A Hop sub-TLV also specifies the role of a Bridge, e.g., if it is the root or an Edge Bridge. The Topology sub-TLV of a loose tree comprises only the Hop sub-TLVs of the Bridges that have special roles in the tree. The Hop sub-TLV may also specify a delay budget for a loose hop.

By default, the Edge Bridges both transmit and receive with respect to each VID associated with an explicit tree, except for an LTS associated with a learning VLAN [45.1.3, item e) in 45.1.9], which uses a unidirectional VID per Bridge. The Hop sub-TLV allows different configuration by means of the VID's Transmit (T) and Receive (R) flags conveyed in the sub-TLV. The VID and its T/R flags are present in the Hop sub-TLV only if the behavior of the Edge Bridges differs from the default [defined in item e) in 45.1.9]. The T/R flags of an I-SID associated with an explicit tree in a PBBN are set in the SPBM Service Identifier and Unicast Address sub-TLV (28.12.10), which also provides the association of the I-SID with the B-VID.

Figure 45-8 shows the format of the variable-length Hop sub-TLV, which shall be conveyed by a Topology sub-TLV (45.1.9).

		Octet	Length	
	Type (22)	1	1	
	Length	2	1	
Hop Flags	Circuit	3	1 bit	8 bits
	VID	3	1 bit	
	Edge Bridge	3	1 bit	
	Root	3	1 bit	
	Leaf	3	1 bit	
	Exclude	3	1 bit	
	reserved	3	2 bits	
	System ID	4–9	6	
	Extended Local Circuit ID	10–13	0 or 4	
	Number of VIDs	10 or 14	0 or 1	
VID Tuple *1*	T	11 or 15	1 bit	0 or 16 bits
	R	11 or 15	1 bit	
	reserved	11 or 15	2 bits	
	VID	11–12 or 15–16	12 bits	
	...			
VID Tuple *n*	T	(2*n*+9) or (2*n*+13)	1 bit	0 or 16 bits
	R	(2*n*+9) or (2*n*+13)	1 bit	
	reserved	(2*n*+9) or (2*n*+13)	2 bits	
	VID	(2*n*+9)–(2*n*+10) or (2*n*+13)–(2*n*+14)	12 bits	
	Delay Constraint	10–15 or 14–19 or (2*n*+13)–(2*n*+16) or (2*n*+17)–(2*n*+20)	0 or 6	

Figure 45-8—Hop sub-TLV

The parameters of a hop are encoded as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 22.

b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field.

c) Hop Flags (8 bits). Octet 3 conveys the Hop flags. The Circuit and the VID flags influence the length of the Hop sub-TLV. Table 45-3 summarizes the use of the flags in the case of the different explicit ECT Algorithms.

   1) Circuit flag (1 bit). The Circuit flag indicates whether the Extended Local Circuit ID parameter is present. If the flag is set, then an Extended Local Circuit ID is also included in the Hop sub-TLV.

   2) VID flag (1 bit). The VID flag indicates whether one or more VIDs are conveyed by the Hop sub-TLV. If the flag is set, then the Number of VIDs parameter is present and indicates how many VIDs are conveyed by the Hop sub-TLV. If the VID flag is reset, then neither the Number of VIDs parameter nor VIDs are present in the Hop sub-TLV.

   3) Edge Bridge flag (1 bit). The Edge Bridge flag indicates whether the given System is an Edge Bridge, i.e., transmitter and/or receiver. If the System is an Edge Bridge, then the Edge Bridge flag is set. The Edge Bridge flag indicates that FDB entries have to be installed for the given hop as specified by its SPBV MAC address sub-TLV or SPBM Service Identifier and Unicast Address sub-TLV.

Table 45-3—Hop sub-TLV flags

		Flag			
		Edge Bridge	**Root**	**Leaf**	**Exclude**
ECT Algorithm	**Strict Tree**	The Bridge is an Edge Bridge.	The Bridge is the root of the tree. (first hop)	The Bridge is a leaf of the tree. (always an Edge Bridge)	—
	Loose Tree	The Bridge is an Edge Bridge. (set for every hop of multi-point trees except for exclude hops)	The Bridge is the root of the tree. (first hop)	The Bridge is a leaf of the tree. (always an Edge Bridge)	The Bridge has to be excluded from the tree.
	Loose Tree Set	The Bridge is an Edge Bridge. (set for every hop of multi-point trees except for exclude hops)	The Bridge roots a tree. (every Bridge that is Edge Bridge)	—	The Bridge has to be excluded from each tree.
	MRT	The Bridge is an Edge Bridge.	The Bridge is an MRT Root. (always an Edge Bridge)	—	The Bridge has to be excluded from the MRTs.
	MRT with GADAG	The Bridge is an Edge Bridge.	The Bridge is an MRT Root. (always an Edge Bridge)	The Bridge is the end of a topology block.	—

4) Root flag (1 bit). The Root flag indicates whether the given System is a root of the explicit tree specified by the Topology sub-TLV. If the System is a root of a tree, then the Root flag is set.

   If the Topology sub-TLV specifies a single tree, i.e., the Base VIDs conveyed by the Topology sub-TLV are associated with either the ST ECT Algorithm or the LT ECT Algorithm, then the Root flag is set only for one of the Systems conveyed by the Topology sub-TLV. Furthermore, the first Hop sub-TLV of the Topology sub-TLV conveys the System that is the root of the tree. If the Topology sub-TLV specifies a Loose Tree Set, i.e., the Base VIDs conveyed by the Topology sub-TLV are associated with the LTS ECT Algorithm (Table 45-1), then the Root flag is set for each Edge Bridge as each of them roots a tree. The first Hop sub-TLV of the Topology sub-TLV conveys a root.

   If the Topology sub-TLV is used for MRT operations, i.e., the Base VIDs conveyed by the Topology sub-TLV are associated with either the MRT ECT Algorithm or the MRTG ECT Algorithm (Table 45-1), then the Root flag is set for each MRT Root. If no MRT Root is specified by a Topology sub-TLV specifying a GADAG, then each SPT Root is an MRT Root as well.

   If the Base VIDs conveyed by the Topology sub-TLV are associated with the MRTG ECT Algorithm (Table 45-1), then the Topology sub-TLV specifies a GADAG, and the very first Hop sub-TLV specifies the GADAG Root. There is no flag for indicating the GADAG Root.

5) Leaf flag (1 bit). The Leaf flag indicates whether the given System is a leaf of the explicit tree specified by the Topology sub-TLV. If the System is a leaf, then the Leaf flag is set.

   The Leaf flag is used to mark a leaf of a tree only if the Topology sub-TLV specifies a single tree, i.e., the Base VIDs are associated with either the ST ECT Algorithm or the LT ECT Algorithm (Table 45-1).

   The Leaf flag is not used for marking leaves if the ECT Algorithm produces multiple trees because a Bridge that is leaf in one tree can be the root of another tree.

The Leaf flag is used to indicate the end of a topology block (3.272) if the Topology sub-TLV specifies a GADAG; see item f) in 45.1.9 and see 45.3.4.

6) Exclude flag (1 bit). The Exclude flag indicates whether the given System has to be excluded from the topology. The Exclude flag and the Root flag cannot be set for a given hop at the same time.
7) reserved (2 bits). Two bits of Octet 3 are reserved for future use, transmitted as 0, and ignored on receipt.

d) System ID (48 bits). Octets 4 through 9 convey the 6-byte IS-IS System Identifier of the Bridge to which the Hop sub-TLV refers.

e) Extended Local Circuit ID (32 bits). Octets 10 through 13 convey the Extended Local Circuit ID as specified by IETF RFC 5303 if Extended Local Circuit ID is present in the Hop sub-TLV, as indicated by the Circuit flag.

Parallel links corresponding to different IS-IS adjacencies between a pair of neighbor SPT Bridges can be distinguished by means of the Extended Local Circuit ID. The Extended Local Circuit ID is conveyed by the Hop sub-TLV specifying the Bridge nearer to the root of the tree and identifies a circuit that attaches the given Bridge to its neighbor cited by the next Hop sub-TLV of the Topology sub-TLV. The Extended Local Circuit ID can be used only in strict trees.

f) Number of VIDs (8 bits). A single octet conveys the Number of VIDs parameter, which is Octet 10 if the Extended Local Circuit ID parameter is absent whereas it is Octet 14 if the Extended Local Circuit ID parameter is present. If the Hop sub-TLV does not convey VIDs, then the Number of VIDs parameter is not present, as indicated by the VID flag.

g) VID and its T/R flags (14 bits). Two octets convey the VID and its T/R flags parameters. The first one is Octet 2n+9 and the second one is Octet 2n+10 if the Extended Local Circuit ID parameter is absent whereas the first one is Octet 2n+13 and the second one is Octet 2n+14 if the Extended Local Circuit ID parameter is present.

The VID and its T/R flags are present in the Hop sub-TLV only if the given Bridge is an Edge Bridge and it behaves differently from the default with respect to that particular VID. (The default behavior is defined in item e of the Topology sub-TLV (45.1.9).)

1) T flag (1 bit). This bit is the Transmit allowed flag for the VID following the flag.
2) R flag (1 bit). This bit is the Receive allowed flag, i.e., R flag for the VID following the flag.
3) reserved (2 bits). Two bits of the first Octet are reserved for future use, transmitted as 0, and ignored on receipt.
4) VID (12 bits). The VID can be a Base VID, an MRT VID, or a VID in support of a learning VLAN associated with the LTS ECT Algorithm.

h) Delay Constraint (48 bits). The last six octets specify a delay constraint if they convey a Unidirectional Link Delay sub-TLV [item f) in 45.1.8]. The delay constraint can be used in a Topology sub-TLV that specifies a single loose tree, i.e., the Base VIDs are associated with the LT ECT Algorithm (Table 45-1). If delay constraint is applied, then the loose hop has to fit in the delay budget specified by the Delay parameter of the Unidirectional Link Delay sub-TLV [item f) in 45.1.8] conveyed by the Hop sub-TLV. If the Topology sub-TLV specifies a single leaf, then the path between the preceding Hop sub-TLV and the current Hop sub-TLV has to meet the delay budget. If the Topology sub-TLV specifies multiple leaves, then the path between the root and the current Hop sub-TLV has to meet the delay budget. If the tree is used as a reverse congruent tree, then the delay constraint applies in both directions. If the tree is used as a directed tree, then the delay constraint applies in the direction of the tree.

NOTE 1—The T and R flags can be used to establish asymmetric VLANs, e.g., for rooted-multipoint connectivity.

NOTE 2—The Root and Leaf flags specify the role of the Bridges only in the explicit tree, i.e., the active topology. Roots and leaves with respect to data traffic are specified by the T/R flags of VIDs and MAC addresses associated with the Edge Bridges. Roots and leaves of the active topology and data flows do not necessarily coincide, e.g., see Figure 45-7.

45.1.11 Administrative Group sub-TLV

The Administrative Group sub-TLV may be included in a Topology sub-TLV (45.1.9) in order to put a constraint on loose hops. In this case, each LAN included in a loose hop has to be a member of the Administrative Group(s) indicated by the Administrative Group sub-TLV. The format of the Administrative Group sub-TLV is specified by IETF RFC 5305 as shown in Figure 45-9. In other words, the same format is used for the constraint as for the TE attribute; therefore, their comparison is easy.

	Octet	Length
Type (3)	1	1
Length (4)	2	1
Administrative Group	3–6	4

Figure 45-9—Administrative Group sub-TLV

The administrative groups are encoded as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 3.
b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field. The value of the Length field is 4.
c) Administrative Group (32 bits). Octets 3 through 6 convey the Administrative Group parameter. It comprises 32 flags, and each flag belongs to a distinct group. Group membership is indicated by the flags set.

45.1.12 Bandwidth Constraint sub-TLV

The Bandwidth Constraint sub-TLV may be included in a Topology sub-TLV (45.1.9) in order to specify how much available bandwidth is to be provided by the tree. Each loose hop has to meet the bandwidth constraint. The bandwidth value of the constraint is a total value, or it refers only to a single PCP as specified by the sub-TLV. Figure 45-10 shows the format of the Bandwidth Constraint sub-TLV.

	Octet	Length
Type (23)	1	1
Length (5)	2	1
PCP	3	3 bits
DEI	3	1 bit
PCP flag	3	1 bit
reserved	3	3 bits
Available Bandwidth	4–7	4

Figure 45-10—Bandwidth Constraint sub-TLV

The parameters of the bandwidth constraint are encoded as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 23.
b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field, The value of the Length field is 5 bytes.
c) PCP (3 bits). Octet 3 conveys the PCP parameter, which determines the traffic class to which the Available Bandwidth parameter refers.
d) DEI (1 bit). Octet 3 also conveys the DEI parameter.

   If the DEI parameter is clear, then the bandwidth constraint refers to committed information rate.
   If the DEI parameter is set, then the bandwidth constraint refers to peak information rate.

e) PCP flag (1 bit). Octet 3 also conveys the PCP flag. If it is set, then the PCP parameter is taken into account.

f) reserved (3 bits). Three bits of Octet 3 are reserved for future use, transmitted as 0, and ignored on receipt.

g) Available Bandwidth (32 bits). Octets 4 through 7 convey the Available Bandwidth. The Available Bandwidth is specific to the traffic class identified by the PCP parameter if the PCP flag is set; otherwise, it is total bandwidth. In line with the bandwidth parameters specified in IETF RFC 5305, the Available Bandwidth is encoded as a 32-bit IEEE floating point number, and the units are bytes (not bits!) per second. Thus, the Available Bandwidth constraint applied for a traffic class is easily comparable with the Unreserved Bandwidth stored in the TED for the given traffic class (see sub-TLV 11 specified by IETF RFC 5305).

   The bandwidth constraint applies for both directions in the case of symmetric (3.264) explicit trees. Nevertheless, a VID associated with an explicit tree can be made unidirectional by means of the T/R flags belonging to the VID in the Hop sub-TLV (45.1.10) of the Edge Bridges. If all the VIDs of the Topology sub-TLV (45.1.9) are unidirectional and all belong to the traffic class identified by the PCP parameter of the Bandwidth Constraint sub-TLV, then it is enough to meet the bandwidth constraint in the direction applied for those VIDs.

NOTE—The peak information rate is the committed information rate plus the excess information rate.

45.2 Reservation

ISIS-PCR may be used for recording bandwidth assignment for explicitly placed data traffic in an SPT Region if MSRP is not used within the region. If MSRP is used in an SPT Region, then only MSRP performs reservations and IS-IS does not.

45.2.1 Bandwidth Assignment sub-TLV

ISIS-PCR can record bandwidth assignment for explicitly placed data traffic. ISIS-PCR can be used for recording bandwidth assignment only within an SPT Region where MSRP is not used.

If precedence order has to be determined among bandwidth assignments in an SPT Region with multiple PCEs, then ISIS-PCR provides it as specified in 45.2.3.

The Bandwidth Assignment sub-TLV can be used to define the amount of bandwidth whose assignment is to be recorded by ISIS-PCR at each hop of the explicit tree described by the corresponding Topology sub-TLV (45.1.9). The Bandwidth Assignment sub-TLV is conveyed by a Topology sub-TLV (45.1.9).

The Bandwidth Assignment sub-TLV is used by ISIS-PCR for the recording of bandwidth assignment for a traffic class. Figure 45-11 shows the format of the Bandwidth Assignment sub-TLV.

	Octet	Length
Type (24)	1	1
Length (5)	2	1
PCP	3	3 bits
DEI	3	1 bit
Importance	3	3 bits
reserved	3	1 bit
Bandwidth	4–7	4

Figure 45-11—Bandwidth Assignment sub-TLV

The parameters for bandwidth assignment recorded by ISIS-PCR are encoded as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 24.
b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field. The value of the Length field is 5.
c) PCP (3 bits). Octet 3 conveys the PCP parameter, which specifies the traffic class for which the bandwidth is to be assigned.
d) DEI (1 bit). Octet 3 also conveys the DEI parameter.

   If the DEI parameter is clear, then the bandwidth assignment is performed to provide committed information rate.

   If the DEI parameter is set, then the bandwidth assignment is performed to provide peak information rate.
e) Importance (3 bits). Octet 3 also conveys the Importance parameter for determining precedence order among bandwidth assignments within a PCP as specified in 45.2.3. A lower numerical value indicates a more important bandwidth assignment within a PCP. The default value of the Importance parameter is 7.
f) reserved (1 bit). One bit of Octet 3 is reserved for future use, transmitted as 0, and ignored on receipt.
g) Bandwidth (32 bits). Octets 4 through 7 convey the amount of bandwidth to be assigned for the traffic class identified by the PCP parameter. In line with the bandwidth values specified in IETF RFC 5305, the Bandwidth parameter is encoded as a 32-bit IEEE floating point number, and the units are bytes (not bits!) per second.

   The bandwidth assignment applies for both directions in the case of symmetric (3.264) explicit trees. Nevertheless, a VID associated with an explicit tree can be made unidirectional by means of the T/R flags belonging to the VID in the Hop sub-TLV (45.1.10) of the Edge Bridges. If all the VIDs having the same PCP in the Topology sub-TLV (45.1.9) are unidirectional, then the bandwidth is assigned only in the direction applied for those VIDs.

If bandwidth is to be assigned both for committed information rate and for peak information rate, then the Topology sub-TLV conveys two Bandwidth Assignment sub-TLVs: one with DEI cleared and another with DEI set.

45.2.2 Timestamp sub-TLV

The Timestamp sub-TLV may be included in a Topology sub-TLV (45.1.9) in order to provide precedence order among equally important bandwidth assignments within a PCP as specified in 45.2.3. Figure 45-12 shows the format of the Timestamp sub-TLV.

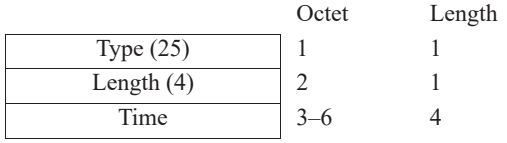


Figure 45-12—Timestamp sub-TLV

The timestamp represents a positive time with respect to the Precision Time Protocol (PTP) epoch, and it is encoded as follows:

a) Type (8 bits). Octet 1 conveys the type of the sub-TLV, and its value is 25.
b) Length (8 bits). Octet 2 conveys the total number of bytes contained in the Value field. The value of the Length field is 4.

c) Time (32 bits). Octets 3 through 6 convey the time in units of seconds with respect to the PTP epoch.

NOTE—The Timestamp sub-TLV carries the seconds portion of PTP as specified by IEEE Std 1588 [B15]. The epoch is 1970-01-01 00:00:00 TAI (i.e., the PTP time does not include leap seconds).

45.2.3 Precedence ordering

The PCEs are collectively responsible for making a consistent set of bandwidth assignments when ISIS-PCR is used for recording bandwidth allocations. Despite that responsibility, if precedence ordering is required among bandwidth assignments, then ordering based on the following parameters has to be applied:

1) PCP parameter of Bandwidth Assignment Sub-TLV
2) Importance parameter of Bandwidth Assignment Sub-TLV
3) Timestamp sub-TLV (if present in the Topology sub-TLV)

A bandwidth assignment takes precedence if it has higher PCP, or higher Importance within a PCP, or earlier timestamp in the case of equal Importance within a PCP. A bandwidth assignment associated with a timestamp takes precedence over a bandwidth assignment without timestamp when PCP and Importance of different bandwidth assignments are both equal.

If resolution is not possible based on the above parameters or they are not available, e.g., each bandwidth assignment lacks timestamp or the precedence order has to be determined for the use of a VID, then the item is granted to the PCE whose LSP has the numerically least LSP ID.

45.3 Redundancy

This subclause specifies IS-IS extensions in support of redundancy schemes, i.e., protection and restoration for data flows.

Local protection for unicast data flows based on loop-free alternates is described in 45.3.1.

Protection schemes are often based on two or more redundant trees, or if that is not possible, then on maximally redundant trees. Maximally Redundant Trees (MRTs) can be used either in a static fashion or with cautious restoration for ISIS-PCR. This subclause specifies how MRTs are installed and maintained leveraging the tools provided by 45.1. The use of static MRTs is described in 45.3.2. Setting up and maintaining MRTs with cautious restoration is described in 45.3.3 and 45.3.4.

45.3.1 Loop-free alternates for unicast data flows

Downstream Loop-Free Alternates (LFAs) provide a simple redundancy scheme, which may be supported by ISIS-SPB for unicast flows of an SPBM VLAN and for SPBV VLANs. A path toward an individual destination MAC address is downstream if it is ensured that the distance to the destination decreases at each hop along the path. Downstream paths are always loop-free alternates to each other with respect to an individual destination MAC address. Therefore, a downstream alternate path can be safely used for local protection as a loop-free backup path.

NOTE—The Alternate Ports of RSTP and MSTP leverage the loop-free alternate paths provided by the physical topology to the Root Bridge. In the case of spanning trees, ‘up’ or ‘upward’ to the Root is used to refer to the same direction as ‘downstream’ for destination rooted trees.

LFA can be provided for SPBV by SPTs (13.17, Clause 27, Clause 28). The LFA mechanism is the same for an SPT as for an MSTI where Alternate Ports leverage LFA paths.

Loop mitigation (6.5.4.2) may be relaxed in order to allow LFAs for unicast SPBM traffic. Ingress checking is modified and relaxed in order to allow the reception of a unicast frame from any SPT Bridge that is upstream with respect to the given individual destination MAC address. Thus, relaxed ingress checking

implements a split horizon for loop mitigation by ensuring that a frame is admitted only if it is received from an SPT Bridge that is farther from the destination than the receiving SPT Bridge, which determines the valid set of ingress ports.

In the case of a failure at an SPT Bridge's Port or LAN on the shortest path toward individual MAC addresses, the SPT Bridge acts as a Point of Local Repair (PLR) and forwards frames through ports providing downstream LFA paths toward the given individual MAC addresses, if any.

An SPT Bridge updates its relaxed ingress checking after detecting a mismatch in the Agreement Digest. An ingress port is removed from the valid set of ingress ports with respect to a particular individual destination MAC address if a formerly upstream SPT Bridge is no longer farther from the destination than the given SPT Bridge. An LFA path is removed if the corresponding formerly downstream neighbor is not closer any more to the destination than the given SPT Bridge.

An SPT Bridge updates its LFA paths and relaxed ingress checking after finishing the updates of multicast states. If LFA paths with respect to an individual MAC address have been changed, then the new LFA paths are added. The valid set of ingress ports is extended with the new upstream Bridges with respect to an individual MAC address, if any.

45.3.2 Static redundant trees

The trees associated with the ST ECT Algorithm (00-80-C2-17, Table 45-1) are static in the sense that no entity other than the owner PCE can update them. In other words, ISIS-PCR only installs the strict trees and does not take any further action on them; i.e., ISIS-PCR neither restores them nor maintains them. In the case of a topology change, it is the task of the owner PCE to detect the topology change, e.g., based on the changes in its LSDB, and also update the strict trees if needed. This requires the owner PCE to compute the new tree and to assemble the corresponding new Topology sub-TLV (45.1.9). The PCE then sends the updated LSP conveying the new Topology sub-TLV, and ISIS-PCR updates the strict explicit tree. The owner PCE can withdraw an explicit tree by sending an updated LSP that does not include the Topology sub-TLV. If a Topology sub-TLV is removed from an LSP (or has been changed), so that (previous) Topology sub-TLV is no longer present (or has been changed) in the LSDB, then that (previous) Topology sub-TLV is implicitly withdrawn. ISIS-PCR then removes (or updates) the explicit tree.

NOTE 1—The PCE preferably does not initiate the update of explicit trees if there is any reason to suspect that the SPT Bridges of the SPT Region do not share a common view on network topology.

NOTE 2—The PCE can have a hot standby backup PCE in order to avoid a single point of failure.

Strict explicit trees can be used for Maximally Redundant Trees (MRTs), especially if more than two redundant trees are needed. Each tree is described by a distinct Topology sub-TLV (45.1.9). The VLAN configuration of strict trees is specified in 45.1.3.

The PCE or its PCA assembles and floods the corresponding Topology sub-TLVs (45.1.9); thus ISIS-PCR installs the explicit trees throughout the SPT Region as specified in 45.1. All of the maximally redundant trees are installed independently of each other, i.e., ISIS-PCR is not aware of any relationship between them. Maintaining the association among the redundant strict trees is not the responsibility of ISIS-PCR, but the entity that requests and uses them, e.g., the owner PCE and the management entity responsible for configuring the protection scheme in use. Therefore, no parameters for association of static explicit trees are present in the ISIS-PCR sub-TLVs.

NOTE 3—For instance, two static redundant trees can be used for CFM-based protection switching as specified in 26.10, where the association and the use of the paths are provided. Static redundant trees can be also used for 1+1 types of protection schemes, where a copy of each data frame is forwarded on each of the redundant paths.

The algorithm used by the owner PCE for the computation of static redundant trees is not specified by this standard. Number *K*, the number of trees to be computed, is an input for the owner PCE. The Topology sub-TLVs (45.1.9) are the output of the owner PCE. Other outputs can include the number of common links and their identity.

45.3.3 Maximally Redundant Trees (MRTs)

SPT Bridges may support MRTs. The BLCE of SPT Bridges is also involved in the computation of MRTs. The MRTs can be, for example, used for point-to-multipoint protection if the MRTs are source rooted or for multipoint-to-point protection if the MRTs are destination rooted. The MRTs can be used to protect an SPT rooted at the MRT Root. The MRTs can be also used so that they protect each other, e.g., in a 1+1 type of protection scheme where data frames are sent on both MRTs. An MRT provides an undirected active topology just like an SPT or a spanning tree instance (which is also a shortest path tree rooted at the spanning tree root). Correspondingly, MRTs can be used for bidirectional or unidirectional traffic, as determined by the T/R parameters of the data traffic carried on the tree.

The MRT ECT Algorithm (00-80-C2-18, Table 45-1) is used for the establishment and maintenance of MRTs in a distributed fashion as specified by this subclause. The MRT Lowpoint Algorithm specified by IETF RFC 7811 has to be used for the computation of MRTs that span more than two Edge Bridges. If only two Edge Bridges are to be connected, then the algorithm specified in this subclause has to be used for path computation. The MRT Lowpoint Algorithm produces two MRTs for an MRT Root: MRT-Blue and MRT-Red. If the MRTs are used in a primary and backup fashion, then MRT-Blue is the primary and MRT-Red is the backup. The MRTs are cautiously restored after a topology change as described in this subclause.

NOTE 1—If more than two maximally redundant trees are required, then static redundant trees (45.3.2) have to be used.

When the MRT Lowpoint Algorithm is used by ISIS-PCR, then the input parameters of the Interface_Compare function are as follows: The Interface_compare_metric is the SPB Link Metric (28.12.7), and the maximum metric value is used in cases where the metrics advertised by adjacent Bridges for a given link are different. The Interface_compare_unique_node_identifier is the 8-byte Bridge Identifier, which comprises a 6-byte IS-IS System Identifier and a 2-byte Bridge Priority.

The MRT Lowpoint Algorithm first computes the GADAG, and the computation requires the selection of the GADAG Root. The Bridge with the best Bridge Identifier is selected as the GADAG Root, where the numerically lower value indicates the better identifier. The manageable Bridge Priority component of the Bridge Identifier allows the configuration of the GADAG Root. The Bridge Priority is conveyed by Octets 15 and 16 of the SPB Instance sub-TLV (28.12.5). Based on its LSDB, each SPT Bridge can locally determine which Bridge is the GADAG Root and then compute the GADAG. The MRTs are then computed based on the GADAG. Examples for a GADAG and two corresponding MRTs are shown in Figure 45-13 and Figure 45-14, respectively. If tie-breaking is required among equal cost paths while the MRTs are computed, then the tie-breaking specified by the LowPATHID algorithm (28.7) has to be used. If MRTs support a VLAN having multiple multicast sources, then the BLCEs of the Bridges have to compute the MRTs of other Bridges in addition to their own MRTs due to the need to apply source-specific (S,G) multicast. This is similar to the application of All Pairs Shortest Path computation in ISIS-SPB. (See 45.1.1 for further details on source-specific (S,G) multicast.)

The MRT Lowpoint Algorithm is specified in terms of determining next hop FDB entries toward a particular unicast destination. This generates a tree directed to the root, which is the destination. By inverting the direction of this destination rooted tree, a source rooted tree can be retrieved.

If MRTs are required for a VLAN so that each Bridge performs all the MRT computation steps on its own including GADAG computation, i.e., the MRT computation is fully distributed, then the VLAN has to be associated with the MRT ECT Algorithm (Table 45-1) as specified in 45.1.3.

Just using the MRT ECT Algorithm creates MRT-Blue and MRT-Red for each SPT Root, i.e., each SPT Root is also an MRT Root, and IS-IS maintains all the MRTs. Furthermore, the MRTs are spanning trees in this case, i.e., each Bridge of the SPT Region is included in both MRT-Blue and MRT-Red. This operation mode is selected by providing the VLAN configuration in the SPB Base VLAN Identifiers sub-TLV (28.12.4) and in the SPB Instance sub-TLV (28.12.5) as specified in 45.1.3. The Topology sub-TLV (45.1.9) is not used in this case, i.e., only ISIS-SPB sub-TLVs are used.

If the level of redundancy provided by each SPT Root also being an MRT Root is not required, then the MRT Roots can be specified by a Topology sub-TLV (45.1.9); this approach can be also applied when MRTs protect each other and SPTs are not used. The Topology sub-TLV describes loose explicit trees in this case, i.e., it specifies only the Edge Bridges that the MRTs are to span, and each Edge Bridge is a loose hop. An MRT Root is specified by setting the Root flag [item c4) in 45.1.10] in the corresponding Hop sub-TLV (45.1.10). An MRT Root is typically an Edge Bridge too. MRTs provide a path from each Edge Bridge to the MRT Root, i.e., each Edge Bridge is a leaf except for the MRT Root. If a Topology sub-TLV specifies multiple MRT Roots, then an Edge Bridge has different roles in the MRTs rooted at different Bridges. Therefore, the Leaf flag [item c5) in 45.1.10] is not used to mark leaves of MRTs. The Topology sub-TLV can include a hop with the Exclude flag [item c6) in 45.1.10] set for a Bridge that is to be avoided by the MRTs, in which case the Bridge is excluded from the GADAG, too. The Topology sub-TLV can convey one or more Base VIDs that are associated with the MRT ECT Algorithm. Whether the MRTs are unidirectional or bidirectional is determined by the T/R flags corresponding to the VIDs, I-SIDs, and MAC addresses associated with the given MRTs.

NOTE 2—For instance, if a VLAN is supported by ISIS-SPB in SPBM mode (Clause 27, Clause 28) and MRTs are used for the protection of SPTs, then only three VIDs are required to support the VLAN. The Base VID is used for all the SPTs. Another VID is used for all MRT-Blues, and a third VID is used for all MRT-Reds. The MRTs are then used as destination rooted trees for unicast traffic and as source rooted trees for multicast traffic just like the SPTs. The T/R parameters for the MRT VIDs are exactly the same as for the Base VID; therefore, IS-IS populates the FDBs for the MRTs the same way as for the SPTs, i.e., just uses the corresponding MRT VID instead of the Base VID.

If the Topology sub-TLV specifies only two Edge Bridges, then the following algorithm is used for the computation of the two maximally redundant paths instead of the MRT Lowpoint Algorithm. As they interconnect only two Edge Bridges, the MRTs are reverse path congruent maximally redundant paths in this case. According to the algorithm below, one of the two maximally redundant paths is the shortest path. The two paths are used to protect each other. A VLAN associated with maximally redundant paths has to be configured as specified in 45.1.3 for the MRT ECT Algorithm. The VID of MRT-Blue is used for the shortest path, and the VID of MRT-Red is used for the other path. The establishment of the redundant paths is initiated by the flooding of a Topology sub-TLV (45.1.9). The paths are then determined by the BLCE of the SPT Bridges and then installed by ISIS-PCR. The Topology sub-TLV can convey constraint sub-TLVs, which have to be also taken into account when determining the paths. The BLCEs perform the following path computation algorithm:

1) Prune the topology according to the constraints of the Topology sub-TLV (45.1.9), if any. The rest of the computation steps are performed on the pruned topology. If pruning splits the SPT Region, then the outcome can be that no path is available.
2) Run Dijkstra to get the (constrained) shortest path, which is the primary path.
3) Install the FDB entries corresponding to the VID of MRT-Blue along the primary path.
4) Update th network graph by the appropriate method as follows:
   a) Prune the links of the primary path if that does not partition the SPT Region.
   b) Otherwise, multiply by 1000 the link metric of the links taking part in the primary path.
5) Run Dijkstra to get the backup path.
6) Install the FDB entries corresponding to the VID of MRT-Red along the backup path.

It is recommended to use distinct VIDs for MRT-Blue and MRT-Red, which are loose trees and therefore computed by multiple entities. As a strict tree is controlled by a single PCE, it is easier to ensure unambiguous forwarding and allow the use of the same VID for different strict trees as described in 45.1.4 than to do so for loose trees.

MRTs have to be restored cautiously after a topology change. The restoration should not be initiated if there is any reason to suspect that the SPT Bridges of the SPT Region do not share a common view on the network topology. BLCEs then perform path computation, and MRTs are updated as follows.

If MRTs are used for SPT protection, then MRTs are restored only after the restoration of the SPTs. Upon a failure event, Point of Local Repair (PLR) Bridges redirect data traffic to the MRT that is not affected by the failure, if any. As the topology change is announced by the corresponding LSPs, the SPT Bridges compute and install the new SPTs. If each SPT Bridge has installed the new SPT, then data traffic is directed back to the SPTs. After that, the new MRTs are computed and installed by the Bridges.

If MRTs support a non-learning VLAN, then the PLRs can redirect traffic by replacing the FDB entry belonging to the tree of normal operation (i.e., the SPT or an MRT) with the FDB entry belonging the protection tree (i.e., with MRT-Blue or MRT-Red) upon a failure event. If MRTs support a learning VLAN, then the PLRs can redirect traffic by updating VID translation at the Ingress Port from the VID of normal operation to the VID of the protection tree (i.e., to MRT-Blue or MRT-Red) upon a failure event.

If MRTs protect each other, then only one of the MRTs is restored at a time. Upon a failure event, PLR Bridges direct all data traffic to the MRT (e.g., MRT-Red) that is not affected by the failure. If a 1+1 type of protection scheme is used, then there is no need to react to a failure event as data frames are forwarded on both MRTs, i.e., there are no PLRs. When each SPT Bridge has the same view on the network topology again, then the SPT Bridges compute the new MRTs. The broken MRT (e.g., MRT-Blue) then is restored while the other MRT (e.g., MRT-Red) is not touched. If each SPT Bridge has installed the new MRT (e.g., the new MRT-Blue), then data traffic is directed to this newly restored MRT. The SPT Bridges then install the other MRT (e.g., the new MRT-Red). The same restoration procedure is followed if both MRTs are affected by the failure so that MRT-Blue is restored first.

Loop prevention (6.5.4.1, 27.9) has to be applied for MRTs during the period when they are being restored by ISIS-PCR.

There is a non-zero probability of out-of-order frame delivery while ISIS-PCR restores loose explicit trees, e.g., MRTs. This probability is similar to the probability of out-of-order frame delivery while ISIS-SPB restores SPTs.

If there are two maximally redundant paths between a pair of Edge Bridges and only the backup path went down, then just Steps 4–6 of the above algorithm are performed again. If only the primary path went down, then data traffic takes the backup path, i.e., only the backup path is in use by the applied protection mechanism. The primary path is then updated according to Steps 1–3. No further steps are taken until the primary path is up again. The protection scheme can then revert to the primary path, and the backup path can be updated according to Steps 4–6. If both paths went down, then Steps 1–6 are performed again.

NOTE 3—The method to be used for verifying whether the SPT Bridges have a common view on the topology and whether SPTs and MRTs have been restored is left to the implementer and the network operator. A common method is to wait some time after the reception of the last LSP indicating a topology change. Alternatively, OAM can be used for instance.

45.3.4 MRTs with centralized GADAG computation

The GADAG is identical for all the MRTs within a network domain, as a consequence of the use of the MRT Lowpoint Algorithm (IETF RFC 7811). The GADAG is computed by a single entity for VLANs associated with the MRTG ECT Algorithm (Table 45-1). This entity is referred to as the GADAG Computer and is either a PCE or the BLCE of the GADAG Root.

SPT Bridges may support the MRTG ECT Algorithm (00-80-C2-19, Table 45-1). MRTs are then computed by the SPT Bridges based on the GADAG provided by the GADAG Computer in a Topology sub-TLV (45.1.9). The GADAG and the MRTs are computed as specified by the MRT Lowpoint Algorithm (IETF RFC 7811). The MRTs produced by the MRTG ECT Algorithm are cautiously restored after a failure event as described in this subclause. A VLAN is associated with the MRTG ECT Algorithm as specified in 45.1.3 if MRTs with central GADAG computation are to be used for that VLAN.

The GADAG Root is determined based on the Bridge Identifier as described in 45.3.4, which also determines the sole SPT Bridge computing the GADAG if the GADAG Root is the GADAG Computer. Otherwise, the GADAG Computer PCE determines the GADAG Root, which also allows direct configuration of the GADAG Root.

The GADAG Computer performs the GADAG computation as specified by the MRT Lowpoint Algorithm (IETF RFC 7811). The GADAG Computer then encodes the GADAG in a Topology sub-TLV (45.1.9), which is then flooded throughout the domain. A GADAG is encoded in a Topology sub-TLV by means of directed ear decomposition as follows: A directed ear is a directed point-to-point path whose end points can coincide, but no other element of the path is repeated in the ear. Each ear is specified by an ordered list of hops, and that order of hops is according to the direction of the arcs in the GADAG. There are no leaves in a GADAG; hence, the Leaf flag [item c5) in 45.1.10] is used to ease the parsing of the Topology sub-TLV and to mark the end of a topology block (3.272). The sequence of ears in the Topology sub-TLV is such that the end points of an ear belong to former ears. The GADAG Root is not marked by any flag, but the GADAG Root is the first hop in the Topology sub-TLV; correspondingly the first ear starts and ends with the GADAG Root. MRT Roots are marked by the Root flag [item c4) in 45.1.10], and all other Edge Bridges are leaves of the given MRTs. If no MRT Root is specified, then each SPT Root is also an MRT Root. If a Bridge has to be excluded from the MRTs, then it is not part of the GADAG.

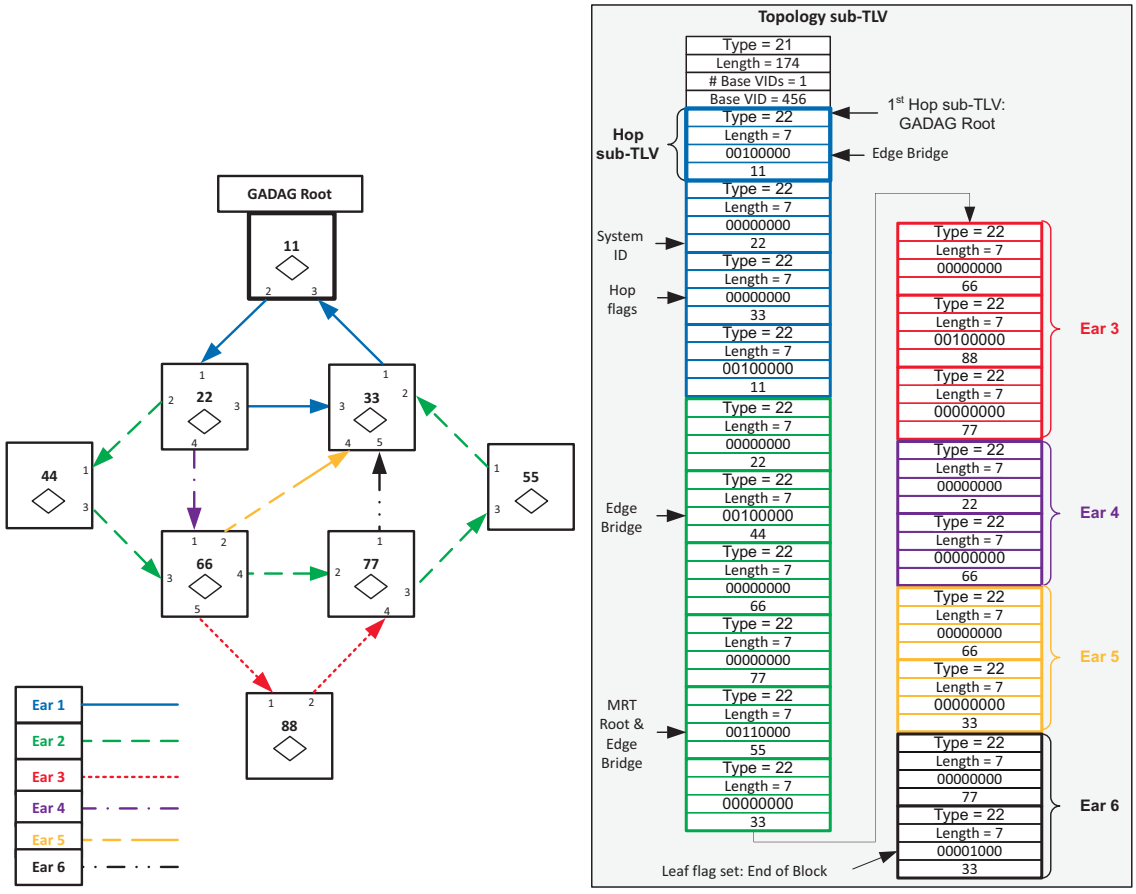


Figure 45-13—A GADAG and its descriptor Topology sub-TLV

Figure 45-13 shows the GADAG for the network topology depicted in Figure 45-1 and Figure 45-2 when SPT Bridge 11 is the GADAG Root. The graph shown in Figure 45-13 is in fact an ADAG, and removing the arc going from Bridge 33 to Bridge 11 (the GADAG Root) makes it a DAG. Figure 45-13 also shows the

Topology sub-TLV that specifies the GADAG. The first directed ear starts and ends at the GADAG Root, i.e., Bridge 11. The second ear (Ear 2) starts at Bridge 22 and ends at Bridge 33. The third ear (Ear 3) comprises Bridges 66, 88, and 77. Each of the remaining arcs is an individual ear added by a pair of Hop sub-TLVs according to the direction of the arc. Bridges 11, 44, 55, and 88 are Edge Bridges. Bridge 55 is the only MRT Root.

The MRTs are then computed by the SPT Bridges as specified by the MRT Lowpoint Algorithm (IETF RFC 7811) based on the GADAG descriptor received from the GADAG Computer. Whether the MRTs are unidirectional or bidirectional is determined by the T/R flags corresponding to the VIDs, I-SIDs, and MAC addresses associated with the given MRTs. Figure 45-14 shows MRT-Blue and MRT-Red if the GADAG descriptor Topology sub-TLV of Figure 45-13 is used for MRT computation, i.e., SPT Bridge 55 is the only MRT Root. Figure 45-14 also shows that an Edge Bridge is not necessarily a leaf; see Bridge 11.

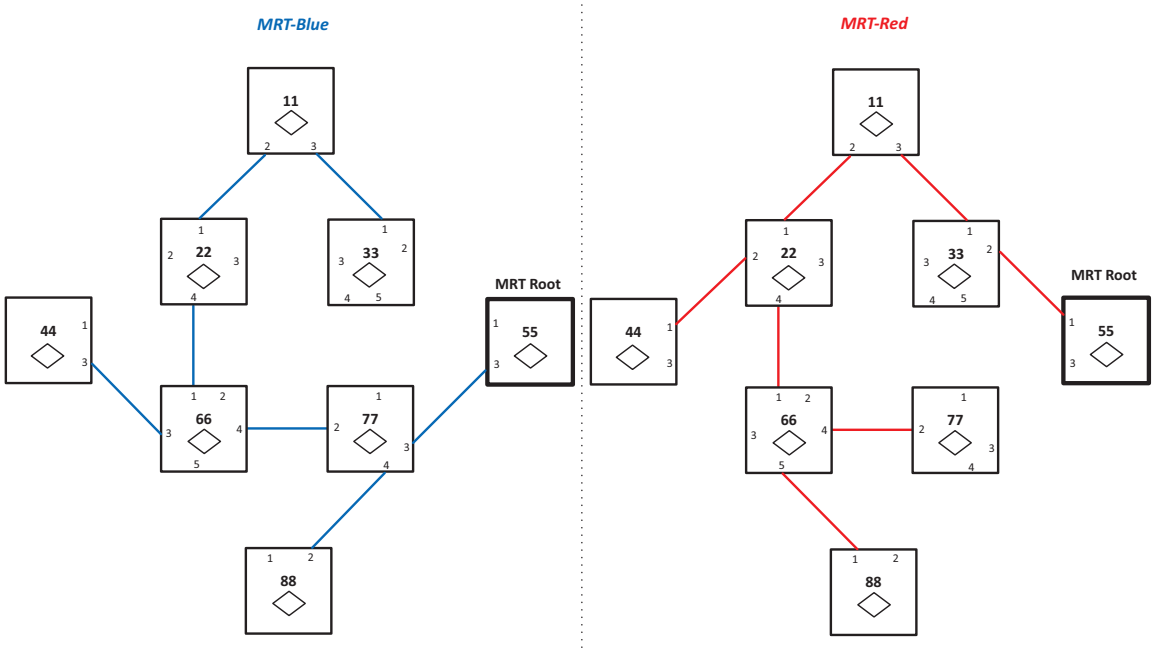


Figure 45-14—MRT-Blue and MRT-Red for MRT Root 55

The Topology sub-TLV specifying the GADAG can convey Base VIDs associated with the MRTG ECT Algorithm, which specifies the VLANs for which the GADAG is relevant. If there is no Base VID parameter in the Topology sub-TLV specifying a GADAG, then the given GADAG has to be used for all VLANs whose Base VID is associated with the MRTG ECT Algorithm.

A network topology can comprise multiple topology blocks (3.272), like the one illustrated in Figure 45-15, which comprises four blocks because each cut-link with the two Bridges at either end is a block. A GADAG is also shown in Figure 45-15. Note that two arcs with opposite direction represent a cut-link in a GADAG, e.g., see the cut-link between Bridges 75 and 77. The encoding starts with the block (ADAG) involving the GADAG Root as illustrated in Figure 45-15. The first hop in the Topology sub-TLV is the GADAG Root (Bridge 11 in this example). The ADAG of the first block is then described using the ear decomposition, as described above. In this example, the first block has been completely traversed at the second occurrence of Bridge 11 in the GADAG descriptor. The end of a block is indicated by setting the Leaf flag for the last hop of the block, e.g., for the second occurrence of Bridge 11 in the example GADAG descriptor. The next Bridge that appears in the GADAG descriptor (Bridge 44 in this case) is the localroot for the Bridges in the

next block. Continuing this process, the Leaf flag is set for the third occurrence of Bridge 44, the third occurrence of Bridge 75, and the third occurrence of Bridge 77, each indicating the end of a block.

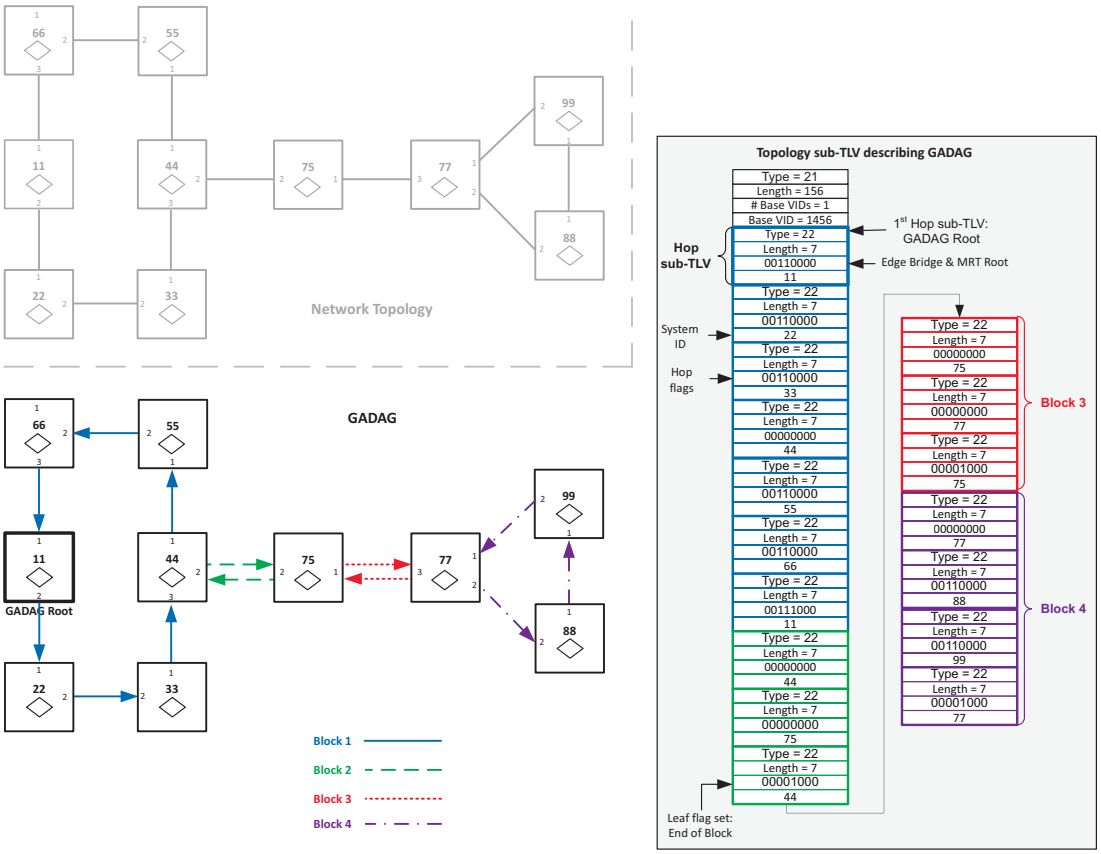


Figure 45-15—A GADAG for a topology with multiple blocks

The first hop of the first block is the GADAG Root; the first hop in the rest of the blocks is the localroot. The position of the set Leaf flags helps to determine the localroot, which is the next hop. In the example GADAG descriptor, one can determine that Bridge 11 is the localroot for Bridges 22, 33, 44, 55, and 66 (and Bridge 11 is the GADAG Root). Bridge 44 is the localroot for Bridge 75. Bridge 75 is the localroot for Bridge 77. Bridge 77 is the localroot for Bridges 88 and 99. The GADAG Root is assigned a localroot of None.

Block IDs are reconstructed while parsing a Topology sub-TLV specifying a GADAG. The current Block ID starts at 0 and is assigned to the GADAG Root. A Bridge appearing in the GADAG descriptor without a previously assigned Block ID value is assigned the current Block ID. The current Block ID is incremented by 1 after processing the localroot of a block. Note that the localroot of a block will keep the Block ID of the firsts block in which it is assigned a Block ID. In the example shown in Figure 45-15, Bridge 11 has Block ID=0. Bridges 22, 33, 44, 55, and 66 have Block ID=1. Bridge 75 has Block ID=2. Bridge 77 has Block ID=3. Bridges 88 and 99 have Block ID=4.

MRTs have to be restored cautiously after a topology change. The restoration should not be initiated if there is any reason to suspect that the SPT Bridges of the SPT Region do not share a common view on the network topology.

If MRTs are used for SPT protection, then MRTs are restored only after the restoration of the SPTs. Upon a failure event, PLR Bridges redirect data traffic to the MRT that is not affected by the failure, if any. As the topology change is announced by the corresponding LSPs, SPT Bridges and the GADAG Computer become aware of the change. The SPT Bridges then compute and install the new SPTs. When each SPT Bridge has installed the new SPT, then data traffic is directed back to the SPTs. The GADAG Computer then computes the new GADAG and floods its descriptor. The SPT Bridges then compute and install the new MRTs if each SPT Bridge has already directed traffic back to the SPTs.

If MRTs protect each other, then only one of the MRTs is restored at a time. Upon a failure event, PLR Bridges direct all data traffic to the MRT that is not affected by the failure (e.g., MRT-Red). If a 1+1 type of protection scheme is used, then there is no need to react to a failure event as data frames are forwarded on both MRTs, i.e., there are no PLRs. When the GADAG Computer and the SPT Bridges have the same view on the network topology again, then the GADAG Computer computes the new GADAG and floods its descriptor. Upon reception of the Topology sub-TLV describing the new GADAG, the SPT Bridges compute the new MRTs. The broken MRT (e.g., MRT-Blue) then is restored while the other MRT (e.g., MRT-Red) is not touched. If each SPT Bridge has installed the new MRT (e.g., the new MRT-Blue), then data traffic is directed to this newly restored MRT. The SPT Bridges then install the other MRT (e.g., the new MRT-Red). The same restoration procedure is followed if both MRTs are affected by the failure so that MRT-Blue is restored first.

NOTE—The method to be used for verifying whether the SPT Bridges have a common view on the topology and whether SPTs and MRTs have been restored is left to the implementer and the network operator. A common method is to wait some time after the reception of the last LSP indicating a topology change. Alternatively, OAM can be used, for instance.

46. Time-Sensitive Networking (TSN) configuration

Time-Sensitive Networking (TSN) is a collection of features in IEEE 802.1 standards that provide the following:

— Time synchronization among Bridges and end stations
— Significant reduction in frame loss due to faults in network equipment
— Significant reduction in, or the elimination of, frame loss due to egress Port congestion
— Bounded latency

This clause provides specifications for the configuration of TSN features in a network. The configuration process begins when Talkers and Listeners pass their requirements to the network and proceeds with the configuration of TSN features in Bridges along a tree from each Talker to its Listener(s).

46.1 Overview of TSN configuration

46.1.1 User/Network Interface (UNI)

TSN configuration uses the concept of a Stream that is transmitted by a Talker to one or more Listeners. The Talkers and Listeners are located within end stations.

This clause specifies configuration information that is exchanged over a User/Network Interface (UNI). The user side of the interface represents Talkers and Listeners. The network side of the interface represents the Bridges that transfer frames of the Stream from each Talker to its Listeners. Each user specifies requirements for its data, but without detailed knowledge of the network. The network obtains requirements from users, analyzes the topology and TSN capabilities of Bridges, and configures the Bridges to meet user requirements. The network returns the success or failure of each Stream's configuration to the user.

46.1.2 Modeling of user/network configuration information

A variety of protocols can be used for the exchange of configuration information over the TSN UNI (e.g., signaling protocols, remote network management protocols). These protocols can exchange the configuration information as text or as binary fields. To enable flexible integration of TSN configuration into a variety of protocols, 46.2 specifies the TSN user/network configuration information in a manner that is independent of schema, encoding, or protocol.

Specific TSN-capable products list the user/network protocol that is supported as part of their conformance [e.g., 5.18.3, item c) in 5.29]. Each user/network protocol will specify a specific schema and/or encoding for the configuration information in 46.2. Examples of these protocols are described for each of the TSN configuration models in 46.1.3.

46.1.3 TSN configuration models

This subclause describes three models for TSN user/network configuration. These models provide an architectural context for subsequent specifications. Each model specification shows the logical flow of user/network configuration information between various entities in the network.

46.1.3.1 Fully distributed model

In the fully distributed model, the end stations that contain users of Streams (i.e., Talkers and Listeners) communicate the user requirements directly over the TSN user/network protocol. The network is configured in a fully distributed manner, without a centralized network configuration entity. The distributed network configuration is performed using a protocol that propagates TSN user/network configuration information along the active topology for the Stream (i.e., Bridges in the tree from Talker to Listeners).

As user requirements propagate through each Bridge, management of the Bridge's resources is effectively performed locally. This local management is limited to the information that the Bridge has knowledge of and does not necessarily include knowledge of the entire network.

Figure 46-1 provides a graphical representation of the fully distributed model.

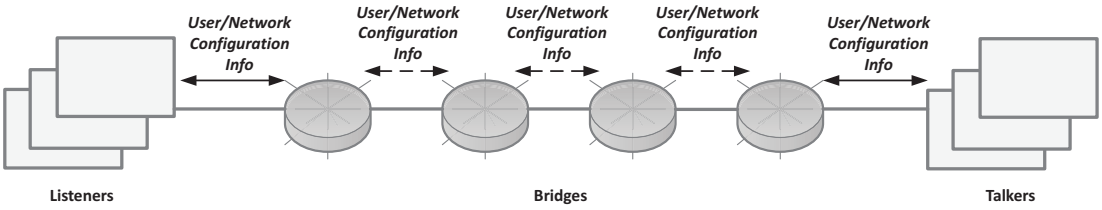


Figure 46-1—Fully distributed model

In the figure, the solid arrows represent the protocol that is used as the UNI for exchange of configuration information between Talkers/Listeners (users) and Bridges (network). This configuration information is specified in 46.2.

In the figure, the dashed arrows represent the protocol that propagates configuration information within the network. This protocol carries the TSN user/network configuration information (46.2) as well as additional information that is specific to network configuration.

The following TSN features can be configured by Bridges using this model:

a) Credit-based shaper algorithm (8.6.8.2) and its configuration (Clause 34)

The Stream Reservation Protocol (SRP) of Clause 35 can be used as the UNI and to propagate configuration information throughout the network of Bridges. SRP exchanges configuration information as binary fields using the Type-Length-Value (TLV) technique. Using this technique, the protocol's top-level message contains a list of one or more TLVs. Each TLV consists of a Type field that specifies what the Value field contains, a Length field that specifies the number of octets in the Value field, and the Value field. In SRP specifications, each TLV Type identifies one of the groups specified in 46.2, and the TLV Value contains a binary representation of the elements in that group.

46.1.3.2 Centralized network/distributed user model

Some TSN use cases are computationally complex. For example, for scheduled traffic (8.6.8.4), computation of the gate control list of each Port can take significant time. For such use cases, it is helpful to centralize the computation in a single entity (Bridge or end station), rather than perform the computation in all Bridges.

Some TSN use cases can benefit from a complete knowledge of all Streams in the network. For example, if the bandwidth for multiple Streams is greater than the available bandwidth along the shortest path between Talkers and Listeners, it is helpful to forward a subset of those Streams along a path other than the shortest.

For these use cases, a centralized entity can gather information for the entire network in order to find the best configuration.

The centralized network/distributed user model is similar to the fully distributed model in that end stations communicate their Talker/Listener requirements directly over the TSN UNI. In contrast, in the centralized network/distributed user model, the configuration information is directed to/from a Centralized Network Configuration (CNC) entity. All configuration of Bridges for TSN Streams is performed by this CNC using a remote network management protocol.

The CNC has a complete view of the physical topology of the network as well as the capabilities of each Bridge. This enables the CNC to centralize complex computations. The CNC can exist in either an end station or a Bridge.

The CNC knows the address of all Bridges at the edge of the network (those with an end station connected). The CNC configures those edge Bridges to act as a proxy, transferring Talker/Listener information directly between the edge Bridge and the CNC, rather than propagate the information to the interior of the network.

Figure 46-2 provides a graphical representation of the centralized network/distributed user model.

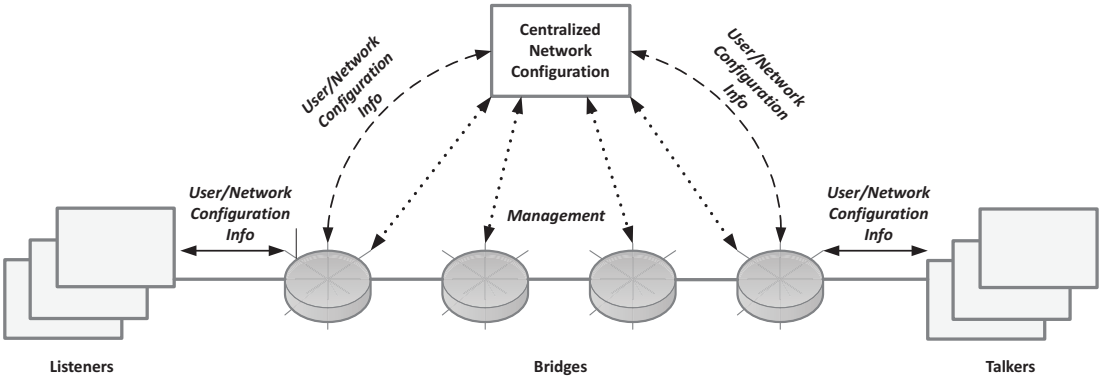


Figure 46-2—Centralized network/distributed user model

In the figure, the solid arrows represent the protocol that is used as the UNI for exchange of configuration information between Talkers/Listeners (users) and Bridges (network). This configuration information is specified in 46.2.

In the figure, the dashed arrows represent the protocol that transfers configuration information between edge Bridges and the CNC. This configuration information is specified in 46.2.

In the figure, dotted arrows represent the remote network management protocol. The CNC acts as the management client, and each Bridge acts as the management server. The CNC uses remote management to discover physical topology, retrieve Bridge capabilities, and configure TSN features in each Bridge. Talkers and Listeners are not required to participate in this remote network management protocol. The information carried by the remote network management protocol is specified in Clause 12.

NOTE 1—If the Talker/Listener protocol of the fully distributed model is selected to be the same as the Talker/Listener protocol of the centralized network/distributed user model, end stations can support both models without explicit knowledge of how the network is configured.

The following TSN features can be configured by the CNC using this model:

a) Credit-based shaper algorithm (8.6.8.2) and its configuration (Clause 34)
b) Frame preemption (6.7.2)
c) Scheduled traffic (8.6.8.4, 8.6.9)
d) Frame Replication and Elimination for Reliability (IEEE Std 802.1CB)
e) Per-Stream Filtering and Policing (8.6.5.1)
f) Cyclic queuing and forwarding (Annex T)

SRP (Clause 35) can be used as the UNI (solid arrows of Figure 46-2). SRP's MRP External Control (12.32.4) feature can be used to exchange configuration information with the CNC component (dashed arrows of Figure 46-2). SRP exchanges configuration information using the TLV technique to reference elements in 46.2 (see 46.1.3.1). Examples of a remote network management protocol (dotted arrows of Figure 46-2) include Simple Network Management Protocol (SNMP), NETCONF (IETF RFC 6241 [B39]), and RESTCONF (IETF RFC 8040 [B45]).

NOTE 2—NETCONF and RESTCONF specify a startup datastore: nonvolatile configuration that is applied when the Bridge powers on. The startup datastore feature enables a TSN CNC to configure Bridges and then remove itself from the network. SNMP does not specify a startup datastore feature. If SNMP is used by a TSN CNC, this can be mitigated by a) using a proprietary (Bridge-specific) startup datastore feature or b) ensuring that the TSN CNC is always active in the network in order to reconfigure Bridges that cycle power.

46.1.3.3 Fully centralized model

Many TSN use cases require significant user configuration in the end stations that act as Talkers and Listeners. For example, in many automotive and industrial control applications, the timing of physical inputs and outputs (I/Os) is determined by the physical environment under control, and the timing requirements for TSN Streams are derived from that I/O timing. In some use cases, these I/O timing requirements can be computationally complex and involve detailed knowledge of the application software/hardware within each end station.

In order to accommodate this sort of TSN use case, the fully centralized model enables a Centralized User Configuration (CUC) entity to discover end stations, retrieve end station capabilities and user requirements, and configure TSN features in end stations. The protocols that the CUC uses for this purpose are specific to the user application and outside the scope of this standard.

From a network perspective, the primary difference between the fully centralized model and the centralized network/distributed user model is that all user requirements are exchanged between the CNC and CUC. Therefore, the TSN UNI exists between the CNC and CUC.

Figure 46-3 provides a graphical representation of the fully centralized model.

In the figure, the solid arrows represent the protocol that is used as the UNI for exchange of configuration information between the CUC and the CNC. This configuration information is specified in 46.2.

In the figure, the dotted arrows represent the remote network management protocol. The CNC acts as the management client, and each Bridge acts as the management server. The CNC uses remote management to discover physical topology, retrieve Bridge capabilities, and configure TSN features in each Bridge. Talkers and Listeners are not required to participate in this remote network management protocol. The information carried by the remote network management protocol is specified in Clause 12.

In this fully centralized model, a protocol is used between the CUC and end stations (Talkers and Listeners) to retrieve end station capabilities and requirements and to configure the end stations. Since that protocol is user-to-user, its configuration information is considered to be outside the scope of this standard, and it is not shown in Figure 46-3.

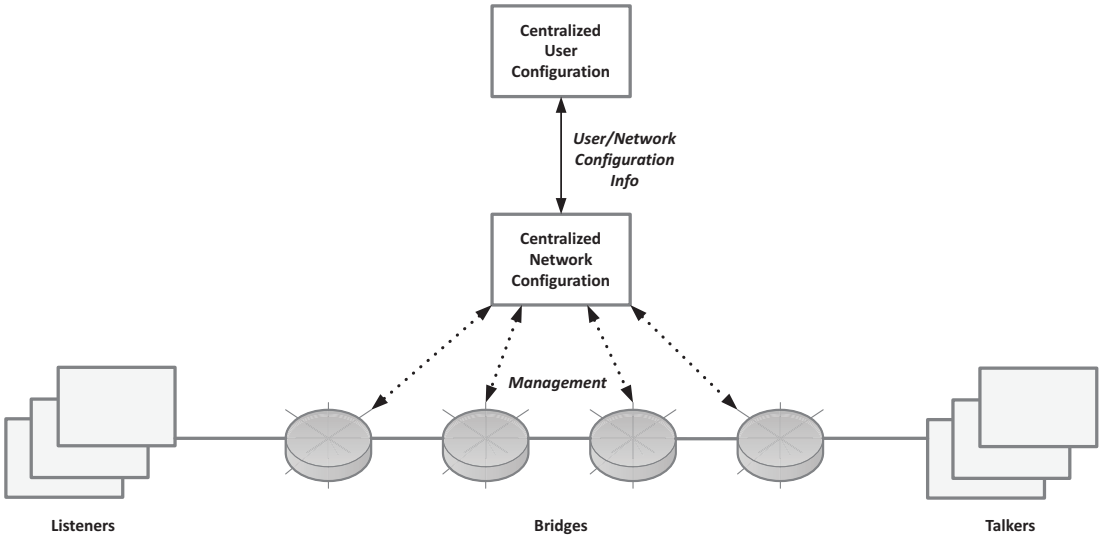


Figure 46-3—Fully centralized model

The following TSN features can be configured by the CNC using this model:

a) Credit-based shaper algorithm (8.6.8.2) and its configuration (Clause 34)
b) Frame preemption (6.7.2)
c) Scheduled traffic (8.6.8.4, 8.6.9)
d) Frame Replication and Elimination for Reliability (IEEE Std 802.1CB)
e) Per-Stream Filtering and Policing (8.6.5.1)
f) Cyclic queuing and forwarding (Annex T)

YANG (IETF RFC 7950) is a data modeling language used to model configuration data and state data for remote network management protocols. The remote network management protocol uses a specific encoding such as XML or JSON. For a particular feature, a YANG module specifies the organization and rules for the feature's management data, and a mapping from YANG to the specific encoding enables the data to be understood correctly by both client (e.g., network manager) and server (e.g., Bridge). Technically speaking, the TSN user/network configuration is not network management, in that information is exchanged between user and network, and not between a network manager and the network's Bridges (Clause 12). Nevertheless, the concepts are sufficiently similar that YANG is useful for modeling the configuration and state data for the TSN user/network configuration information.

In order to support the use of YANG-based protocols for the fully centralized model, 46.3 specifies a YANG module. The YANG module specifies a YANG typedef/grouping for each group of information in 46.2.

NOTE—At the time that this clause was developed, specific protocol implementations for the fully centralized model were a work in progress. One protocol explored for the UNI between CUC and CNC is RESTCONF (IETF RFC 8040 [B45]). A complete YANG module for the TSN UNI can be specified in a document other than IEEE Std 802.1Q. In order to conform with this clause, the complete TSN UNI YANG module imports the YANG module of 46.3 for use within its containers and lists. The complete TSN UNI YANG module will presumably specify features outside the scope of this clause, such as operations to control the deployment of Stream configuration to the network. The JSON encoding can be used with RESTCONF. Although the TSN UNI is technically not network management, use of RESTCONF provides a simple and effective application programming interface (API) for TSN configuration.

For an informative example workflow using the fully centralized model, refer to U.2.

46.1.4 Stream transformation

TSN configuration uses the concept of a Stream of data that is transmitted by a Talker to one or more Listeners. The Talkers and Listeners are end stations.

In order to apply TSN behavior to Streams (e.g., reserved bandwidth guarantees), the network must be able to distinguish one Stream from another Stream and distinguish Streams from non-TSN traffic (e.g., best-effort). Therefore, each frame of the Stream must contain fields in its header that uniquely identify the Stream.

The goal of TSN configuration is to allow Talkers and Listeners to use their existing transport layer and application layer protocols for data, rather than requiring a TSN-specific frame format. TSN achieves this goal by identifying each Stream using fields from well-established frame formats such as Transmission Control Protocol (TCP), User Datagram Protocol (UDP), and IEEE 802.1 (i.e., MAC addresses and VLAN identifier).

As the frames of each Stream cross the user/network boundary, the identification of the Stream in its frames can be different between the network and the user. For example, the user can use UDP without an awareness of VLAN IDs, but the network can require a specific VLAN ID in order to apply TSN features. In order to support this sort of difference in frame format, the TSN user/network configuration information (46.2) provides features to enable transformation of the Stream's identification at the user/network boundary. The user identification translates to/from the network identification at the boundary, either within the end station or a nearest Bridge. This transformation has the benefit of allowing the user's identification to match its higher layer application protocol and the network's identification to match the bridging technology.

Stream transformation can be accomplished using the functions specified in IEEE Std 802.1CB. The functions of IEEE Std 802.1CB can be implemented in the end station (Talker/Listener) or within the nearest Bridge. The descriptions in this clause focus on Stream transformation in the end station and use features of the TSN user/network configuration information (46.2).

NOTE 1—In this clause, Stream transformation refers to changes to the fields of a frame that identify the Stream. IEEE Std 802.1CB specifies Stream transformation for identification as well as for frame replication and elimination (redundancy).

NOTE 2—Stream transformation is an optional capability of end stations and Bridges. If stream transformation is not supported, the user's identification of the Stream must be the same as the network's identification, and the user must use an identification that is consistent with bridging as specified for TSN features in this standard (e.g., VLAN tag and group destination MAC address).

Figure 46-4 provides an example of Stream transformation in the Talker end station. Stream transformation in the Listener end station is similar. The example of Figure 46-4 assumes use of the centralized network/ distributed user model (46.1.3.2). Use of the fully centralized model (46.1.3.3) is similar.

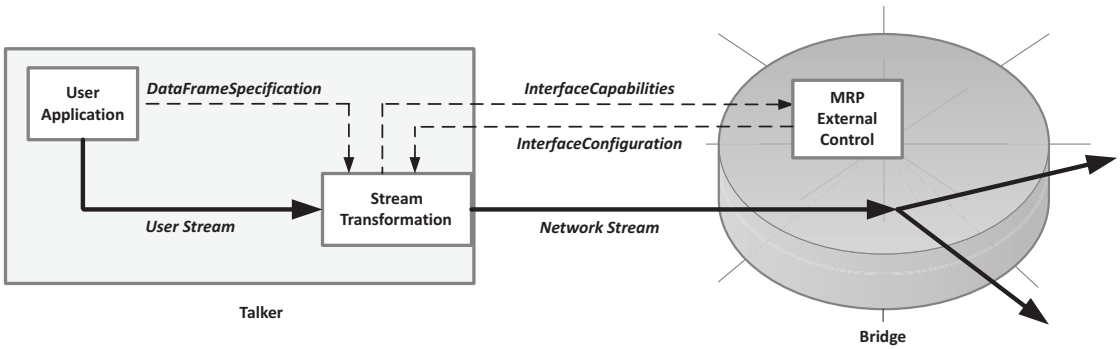


Figure 46-4—Example of Stream transformation in Talker end station

For Stream transformation in the end station, the end station's interface to the network can provide the transformation capability, acting as a network entity within the user's end station.

The identification of the Stream in the user originates from the User Application block, specified by the Talker as the DataFrameSpecification (46.2.3.4). The end station knows this user identification, but not the identification that the network requires. To negotiate the network identification, the Talker uses SRP to transmit InterfaceCapabilities (46.2.3.7) that describe its Stream transformation capabilities to the nearest Bridge. The Bridge uses MRP External Control (12.32.4) to send the InterfaceCapabilities to a CNC. The CNC consults its configuration of network identification and uses MRP External Control to send InterfaceConfiguration (46.2.5.3) along with successful Status (46.2.5) back to the Bridge. When the Bridge receives this information, it propagates back to the Talker using SRP. The InterfaceConfiguration provides the network identification, which the end station uses to perform Stream transformation for data frames.

NOTE 3—The network identification typically entails allocation of a group MAC address for the Stream. If a CNC is used, the CNC can allocate a group MAC address from a pool that it maintains.

Figure 46-5 provides an example of IEEE 802.1CB functions within the Stream Transformation block in the Talker end station. The example assumes that the user identification uses an Internet Protocol (IP) packet for identification and that the frame conveying the IP packet does not use the appropriate MAC address and VLAN tag for TSN features in Bridges (e.g., IP packet unicast destination MAC address, untagged). The IEEE 802.1CB function for IP Stream identification uses fields of the IP packet to identify the packet as a specific TSN stream. That stream identification is then applied to the IEEE 802.1CB function for Active Destination MAC and VLAN Stream identification to replace the destination MAC address and add a VLAN tag for TSN Bridge features. The IP fields of the packet are not changed. The IEEE 802.1CB functions can be implemented in software (e.g., operating system driver) or in hardware.

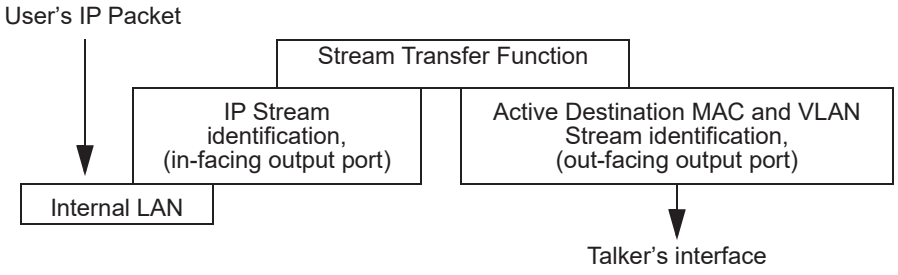


Figure 46-5—Example of IEEE 802.1CB functions in Talker end station

Figure 46-6 provides a corresponding example of IEEE 802.1CB functions within the Stream Transformation block in the Listener end station. In this direction, the IEEE 802.1CB function for Active Destination MAC and VLAN Stream identification provides both functions. The IEEE 802.1CB function uses the group destination MAC address and VLAN tag of the received frame to identify a specific Stream. The IEEE 802.1CB function then transforms the destination MAC address and VLAN tag to restore the Stream's frame to its original format (as transmitted by the Talker).

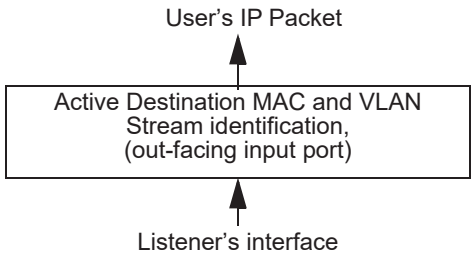


Figure 46-6—Example of IEEE 802.1CB functions in Listener end station

46.2 User/network configuration information

This subclause specifies the user/network configuration information that is used for the three TSN configuration models (46.1.3). The semantics for the TSN user/network configuration information is specified independent of schema, encoding, or protocol.

A schema or encoding of a protocol for the TSN user/network configuration information will reference 46.2 as part of its normative specifications. For the two distributed models, SRP specifies TLVs in 35.2.2.10 that reference information in 46.2. For the fully centralized model, the YANG module in 46.3 references information in 46.2.

Within this subclause, the word element refers to a single item of information used for TSN configuration. The word group refers to a collection of related elements. Groups are organized hierarchically, such that a group can be contained within another group. A single low-level group can be contained within multiple higher level groups. The dot-separated notation is used to refer to a specific element in text. For example, “Talker.StreamID.UniqueId” refers to the UniqueId element of the StreamID group that is contained within the Talker group.

This subclause specifies each group in a table. Each row of the table specifies an element of the group. Each element’s row specifies its name, data type, and a reference to normative text that specifies its semantics (i.e., meaning). The data type of each element uses one of the values from 46.2.1. Other specifications such as conformance (i.e., required or optional), direction of transfer (i.e., user to network or network to user), default value, and range limitations are specified with normative text instead of with the table.

Each element name uses a camel-case naming convention (e.g., “MacAddress”) to align with naming conventions used in other clauses of IEEE Std 802.1Q. A specific protocol can use a different naming convention (e.g., 46.3) as long as the protocol’s name for the element can be associated with the element’s specification in 46.2.

46.2.1 Data types

The data type of each element is limited to semantics, independent of a specific encoding or protocol. Data types in the tables include the following:

a) Boolean
b) int8, for a signed 8-bit integer
c) int16, for a signed 16-bit integer
d) int32, for a signed 32-bit integer
e) uint8, for an unsigned 8-bit integer
f) uint16, for an unsigned 16-bit integer
g) uint32, for an unsigned 32-bit integer
h) string
i) enumeration, for a collection of named values
j) rational, for a rational number consisting of a uint32 numerator and uint32 denominator
k) mac-address-type, for an IEEE 802 MAC address
l) ipv4-address-type, for an IPv4 address (IETF RFC 791 [B18])
m) ipv6-address-type, for an IPv6 address (IETF RFC 8200 [B46])
n) sequence of <X>, for a list of zero or more instances of data type <X> (e.g., sequence of uint32)

If the data type shown in the table is not from the preceding list, then the data type is specified in the normative text for the element.

46.2.2 Protocol integration

The TSN user/network configuration information consists of three high-level groups:

— **Talker:** Elements from user to network that specify the Talker for a single Stream.
— **Listener:** Elements from user to network that specify the Listener for a single Stream.
— **Status:** Elements from network to user that specify the status of the Stream's network configuration for a Talker or Listener. This group notifies the user when the Stream is ready for use (or a failure occurred).

A protocol that supports TSN user/network configuration information shall integrate the three groups using the specifications in this clause. The integration is provided in each protocol's specifications (not in this clause). For examples of such protocol integration, see Clause 35 and 46.3.

Each TSN configuration protocol shall use the StreamID of this clause (46.2.3.1) as the unique identifier of each Stream's configuration. The StreamID identifies configuration, not data, so it has no formal relation to the data frame encoding for the Stream.

TSN configuration can be viewed conceptually as a request/response exchange:

— Request: End station or CUC transmits a protocol message that contains a Talker or Listener group.
— Response: Bridge or CNC transmits a protocol message that contains a Status group.

The StreamID of each group correlates each request to its corresponding response, such that configuration of multiple Streams can overlap in time. For example, a possible sequence of messages is Talker request for StreamID 1, Talker request for StreamID 2, Listener request for StreamID 2, Status to Talker for StreamID 2, Status to Listener for StreamID 2, Listener request for StreamID 1, and so on.

For the fully distributed model (46.1.3.1), the Status response to a Talker is communicated in a message along with the Listener request(s). When there is more than one Listener per Stream, the Listener and Status groups must be merged as they propagate through Bridges to the Talker. The methodology for this merger is specified in the TSN configuration protocol (not in this clause).

For the fully centralized model (46.1.3.3), the CUC combines multiple Talker groups and Listener groups into a single transfer from CUC to CNC for computation together in the CNC. After the CNC computation is complete, a single transfer from CNC to CUC combines multiple Status groups. Each Status group can provide sub-groups for each Talker/Listener and merged groups for the entire Stream. The methodology for these combinations and mergers is specified in the TSN configuration protocol (not in this clause).

In addition to the request/response exchange, end stations can transmit Talker/Listener messages as advertisement (e.g., for a Talker to notify potential Listeners of its presence). The methodology for this advertisement is specified in the TSN configuration protocol (not in this clause).

For each Talker group and Listener group, there are two operations for each Stream:

— **Join:** Talker/Listener request to join the Stream and to configure network resources for this Stream's data transfer.
— **Leave:** Talker/Listener request to leave the Stream and to release the network resources for this Stream.

The groups in this clause specify requirements for the join and leave operation, but the encoding of the operation is not specified in this clause. Each TSN configuration protocol shall specify the encoding of the join/leave operation as part of its integration. For example, SRP specifications of this standard (Clause 35) encode the join/leave operation within the Multiple Registration Protocol (MRP) (Clause 10) that serves as its foundation.

The protocol message(s) that invoke the join or leave operation are not required to coincide with the protocol message(s) that contain the associated groups (Talker, Listener, or Status). Nevertheless, the groups specify elements that are required for a subsequent join or leave operation to be valid. For example, for the fully centralized model (46.1.3.3), the CUC can transfer a list of Talker/Listener groups to the CNC, followed by a separate protocol message with a join request that applies to the entire list. For the join request to succeed, each of the Talker/Listener groups must contain the required elements. At a later time, the CUC can read the resulting list of Status groups from the CNC, which provides the response to the join.

46.2.3 Talker

The Talker group specifies the following:

— Talker's behavior for Stream (how/when transmitted)
— Talker's requirements from the network
— TSN capabilities of the Talker's interface(s)

In the fully distributed model and the centralized network/distributed user model, this group originates from the Talker's end station. In the fully centralized model, this group originates from the CUC.

The Talker group contains the following groups:

— StreamID (46.2.3.1)
— StreamRank (46.2.3.2)
— EndStationInterfaces (46.2.3.3)
— DataFrameSpecification (46.2.3.4)
— TrafficSpecification (46.2.3.5)
— UserToNetworkRequirements (46.2.3.6)
— InterfaceCapabilities (46.2.3.7)

For the join operation, the StreamRank and TrafficSpecification groups shall be included within the Talker group.

For the join operation, the UserToNetworkRequirements and InterfaceCapabilities groups may be included within the Talker group. If a group is omitted, the network uses the default values specified for elements of that group.

For the join operation, the DataFrameSpecification shall be included within the Talker group unless all of the following conditions apply:

a) The InterfaceCapabilities group is included.
b) InterfaceCapabilities.CB-StreamIdenTypeList includes the type for Active Destination MAC and VLAN Stream identification.

The preceding conditions enable the Talker and Listener to perform Stream transformation (46.1.4), and therefore the network does not need the user's data frame identification in DataFrameSpecification. The absence of the DataFrameSpecification group notifies the network that Stream transformation is performed in the end stations for this Stream.

For the join and leave operation, the StreamID group shall be included in the TSN user/network protocol in a location associated with the Stream (e.g., Talker group).

For the join and leave operation, EndStationInterfaces shall be included within the Talker group for the fully centralized model (46.1.3.3). For the join and leave operation, EndStationInterfaces should be included within the Talker group for the fully distributed model (46.1.3.1) or centralized network/distributed user model (46.1.3.2).

46.2.3.1 StreamID

The StreamID group provides a unique identifier of the Stream's configuration and is used by protocols in the network to associate the user's Stream with TSN resources. The StreamID group is used by Talker, Listener, and Status groups.

The elements of the StreamID group are listed in Table 46-1.

Table 46-1—StreamID elements

Name	Data type	Reference
MacAddress	mac-address-type	46.2.3.1.1
UniqueID	uint16	46.2.3.1.2

46.2.3.1.1 MacAddress

MacAddress is a 48-bit IEEE 802 MAC address associated with the Talker sourcing the Stream to the bridged network. The entire range of MAC addresses are acceptable.

NOTE 1—The MAC address component of the StreamID can, but does not necessarily, have the same value as the source_address parameter of any frame in the actual data Stream. For example, the StreamID can be assigned by a TSN CUC (see 46.1.3.3), using a pool of MAC addresses that the TSN CUC maintains.

NOTE 2—If the MAC addresses used to construct StreamIDs are not unique within the network, duplicate StreamIDs can be generated, with unpredictable results.

46.2.3.1.2 UniqueID

UniqueID is used to distinguish between multiple Streams within the end station identified by MacAddress.

46.2.3.2 StreamRank

The StreamRank group provides the rank of this Stream relative to other Streams in the network. This rank is used to determine success/failure of Stream resource configuration and is unrelated to the Stream's data.

The elements of the StreamRank group are listed in Table 46-2.

Table 46-2—StreamRank elements

Name	Data type	Reference
Rank	uint8	46.2.3.2.1

46.2.3.2.1 Rank

The Rank is used by the network to decide which Streams can and cannot exist when TSN resources reach their limit. If a Bridge's Port becomes oversubscribed (e.g., network reconfiguration, IEEE 802.11 bandwidth reduction), the Rank is used to help determine which Streams can be dropped (i.e., removed from Bridge configuration).

The only valid values for Rank shall be zero and one. The configuration of a Stream with Rank zero is more important than the configuration of a Stream with Rank one. The Rank value of zero is intended for emergency traffic, and the Rank value of one is intended for non-emergency traffic.

NOTE—It is expected that higher layer applications and protocols can use the Rank to indicate the relative importance of Streams based on user preferences. Those user preferences are expressed by means beyond the scope of this standard. When multiple applications exist in a network (e.g., audio/video along with industrial control), it can be challenging for the varied applications and vendors to agree on multiple Rank values. To mitigate such challenges, this Rank uses a simple concept of emergency (zero) and non-emergency (one) that can be applied over all applications. For example, in a network that carries audio Streams for fire safety announcements, all applications are likely to agree that those Streams use Rank of zero.

46.2.3.3 EndStationInterfaces

The EndStationInterfaces group provides a list of one or more InterfaceID groups. Each InterfaceID group identifies a physical interface (distinct point of attachment) in the end station acting as a Talker/Listener.

Although many end stations contain a single interface, this list allows for multiple interfaces. Some TSN features allow a single Stream to span multiple interfaces (e.g., seamless redundancy).

In centralized network models, EndStationInterfaces is used by the CNC to locate the interfaces of the Talker/Listener in the topology.

The InterfaceID group is used to identify a distinct point of attachment in EndStationInterfaces, InterfaceConfiguration (46.2.5.3), and FailedInterfaces (46.2.5.4). In the context of EndStationInterfaces and InterfaceConfiguration, each interface is located in an end station only. In the context of FailedInterfaces, each interface can be located within an end station or a Bridge.

The elements of the InterfaceID group are listed in Table 46-3.

Table 46-3—InterfaceID elements

Name	Data type	Reference
MacAddress	mac-address-type	46.2.3.3.1
InterfaceName	string	46.2.3.3.2

46.2.3.3.1 MacAddress

MacAddress is the MAC address (IEEE Std 802) of the interface in the station (end station or Bridge). This MAC address uniquely identifies the station within the local network.

MacAddress shall be included in the InterfaceID group.

NOTE—This MAC address can be discovered in the physical topology using protocols such as IEEE Std 802.1AB (LLDP). LLDP supports MAC address as a subtype for the station's Chassis ID and Port ID. If the station does not use MAC address for its LLDP IDs, remote management can be used to associate this MacAddress to the values provided in the LLDP IDs.

46.2.3.3.2 InterfaceName

InterfaceName is the name of the interface that is assigned locally by the station (end station or Bridge).

InterfaceName may be included in the InterfaceID group.

IEEE Std 802 recommends that each distinct point of attachment to an IEEE 802 network have its own universal MAC address. If the identified station follows this IEEE 802 recommendation, the MacAddress element uniquely identifies the interface as well as the station, and InterfaceName is not needed.

If the MacAddress applies to more than one interface (distinct point of attachment) within the station, InterfaceName provides a locally assigned name that can help to identify the interface.

When YANG is used for management of the station, InterfaceName is the interface name that serves as the key for the station's interface list (IETF RFC 7223 [B43]).

NOTE 1—The TSN CNC is typically located in a different physical product than the station identified by this InterfaceID. Since the InterfaceName is assigned locally by the identified station, it is possible that the station's product will change InterfaceName in a manner that the TSN CNC cannot detect. For example, IETF RFC 7223 [B43] mentions that the YANG interface name can change when a physical attachment point is inserted or removed.

NOTE 2—This interface name can be discovered in the physical topology using protocols such as IEEE Std 802.1AB (LLDP). LLDP supports interface name as a subtype for its Port ID. If the station does not use interface name for its LLDP Port ID, remote management can be used to associate this InterfaceName to the values provided in the LLDP Port ID.

46.2.3.4 DataFrameSpecification

The DataFrameSpecification group specifies the frame that carries the Talker's Stream data. The network uses the specification to identify this Stream's frames as TSN in order to apply the required TSN configuration.

The DataFrameSpecification is based on the user's knowledge of the frame, without any network specifics. In other words, this specifies the frame that the Talker would use in the absence of TSN.

The DataFrameSpecification is provided as a list of fields that the user knows. Each field is provided as one of the following groups:

- IEEE802-MacAddresses (46.2.3.4.1)
- IEEE802-VlanTag (46.2.3.4.2)
- IPv4-tuple (46.2.3.4.3)
- IPv6-tuple (46.2.3.4.4)

The list of fields is ordered from start of frame to end of header. For example, if the Talker uses a VLAN-tagged Ethernet frame (not IP), the list consists of IEEE802-MacAddresses followed by IEEE802-VlanTag. For example, if the Talker uses a UDP/IPv4 packet without knowledge of the Ethernet header, the list consists of IPv4-tuple only.

This group is optional, and its absence indicates that Stream transformation is performed in the Talker and Listeners of this Stream (46.2.3).

46.2.3.4.1 IEEE802-MacAddresses

The IEEE802-MacAddresses group specifies a pair of IEEE 802 MAC addresses for Stream identification.

The use of these fields for Stream identification corresponds to the managed objects for Stream identification in IEEE Std 802.1CB. If inconsistency arises between this specification and IEEE Std 802.1CB, IEEE Std 802.1CB takes precedence.

The elements of the IEEE802-MacAddresses group are listed in Table 46-4.

Table 46-4—IEEE802-MacAddresses elements

Name	Data type	Reference
DestinationMacAddress	mac-address-type	46.2.3.4.1 item a)
SourceMacAddress	mac-address-type	46.2.3.4.1 item b)

The elements of the IEEE802-MacAddresses group:

a) **DestinationMacAddress**—This field specifies a destination MAC address. An address of all 1's specifies that the destination MAC address is ignored for purposes of Stream identification.

b) **SourceMacAddress**—This field specifies a source MAC address. An address of all 1's specifies that the source MAC address is ignored for purposes of Stream identification.

46.2.3.4.2 IEEE802-VlanTag

The IEEE802-VlanTag group specifies a customer VLAN Tag (C-TAG of Clause 9) for Stream identification.

The Drop Eligible Indicator (DEI) field is not relevant from the perspective of a TSN Talker/Listener.

The use of these fields for Stream identification corresponds to the managed objects for Stream identification in IEEE Std 802.1CB. If inconsistency arises between this specification and IEEE Std 802.1CB, IEEE Std 802.1CB takes precedence.

The elements of the IEEE802-VlanTag group are listed in Table 46-5.

Table 46-5—IEEE802-VlanTag elements

Name	Data type	Reference
PriorityCodePoint	uint8	46.2.3.4.2 item a)
VlanId	uint16	46.2.3.4.2 item b)

The elements of the IEEE802-VlanTag group:

a) **PriorityCodePoint**—This field specifies the Priority Code Point (PCP) field of the VLAN tag. The value range is 0 to 7 inclusive. The PriorityCodePoint is not used to identify the Stream, but it does identify a traffic class (queue) in Bridges.

b) **VlanId**—This field specifies the VLAN ID (VID) field of the VLAN tag. The value range is 0 to 4095 inclusive. If only the PriorityCodePoint is known, the VlanId is specified as 0.

46.2.3.4.3 IPv4-tuple

The IPv4-tuple group specifies fields to identify an IPv4 (RFC791) Stream.

The use of these fields for Stream identification corresponds to the managed objects for Stream identification in IEEE Std 802.1CB. If inconsistency arises between this specification and IEEE Std 802.1CB, IEEE Std 802.1CB takes precedence.

The elements of the IPv4-tuple group are listed in Table 46-6.

Table 46-6—IPv4-tuple elements

Name	Data type	Reference
SourceIpAddress	ipv4-address-type	46.2.3.4.3 item a)
DestinationIpAddress	ipv4-address-type	46.2.3.4.3 item b)
Dscp	uint8	46.2.3.4.3 item c)
Protocol	uint16	46.2.3.4.3 item d)
SourcePort	uint16	46.2.3.4.3 item e)
DestinationPort	uint16	46.2.3.4.3 item f)

The elements of the IPv4-tuple group:

a) **SourceIpAddress**—This field specifies the source IPv4 address. An address of all 0's specifies that the IP source address is ignored for purposes of Stream identification.

b) **DestinationIpAddress**—This field specifies the destination IPv4 address.

c) **Dscp**—This field specifies the Differentiated Services Code Point (DSCP) (IETF RFC 2474). A value of 64 decimal specifies that the DSCP is ignored for purposes of Stream identification.

d) **Protocol**—This field specifies the IPv4 Protocol (e.g., UDP). The special value of all 1's (FFFF hex) represents 'None', i.e., Protocol, SourcePort, and DestinationPort are ignored for purposes of Stream identification. For any value other than all 1's, the lower octet is used to match IPv4 Protocol.

e) **SourcePort**—This field specifies the source port of the Protocol.

f) **DestinationPort**—This field specifies the destination port of the Protocol.

46.2.3.4.4 IPv6-tuple

The IPv6-tuple group specifies fields to identify an IPv6 (RFC 8200 [B46]) Stream.

The use of these fields for Stream identification corresponds to the managed objects for Stream identification in IEEE Std 802.1CB. If inconsistency arises between this specification and IEEE Std 802.1CB, IEEE Std 802.1CB takes precedence.

The elements of the IPv6-tuple group are listed in Table 46-7.

Table 46-7—IPv6-tuple elements

Name	Data type	Reference
SourceIpAddress	ipv6-address-type	46.2.3.4.3 item a)
DestinationIpAddress	ipv6-address-type	46.2.3.4.3 item b)
Dscp	uint8	46.2.3.4.3 item c)
Protocol	uint16	46.2.3.4.3 item d)
SourcePort	uint16	46.2.3.4.3 item e)
DestinationPort	uint16	46.2.3.4.3 item f)

The elements of the IPv6-tuple group:

a) **SourceIpAddress**—This field specifies the source IPv6 address. An address of all 0's specifies that the IP source address is ignored for purposes of Stream identification.

b) **DestinationIpAddress**—This field specifies the destination IPv6 address.

c) **Dscp**—This field specifies the DSCP (IETF RFC 2474). A value of 64 decimal specifies that the DSCP is ignored for purposes of Stream identification.

d) **Protocol**—This field specifies the IPv6 Next Header (e.g., UDP). The special value of all 1's (FFFF hex) represents 'None', i.e., Protocol, SourcePort, and DestinationPort are ignored for purposes of Stream identification. For any value other than all 1's, the lower octet is used to match IPv6 Next Header.

e) **SourcePort**—This field specifies the source port of the Protocol.

f) **DestinationPort**—This field specifies the destination port of the Protocol.

46.2.3.5 TrafficSpecification

The TrafficSpecification group specifies how the Talker transmits frames for the Stream. This is effectively the Talker's promise to the network. The network uses this traffic specification to allocate resources and adjust queue parameters in Bridges.

The TrafficSpecification group consists of the following:

a) Its required elements, listed in Table 46-8.

Table 46-8—TrafficSpecification elements

Name	Data type	Reference
Interval	rational	46.2.3.5.1
MaxFramesPerInterval	uint16	46.2.3.5.2
MaxFrameSize	uint16	46.2.3.5.3
TransmissionSelection	uint8	46.2.3.5.4

b) An optional TSpecTimeAware group, whose elements are listed in Table 46-9.

Table 46-9—TSpecTimeAware elements

Name	Data type	Reference
EarliestTransmitOffset	uint32	46.2.3.5.5
LatestTransmitOffset	uint32	46.2.3.5.6
Jitter	uint32	46.2.3.5.7

The presence of TSpecTimeAware specifies that the Talker's traffic is synchronized to a known time on the network (e.g., using IEEE Std 802.1AS). The TSpecTimeAware group provides elements to specify the Talker's time-aware transmit to the network. The Talker and Listeners of a Stream are assumed to coordinate using user (application) mechanisms, such that each Listener is aware that its Talker transmits in a time-aware manner. If MaxFramesPerInterval is greater than one, the time-aware Talker shall transmit multiple frames as a burst within the Interval, with the minimum inter-frame gap allowed by the media.

NOTE—Although scheduled traffic (8.6.8.4) specifies a valid implementation of a time-aware Talker, the TSpecTimeAware group is intended to support alternate implementations of scheduling.

For informative examples using the TSpecTimeAware group of TrafficSpecification, refer to U.1.

46.2.3.5.1 Interval

Interval specifies the period of time in which the traffic specification cannot be exceeded. The traffic specification is specified by MaxFramesPerInterval and MaxFrameSize.

The Interval is a rational number of seconds, defined by an unsigned 32-bit integer numerator and an unsigned 32-bit integer denominator.

If the TSpecTimeAware group is not present, the Interval specifies a sliding window of time. The Talker's transmission is not synchronized to a time on the network, and therefore the traffic specification cannot be exceeded during any Interval in time.

If the TSpecTimeAware group is present, the Interval specifies a window of time that is aligned with the time epoch that is synchronized on the network. For example, if IEEE Std 802.1AS is used with the PTP timescale, the first Interval begins at 1 January 00:00:00 TAI. If CurrentTime represents the current time, then the start of the next Interval (StartOfNextInterval) is:

$$\text{StartOfNextInterval} = N \times \text{Interval}$$

where N is the smallest integer for which the relation:

$$\text{StartOfNextInterval} \geq \text{CurrentTime}$$

would be TRUE.

46.2.3.5.2 MaxFramesPerInterval

MaxFramesPerInterval specifies the maximum number of frames that the Talker can transmit in one Interval.

46.2.3.5.3 MaxFrameSize

MaxFrameSize specifies maximum frame size that the Talker will transmit, excluding any overhead for media-specific framing (e.g., preamble, IEEE 802.3 header, Priority/VID tag, CRC, interframe gap). As the Talker or Bridge determines the amount of bandwidth to reserve on the egress Port (interface), it will calculate the media-specific framing overhead on that Port and add it to the number specified in the MaxFrameSize element.

46.2.3.5.4 TransmissionSelection

TransmissionSelection specifies the algorithm that the Talker uses to transmit this Stream's traffic class. This algorithm is often referred to as the shaper for the traffic class.

The value for this element uses Table 8-6 (in 8.6.8). If no algorithm is known, the value zero (strict priority) can be used.

The Talker's shaping and scheduling of the Stream is considered to be on the user side of the user/network boundary, and this specifies the Talker's behavior to the network. In the fully distributed model, this value can be ignored by a Bridge, and it is not changed during propagation through the Bridge.

46.2.3.5.5 EarliestTransmitOffset

EarliestTransmitOffset specifies the earliest offset within each Interval at which the Talker is capable of starting transmit of its frames. As part of the Status group, the network will return a specific TimeAwareOffset to the Talker (within the earliest/latest range), which the Talker uses to schedule its transmit.

EarliestTransmitOffset is specified as an integer number of nanoseconds.

The Talker's transmit offsets include EarliestTransmitOffset, LatestTransmitOffset, and the TimeAwareOffset returned to the Talker in the Status group. Each of the Talker's offsets is specified at the point when the message timestamp point of the first frame of the Stream in each Interval passes the reference plane marking the boundary between the network media and PHY. The message timestamp point is specified by IEEE Std 802.1AS for various media.

46.2.3.5.6 LatestTransmitOffset

LatestTransmitOffset specifies the latest offset within the Interval at which the Talker is capable of starting transmit of its frames. As part of the Status group, the network will return a specific TimeAwareOffset to the Talker (within the earliest/latest range), which the Talker uses to schedule its transmit.

LatestTransmitOffset is specified as an integer number of nanoseconds.

46.2.3.5.7 Jitter

Jitter specifies the maximum difference in time between the Talker's transmit offsets and the ideal synchronized network time (e.g., IEEE 802.1AS time). Jitter is specified as an unsigned integer number of nanoseconds.

The maximum difference means sooner or later than the ideal (e.g., transmit ± 500 ns relative to IEEE 802.1AS time results in Jitter of 500).

The ideal synchronized network time refers to time at the source (e.g., IEEE 802.1AS grandmaster). The Jitter does not include inaccuracies as time is propagated from the time source to the Talker because those inaccuracies are assumed to be known by the network and time synchronization is a network technology. The Jitter element is intended to specify inaccuracies in the Talker's implementation. For example, if the Talker's IEEE 802.1AS time is ± 812 ns relative to the grandmaster and the Talker schedules using a 100 µs timer tick driven by IEEE 802.1AS time, Jitter is 50 000 (not 50 812).

The Talker's transmit offsets include EarliestTransmitOffset, LatestTransmitOffset, and the TimeAwareOffset returned to the Talker in the Status group.

46.2.3.6 UserToNetworkRequirements

The UserToNetworkRequirements group specifies user requirements for the Stream, such as latency and redundancy.

The network (e.g., CNC) will merge all UserToNetworkRequirements for a Stream to ensure that all requirements are met.

The elements of the UserToNetworkRequirements group are listed in Table 46-10.

Table 46-10—UserToNetworkRequirements elements

Name	Data type	Reference
NumSeamlessTrees	uint8	46.2.3.6.1
MaxLatency	uint32	46.2.3.6.2

46.2.3.6.1 NumSeamlessTrees

NumSeamlessTrees specifies the number of trees that the network will configure to deliver seamless redundancy for the Stream.

The value zero is interpreted as one (i.e., no seamless redundancy).

This requirement is provided from the Talker only. Listeners shall set this element to one.

From each Talker to a single Listener, the network configures a path that relays Stream data through Bridges. If the Talker has more than one Listener, the network configures a tree of multiple paths.

NumSeamlessTrees specifies the number of maximally disjoint trees that the network shall configure from the Talker to all Listeners. Each tree is disjoint from other trees, in that the network evaluates the physical topology to avoid sharing the same Bridge and links in each tree's paths. This computation of disjoint trees is maximal, in that shared Bridges and links are avoided to the maximum extent allowed by the physical topology. For example, if a single link exists from a Bridge to a Listener and NumSeamlessTrees is three, then all three trees will share that link to the Listener.

When NumSeamlessTrees is greater than one, the transfer of the Stream's data frames shall use a seamless redundancy standard, such as IEEE Std 802.1CB. When a link shared by multiple trees diverges to multiple disjoint links, the seamless redundancy standard replicates (i.e., forwards a distinct copy of each data frame to the disjoint trees). When disjoint trees converge to a single link, the seamless redundancy standard eliminates the duplicate copies of each data frame. Assuming that other sources of frame loss are mitigated (e.g., congestion), failure of a link or Bridge in one disjoint tree does not result in frame loss as long as at least one remaining disjoint tree is operational.

If the Talker sets this element to one, the network may make use of redundancy standards that are not seamless (i.e., failure of link results in lost frames), such as MSTP and IS-IS.

If the Talker sets this element to greater than one and seamless redundancy is not possible in the current network (no disjoint paths or no seamless redundancy standard in Bridges), the Status group returns a nonzero FailureCode (46.2.5.1).

If the UserToNetworkRequirements group is not provided within the Talker or Listener group, the network shall use the default value of one for this element.

46.2.3.6.2 MaxLatency

MaxLatency specifies the maximum latency from Talker to Listener(s) for a single frame of the Stream.

MaxLatency is specified as an integer number of nanoseconds.

Latency shall use the definition of 3.119, with additional context as follows: The "known reference point in the frame" is the message timestamp point specified in IEEE Std 802.1AS for various media (i.e., start of the frame). The "first point" is in the Talker at the reference plane marking the boundary between the network media and PHY (see IEEE Std 802.1AS). The "second point" is in the Listener at the reference plane marking the boundary between the network media and PHY.

When this requirement is specified by the Talker, it must be satisfied for all Listeners.

When this requirement is specified by the Listener, it must be satisfied for this Listener only.

If the UserToNetworkRequirements group is not provided within the Talker or Listener group, the network shall use the default value zero for this element.

The special value of zero represents usage of the initial value of Status.AccumulatedLatency as the maximum latency requirement. This effectively locks down the initial latency that the network calculates after successful configuration of the Stream, such that any subsequent increase in latency beyond that value causes the Stream to fail.

The assumption for when the “first point” occurs in the Talker depends on the presence of the TSpecTimeAware group in the Talker’s TrafficSpecification.

a) When TSpecTimeAware is not present:
   1) The Talker is assumed to transmit at an arbitrary time (not scheduled).
b) When TSpecTimeAware is present:
   1) The ‘first point’ is assumed to occur at the start of the Interval as if the Talker’s offsets (EarliestTransmitOffset and LatestTransmitOffset of 46.2.3.5) are both zero. The Talker’s offsets are not typically zero, but use of the start of Interval for purposes of MaxLatency allows the Listener(s) to schedule their application independently from the Talker’s offset configuration.
   2) The Listener determines MaxLatency based on its scheduling of a read function in the application. Nevertheless, the time from frame reception (i.e., “second point”) to execution of the read function is in the user’s scope and therefore not included in MaxLatency.
   3) MaxLatency can be set to a value greater than the Talker’s Interval in order to specify a longer latency requirement. For example, if the Talker’s Interval is 500 μs and MaxLatency is 700 μs, the Listener receives the frame no later than 200 μs into the interval that follows the Talker’s Interval.

46.2.3.7 InterfaceCapabilities

The InterfaceCapabilities group specifies the network capabilities of all interfaces (Ports) contained in the EndStationInterfaces group.

The network may provide configuration of these capabilities in the InterfaceConfiguration group of the Status group.

NOTE—If an end station contains multiple interfaces with different network capabilities, each interface should be specified in a distinct Talker or Listener group (i.e., one interface in EndStationInterfaces). Use of multiple interface in EndStationInterfaces is intended for network capabilities that span multiple interfaces (e.g., seamless redundancy).

The elements of the InterfaceCapabilities group are listed in Table 46-11.

Table 46-11—InterfaceCapabilities elements

Name	Data type	Reference
VlanTagCapable	Boolean	46.2.3.7.1
CB-StreamIdenTypeList	sequence of uint32	46.2.3.7.2
CB-SequenceTypeList	sequence of uint32	46.2.3.7.3

46.2.3.7.1 VlanTagCapable

When VlanTagCapable is true, the interface supports the ability to tag/untag frames using a Customer VLAN Tag (C-TAG of Clause 9) provided by the network.

For a Talker, the network’s tag replaces the tag specified by the DataFrameSpecification. If the DataFrameSpecification is untagged (no IEEE802-VlanTag group), the network’s tag is inserted in the frame as it passes through the interface.

For a Listener, the user's tag from the DataFrameSpecification replaces the network's tag as the frame passes through the interface. If the DataFrameSpecification is untagged (no IEEE802-VlanTag group), the network's tag is removed from the frame as it passes through the interface.

If the end station supports more than one interface (i.e., more than one entry in EndStationInterfaces), VlanTagCapable of true means that a distinct VLAN tag can be applied to each interface. The list of VLAN tags (one for each interface) can be provided by the network in InterfaceConfiguration.InterfaceList (IEEE802-VlanTag choice).

When VlanTagCapable is false, the interface does not support the capability to tag/untag frames using a Customer VLAN Tag (C-TAG of Clause 9) provided by the network.

If the InterfaceCapabilities group is not provided within the Talker or Listener group, the network shall use the default value of false for this element.

46.2.3.7.2 CB-StreamIdenTypeList

CB-StreamIdenTypeList provides a list of the supported Stream Identification types as specified in IEEE Std 802.1CB.

Each Stream Identification type is provided as a 32-bit unsigned integer. The upper 3 octets contain the OUI/CID, and the lowest octet contains the type number.

NOTE—If the Talker/Listener end system supports IEEE Std 802.1CB, Null Stream identification is required, and that Stream Identification type is included in this list. If the Talker/Listener end system does not support IEEE Std 802.1CB, this list is empty.

If the end station supports more than one interface (i.e., more than one InterfaceID in EndStationInterfaces), an empty CB-StreamIdenTypeList means that the end station is capable of transferring the Stream on any one of its interfaces (not all). When this is specified, the network shall decide which interface is best used for TSN purposes and communicate that decision by returning a single interface in InterfaceConfiguration.InterfaceList. The Talker/Listener uses this interface alone for the Stream.

If the InterfaceCapabilities group is not provided within the Talker or Listener group, the network shall use an empty list as the default value for this element.

46.2.3.7.3 CB-SequenceTypeList

CB-SequenceTypeList provides a list of the supported Sequence Encode/Decode types as specified in IEEE Std 802.1CB.

Each sequence type is provided as a 32-bit unsigned integer. The upper 3 octets contain the OUI/CID, and the lowest octet contains the type number.

If the InterfaceCapabilities group is not provided within the Talker or Listener group, the network shall use an empty list as the default value for this element.

46.2.4 Listener

The Listener group specifies the following:

— Listener's requirements from the network
— TSN capabilities of the Listener's interface(s)

In the fully distributed model and the centralized network/distributed user model, this group originates from the Listener's end station. In the fully centralized model, this group originates from the CUC.

The Listener group contains the following groups:

— StreamID (46.2.3.1)
— EndStationInterfaces (46.2.3.3)
— UserToNetworkRequirements (46.2.3.6)
— InterfaceCapabilities (46.2.3.7)

For the join operation, the UserToNetworkRequirements and InterfaceCapabilities groups may be included within the Listener group. If a group is omitted, the network uses the default values specified for elements of that group.

For the join and leave operation, the StreamID group shall be included in the TSN user/network protocol in a location associated with the Stream (e.g., Listener group).

For the join and leave operation, EndStationInterfaces shall be included within the Listener group for the fully centralized model (46.1.3.3). For the join and leave operation, EndStationInterfaces should be included within the Listener group for the fully distributed model (46.1.3.1) or centralized network/distributed user model (46.1.3.2).

46.2.5 Status

The Status group provides the status of a Stream's configuration from the network to each user (Talker or Listener).

In the fully distributed model and the centralized network/distributed user model, this group is delivered to each Talker end station and Listener end station of the Stream. In the fully centralized mode, this group is delivered to the CUC.

The Status group contains the following groups:

— StreamID (46.2.3.1)
— StatusInfo (46.2.5.1)
— AccumulatedLatency (46.2.5.2)
— InterfaceConfiguration (46.2.5.3)
— FailedInterfaces (46.2.5.4)

The AccumulatedLatency and InterfaceConfiguration groups are distinct for each Talker or Listener, and therefore Status is distinct.

The protocol for TSN configuration shall specify that one Status group is received in response to the transmit of a Talker group or Listener group. This provides at least one response to each join or leave request.

StreamID (46.2.3.1) identifies the Stream for which status is provided.

StatusInfo (46.2.5.1) provides the status of the Stream's configuration in the network.

For the join and leave operation, the StreamID and StatusInfo groups shall be included in the TSN user/network protocol in a location associated with the Stream (e.g., Status group).

For the join operation, the AccumulatedLatency group shall be included within the Status group that is sent to a Listener. For the join operation, the AccumulatedLatency group may be included within the Status group that is sent to a Talker.

For the join operation, the InterfaceConfiguration group may be included within the Status group. InterfaceConfiguration provides configuration of the interfaces in a specific end station.

If a group is omitted, the network uses the default values specified for elements of that group.

When a failure occurs in network configuration, FailedInterfaces identifies one or more interfaces (Ports) on which the failure occurred. If the FailureCode of the StatusInfo group (46.2.5.1) is zero, the FailedInterfaces group shall not be included within the Status group. If the FailureCode is nonzero, the FailedInterfaces group may be included within the Status group.

When a Talker and at least one Listener have joined the stream and network resources are configured for the Stream (success or failure), the network shall transmit Status to the Talker and Listener(s). After the initial Status, upon any change in the status of the network configuration (e.g., new Listeners, change in FailureCode), the network shall transmit Status to the Talker and Listener(s). When the Stream does not have a Talker or a Listener, the network configuration is removed, and the network shall transmit a final Status to the remaining Talker and/or Listener(s). Beyond these requirements, additional transmit of Status is specified by the protocol that carries the Status group.

46.2.5.1 StatusInfo

The StatusInfo group provides information regarding the status of a Stream's configuration in the network.

The elements of the StatusInfo group are listed in Table 46-12.

Table 46-12—StatusInfo elements

Name	Data type	Reference
TalkerStatus	enumeration	46.2.5.1.1
ListenerStatus	enumeration	46.2.5.1.2
FailureCode	uint8	46.2.5.1.3

46.2.5.1.1 TalkerStatus

TalkerStatus provides the status of the network configuration for the Stream's Talker.

TalkerStatus uses the enumeration specified in Table 46-13.

Table 46-13—TalkerStatus enumeration

Name	Value	Description
None	0	No Talker detected.
Ready	1	Talker ready (configured).
Failed	2	Talker failed.

46.2.5.1.2 ListenerStatus

ListenerStatus provides the status of the network configuration for the Stream's Listener(s). If there is more than one Listener for the Stream, ListenerStatus provides the status of all Listeners.

ListenerStatus uses the enumeration specified in Table 46-14.

Table 46-14—ListenerStatus enumeration

Name	Value	Description
None	0	No Listener detected.
Ready	1	All Listeners ready (configured).
PartialFailed	2	One or more Listeners ready, and one or more Listeners failed. If Talker is ready, Stream can be used.
Failed	3	All Listeners failed.

46.2.5.1.3 FailureCode

If the Stream encounters a failure (TalkerStatus is Failed, or ListenerStatus is Failed, or ListenerStatus is PartialFailed), FailureCode provides a nonzero code that specifies the problem. If the Stream is configured without a failure, FailureCode is zero.

Table 46-15 specifies the nonzero values for FailureCode.

46.2.5.2 AccumulatedLatency

The AccumulatedLatency group provides the worst-case latency that a single frame of the Stream can encounter along its current path(s).

The elements of the AccumulatedLatency group are listed in Table 46-16.

Table 46-15—TSN Failure Codes

Failure Code	Description of cause
1	Insufficient bandwidth
2	Insufficient Bridge resources
3	Insufficient bandwidth for traffic class
4	StreamID in use by another Talker
5	Stream destination_address already in use
6	Stream preempted by higher rank
7	Reported latency has changed
8	Egress Port is not AVB capable [a]
9	Use a different destination_address (i.e., MAC DA hash table full)
10	Out of MSRP resources
11	Out of MMRP resources
12	Cannot store destination_address (i.e., Bridge is out of MAC DA resources)
13	Requested priority is not an SR Class (3.262) priority
14	MaxFrameSize [item a) in 35.2.2.8.4] is too large for media
15	msrpMaxFanInPorts [item f) in 35.2.1.4] limit has been reached
16	Changes in FirstValue, other than AccumulatedLatency, for a registered StreamID
17	VLAN is blocked or filtered on this egress Port [b]
18	VLAN tagging is disabled on this egress Port (untagged set)
19	SR class priority mismatch
20	Enhanced feature cannot be propagated to original Port
21	MaxLatency exceeded
22	Nearest Bridge cannot provide network identification for stream transformation
23	Stream transformation not supported
24	Stream identification type not supported for stream transformation
25	Enhanced feature cannot be supported without a CNC

[a] A device can use the IEEE Std 802.1AS asCapable variable to help determine if its neighboring device is AVB capable. If the asCapable variable is FALSE for a particular Port, then the neighboring device is not a time-aware system and therefore not AVB capable.

[b] This Failure Code is never declared in a Talker Failed message since Talker attributes are not propagated on egress Ports that have the associated VLAN blocked in the VLAN spanning tree (7.3) or filtered in VLAN Registration Entries (8.8). The Bridge can still be queried by other means to learn why the Talker attribute was not declared.

46.2.5.2.1 AccumulatedLatency

Table 46-16—AccumulatedLatency elements

Name	Data type	Reference
AccumulatedLatency	uint32	46.2.5.2.1

The AccumulatedLatency element provides the worst-case maximum latency that a single frame of the Stream can encounter along its current path(s).

AccumulatedLatency is distinct for each Talker or Listener of the Stream.

When provided to a Listener, AccumulatedLatency is the worst-case maximum latency for that Listener only.

When provided to a Talker, AccumulatedLatency is the worst-case maximum latency for all Listeners (worst path).

AccumulatedLatency is specified as an integer number of nanoseconds.

AccumulatedLatency uses the same definition for latency as UserToNetworkRequirements.MaxLatency (46.2.3.6).

For a successful StatusInfo (46.2.5.1), the network returns a value less than or equal to UserToNetworkRequirements.MaxLatency.

If the TSpecTimeAware group is present in the TrafficSpecification group (46.2.3.5) of the Talker, the value is expressed as nanoseconds after the start of the Talker's Interval.

If the TSpecTimeAware group is not present in the TrafficSpecification group of the Talker, the value is expressed as nanoseconds after the Talker's transmit of any frame in the Stream, at any arbitrary time.

If UserToNetworkRequirements.NumSeamlessTrees is one, AccumulatedLatency shall provide the worst-case maximum latency for the current path from Talker to each Listener. If the path is changed (e.g., by a spanning tree protocol), AccumulatedLatency changes accordingly.

If UserToNetworkRequirements.NumSeamlessTrees is greater than one, AccumulatedLatency shall provide the worst-case maximum latency for all paths in use from the Talker to each Listener.

46.2.5.3 InterfaceConfiguration

The InterfaceConfiguration group provides configuration of interfaces in the Talker/Listener. This configuration assists the network in meeting the Stream's requirements. The InterfaceConfiguration meets the capabilities of the interface as provided in the InterfaceCapabilities group.

The InterfaceConfiguration group is distinct for each Talker or Listener of the Stream.

A distinct configuration is provided for each interface in the Talker/Listener (even if multiple interfaces use the same configuration). Each interface configuration consists of a single InterfaceID (46.2.3.3) group, followed by a list of configuration values for that interface.

The values in InterfaceID shall match one of the InterfaceID entries in the Talker/Listener EndStationInterfaces group.

The list of configuration values uses zero or more of the following groups:

— IEEE802-MacAddresses (46.2.5.3.1)
— IEEE802-VlanTag (46.2.5.3.2)
— IPv4-tuple (46.2.5.3.3)
— IPv6-tuple (46.2.5.3.4)
— TimeAwareOffset (46.2.5.3.5)

If the InterfaceConfiguration group is not provided within the Status group, the network shall assume zero configuration values as the default (no interface configuration).

46.2.5.3.1 IEEE802-MacAddresses

The IEEE802-MacAddresses group provides the source and destination MAC addresses that apply to the network side of the user/network boundary.

NOTE 1—On the user side, the MAC addresses are in DataFrameSpecification.IEEE802-MacAddresses.

NOTE 2—The source MAC address of the network is typically the same as the user. The destination MAC address can be different. For example, the user can use an individual address, but the network can use a group (multicast) address.

This group uses the specifications from DataFrameSpecification.IEEE802-MacAddresses (46.2.3.4.1).

This configuration value is not provided unless IEEE Std 802.1CB is supported and a value for Active Destination MAC and VLAN Stream identification is provided in CB-StreamIdenTypeList of InterfaceCapabilities.

46.2.5.3.2 IEEE802-VlanTag

The IEEE802-VlanTag group provides the Customer VLAN Tag (C-TAG of Clause 9) that applies to the network side of the user/network boundary.

NOTE—On the user side, the VLAN tag is in DataFrameSpecification.IEEE802-VlanTag (including untagged if that field is not provided).

This group uses the specifications from DataFrameSpecification.IEEE802-VlanTag (46.2.3.4.2).

If the user provides a VLAN ID in the IEEE802-VlanTag of DataFrameSpecification, the Stream's data frames are assumed to be limited to the active topology for that VLAN ID. Therefore, if the network uses a different VLAN ID in this configuration value, the network shall ensure that the replacement VLAN ID is limited to the equivalent active topology.

This configuration value is not provided unless VlanTagCapable of InterfaceCapabilities is true.

46.2.5.3.3 IPv4-tuple

The IPv4-tuple group provides the IPv4 identification that applies to the network side of the user/network boundary.

This group uses the specifications from DataFrameSpecification.IPv4-tuple (46.2.3.4.3).

This configuration value is not provided unless IEEE Std 802.1CB is supported and a value for IP Stream identification is provided in CB-StreamIdenTypeList of InterfaceCapabilities.

46.2.5.3.4 IPv6-tuple

The IPv6-tuple group provides the IPv6 identification that applies to the network side of the user/network boundary.

This group uses the specifications from DataFrameSpecification.IPv6-tuple (46.2.3.4.4).

This configuration value is not provided unless IEEE Std 802.1CB is supported and a value for IP Stream identification is provided in CB-StreamIdenTypeList of InterfaceCapabilities.

46.2.5.3.5 TimeAwareOffset

If the TSpecTimeAware group is present in the TrafficSpecification group (46.2.3.5) of the Talker, this configuration value shall be provided by the network to the Talker.

If the TSpecTimeAware group is not present in the TrafficSpecification group (46.2.3.5) of the Talker, this configuration value shall not be provided by the network.

This configuration value shall not be provided to Listeners as it is not applicable.

TimeAwareOffset specifies the offset that the Talker shall use for transmit. The network returns a value between EarliestTransmitOffset and LatestTransmitOffset of the Talker's TrafficSpecification. The value is expressed as nanoseconds after the start of the Talker's Interval. The data type is uint32.

46.2.5.4 FailedInterfaces

When a failure occurs in network configuration (i.e., nonzero FailureCode in StatusInfo group), FailedInterfaces provides a list of one or more physical interfaces (distinct points of attachment) in the failed end station or Bridge. Each identifier is sufficient to locate the interfaces in the physical topology.

The FailedInterfaces group is optional.

FailedInterfaces consists of a sequence of zero or more entries, each entry using the InterfaceID group specified in 46.2.3.3.

46.3 YANG for TSN user/network configuration

In order to support the use of YANG-based protocols for the fully centralized model (46.1.3.3), 48.6.3 specifies a YANG module.

If a YANG-based protocol is specified by another standard for the TSN user/network configuration information (46.2), that specification shall use the YANG module specified in 48.6.3 [see item d) in 5.29].

The YANG module of 48.6.3 provides YANG text for each group of elements in 46.2. Each element is specified using a YANG `leaf`. Each group is specified as a YANG `typedef` or `grouping`. The YANG module for user/network configuration imports the YANG module of 48.6.3 and uses the `typedef` and `grouping` nodes in order to specify the schema tree used for communication between CUC and CNC.

YANG identifiers use a naming convention of hyphens between lowercase names (e.g., "mac-address"). Identifiers for elements and groups in 46.2 use a naming convention of camel case (e.g., "MacAddress"). The specifications for an identifier in 48.6.3 shall be interpreted as applying to the corresponding identifier in 46.2 regardless of differences in naming convention (e.g., requirements for "MacAddress" in 46.2 apply to "mac-address" in 48.6.3).

In the YANG module definitions of 48.6.3, if any discrepancy between the "description" text and the corresponding specifications in 46.2 occurs, the specifications in 46.2 take precedence.

47. Asynchronous Traffic Shaping (ATS) in end stations

47.1 Talker transmission behavior

The operation of ATS traffic classes in Bridges is specified as a combination of per-stream classification and metering for ATS (8.6.5.2.2) and the ATS transmission selection algorithm (8.6.8.5). In order for end station originated data streams to make use of ATS traffic classes in Bridges, it is required that Talkers emit data streams in a compliant manner, and that the parameters of ATS scheduler state machines and ATS scheduler groups in Bridges are consistently set.

47.1.1 ATS traffic class model in Talkers

End stations that are Talkers have to emit streams consistent with the operation of the ATS scheduler state machines in Bridges (8.6.11). This subclause specifies a model of ATS traffic classes that satisfies this purpose. End stations shall exhibit the transmission behavior of this model at the egress ports.

In this model, Talker ports are composed by ATS scheduler instances, which assign eligibility times to the frames of all emitted streams at the egress port, followed by a queue per traffic class, for which the ATS transmission selection algorithm is executed. The relationship between ATS scheduler instances and streams is one-to-one, and each scheduler state machine is associated with a dedicated scheduler group. This effectively eliminates the association of multiple streams to an ATS scheduler instance, as well as the coupling of multiple ATS scheduler instances by ATS scheduler groups.

47.1.2 Simplified ProcessFrame(frame) procedure

Due to the one-to-one relationship between streams and ATS scheduler instances, as well as ATS scheduler instances and scheduler groups, the ProcessFrame(frame) procedure of ATS scheduler state machines, as specified in 8.6.11.3, can be simplified. The simplified procedure is described by the following pseudo-code.

```
ProcessFrame(frame) {
       lengthRecoveryDuration     = length(frame)/
                                    CommittedInformationRate;
       emptyToFullDuration        = CommittedBurstSize/
                                    CommittedInformationRate;
       schedulerEligibilityTime   = BucketEmptyTime +
                                    lengthRecoveryDuration;
       bucketFullTime             = BucketEmptyTime +
                                    emptyToFullDuration;
       eligibilityTime            = max(arrivalTime(frame),
                                        schedulerEligibilityTime);

       BucketEmptyTime      = (eligibilityTime < bucketFullTime) ?
              schedulerEligibilityTime :
              schedulerEligibilityTime + eligibilityTime – bucketFullTime;
       AssignAndProceed(frame,eligibilityTime);
}
```

47.1.3 System clock functions and processing delays

This model has a single implementation specific local system clock function, which is used as:

a) ATS scheduler clock (8.6.11.1) for all ATS scheduler instances and
b) Transmission selection clock (8.6.8.5) of all ATS traffic classes.

The processing delay from the ATS scheduler instances to the transmission selection is zero in this model (8.6.11.3.2):

$$0 = \text{ProcessingDelayMin} = \text{ProcessingDelayMax}$$

47.2 Scheduler parameter consistency

The ATS scheduler parameters CommittedBurstSize (8.6.11.3.5) and CommittedInformationRate (8.6.11.3.6) of Talker streams have to be consistently set to the respective parameters in the Bridge component connected to the Talker. In the Bridge component, a single ATS scheduler instance can be associated with multiple streams of this Talker.

For *n* streams associated with a single ATS scheduler instance in Bridge component, Equation (47-1) and Equation (47-2) can be used for scheduler parameter consistency.

$$CBS_{Bridge} \geq \sum_{i=1}^{n} CBS_i \tag{47-1}$$

$$CIR_{Bridge} \geq \left(\frac{1 + 10^{-6} ClkDev_{Talker}}{1 - 10^{-6} ClkDev_{Bridge}} \right) \sum_{i=1}^{n} CIR_i \tag{47-2}$$

where

CIR_{Bridge} is the CommittedInformationRate parameter of the scheduler instance in the Bridge

CIR_i is the CommittedInformationRate parameter of the *i*th stream in the Talker

CBS_{Bridge} is the CommittedBurstSize parameter of the scheduler instance in the Bridge

CBS_i is the CommittedBurstSize parameter of the *i*th stream in the Talker

$ClkDev_{Bridge}$ is the maximum deviation of the associated ATS scheduler clock (8.6.11.1) in the Bridge from its nominal frequency, in ppm

$ClkDev_{Talker}$ is the maximum deviation of the transmission selection clock (8.6.8.5 and 47.1.3) in the Talker from its nominal frequency, in ppm

48. YANG Data Models

This clause specifies YANG data models that provide control and status monitoring of systems and system components that implement functionality specified in this standard. These data models are based on the set of managed objects and their functionality specified in Clause 12.

This clause:

a) Introduces the YANG framework that governs the naming and hierarchy of configuration and operational data structures in the data models, and the modeling of network interfaces (48.1)

b) Describes each of the data models and its relationship to the operational processes and managed objects specified in the other clauses of this standard, and provides a UML representation of each data model (48.2)

c) Describes the structure of the data models, each of which comprises or makes use of one or more YANG modules (48.3)

d) Reviews security considerations applicable to each of the data models, with specific reference to data nodes in the YANG modules that compose the model (48.4)

e) Includes a schema tree for each of the YANG modules (48.5)

f) Includes each of the YANG modules (48.6)

NOTE 1—The MIB modules specified in Clause 17 were also derived from Clause 12. Consequently, the capabilities and structure of the YANG data models align closely with the MIBs. However the YANG data model has not been derived from the MIB, and there has been no attempt to include data or modeling constructs that might appear in the MIB but not in the information model.

NOTE 2—OMG UML 2.5 [B58] conventions together with C++ language constructs are used in this clause as a representation to convey model structure and relationships.

The YANG data models specified in this clause include the following:

— A VLAN Bridge components data model (48.2.1) that allows control and status monitoring of one or more C-VLAN or S-VLAN Bridge components (8.2) that compose all or part of a system's functionality, and the Bridge Port interfaces that support those components.

— A Two-Port MAC Relay data model (48.2.2) that both subsets and augments the VLAN Bridge components model to model a VLAN-unaware TPMR (3.282)

— A Customer VLAN Bridge model (48.2.3) that comprises a single VLAN Bridge component from the VLAN Bridge components model.

— A Provider Bridges model that uses one or multiple components from the VLAN Bridge components model to compose an S-VLAN component Provider Bridge or a Provider Edge Bridge.

— Connectivity Fault Management (CFM) models (48.2.3) for use with the VLAN Bridge components and related models in systems that provide CFM functionality.

— A Stream filters and stream gates model (48.2.6) that augments the VLAN Bridge components model.

— An Asynchronous Traffic Shaping (ATS) model that augments the VLAN Bridge components model and the Stream filters and stream gates model.

48.1 YANG Framework

This clause has been developed according to the YANG guidelines published in IETF RFC 6087 [B38] as applicable to IEEE standards.

The YANG framework applies hierarchy in the following areas:

1) The uniform resource name (URN), as specified in IEEE Std 802d–2017. The structure of the URN is such that ieee is the root (i.e., name-space identifier), followed by the standard, then the working group developing the standard.
2) The YANG objects form a hierarchy of configuration and operational data structures that define the YANG model. These hierarchical relationships are described in 48.3.

The general YANG framework hierarchy is illustrated in Figure 48-1.

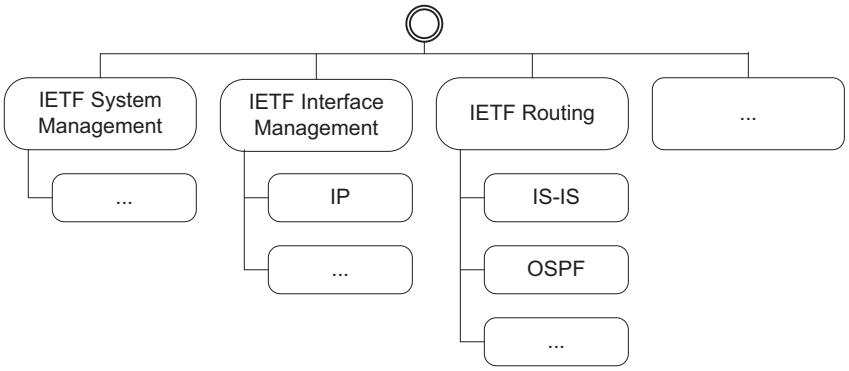


Figure 48-1—General YANG hierarchy

The YANG hierarchical structure that incorporates the IEEE 802.1Q YANG models supported by this standard is represented in Figure 48-2.

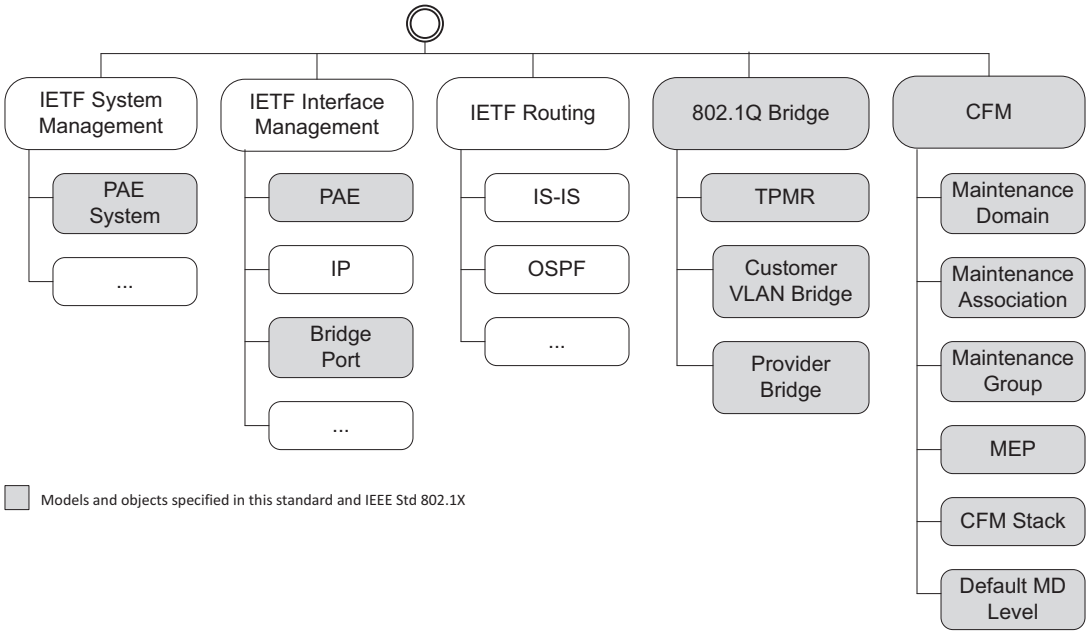


Figure 48-2—YANG root hierarchy with IEEE 802.1Q YANG modules

48.1.1 Interface Management (IETF RFC 8343) Model

Network interfaces are central to the management of protocols. Thus, it is important to establish a common data model for how interfaces are identified, configured, and monitored. The IETF Interface Management model (IETF RFC 8343) defines a generic YANG data model for the management of network interfaces.The Interface Management YANG model is augmented by the IEEE 802.1Q YANG models, and specifically the Bridge Port. A UML representation of the Interface Management model is illustrated in Figure 48-3.[50]

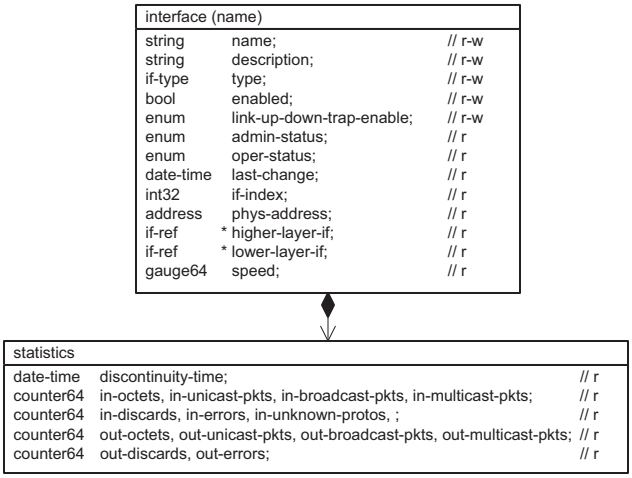


Figure 48-3— Interface YANG model

[50] The representation of the Interface YANG model is derived from IETF RFC 8343.

48.2 IEEE 802.1Q YANG models

The YANG data models are based on the management model outline in Clause 12. UML representations of the models are provided in the following subclauses.

48.2.1 VLAN Bridge components model

A network system can include one or more VLAN Bridge components.

Each VLAN Bridge component (5.4–5.6) comprises a single VLAN-aware MAC Relay Entity and its associated functionality (8.2, Figure 48-4), and is supported by a number of Bridge Ports (3.26, Figure 48-5). Each Bridge Port is associated with a single MAC Relay Entity, presents a single interface (a service access point) to that MAC Relay Entity, and comprises the interface stack that supports that service access point (6.1, 7.4 of IEEE Std 802.1AC-2016). In the 802.1Q YANG models, that interface is represented by the Interface Management (IETF RFC 8343) model augmented as shown in Figure 48-5.

Each MAC Relay Entity has a bridge-type attribute (e.g., customer-vlan-bridge), and the manageable attributes for the component can reflect that type: TPMR components (48.2.2), for example, are VLAN unaware.

A Bridge Port and the attributes associated with a media access method specific MAC entity (e.g, as specified by IEEE Std 802.3) supporting that Bridge Port can both be represented by augmentations of the same IETF_RFC_8343 Interface and identified by the same Interface index (if-index). In other cases *higher-layer-if* and *lower-layer-if* attributes define the interface stacking relationships within the Bridge Port. For example, an Aggregator (as defined by IEEE Std 802.1AX) Interface could be a Bridge Port. The *lower-layer-if* attributes associated with the Aggregator would point to the Aggregation Ports.

Each Bridge Port is uniquely identified, amongst those Bridge Ports supporting a given VLAN Bridge component, by a Port Number (*port-number*). A port number has no mandatory relationship to an Interface index (if-index).

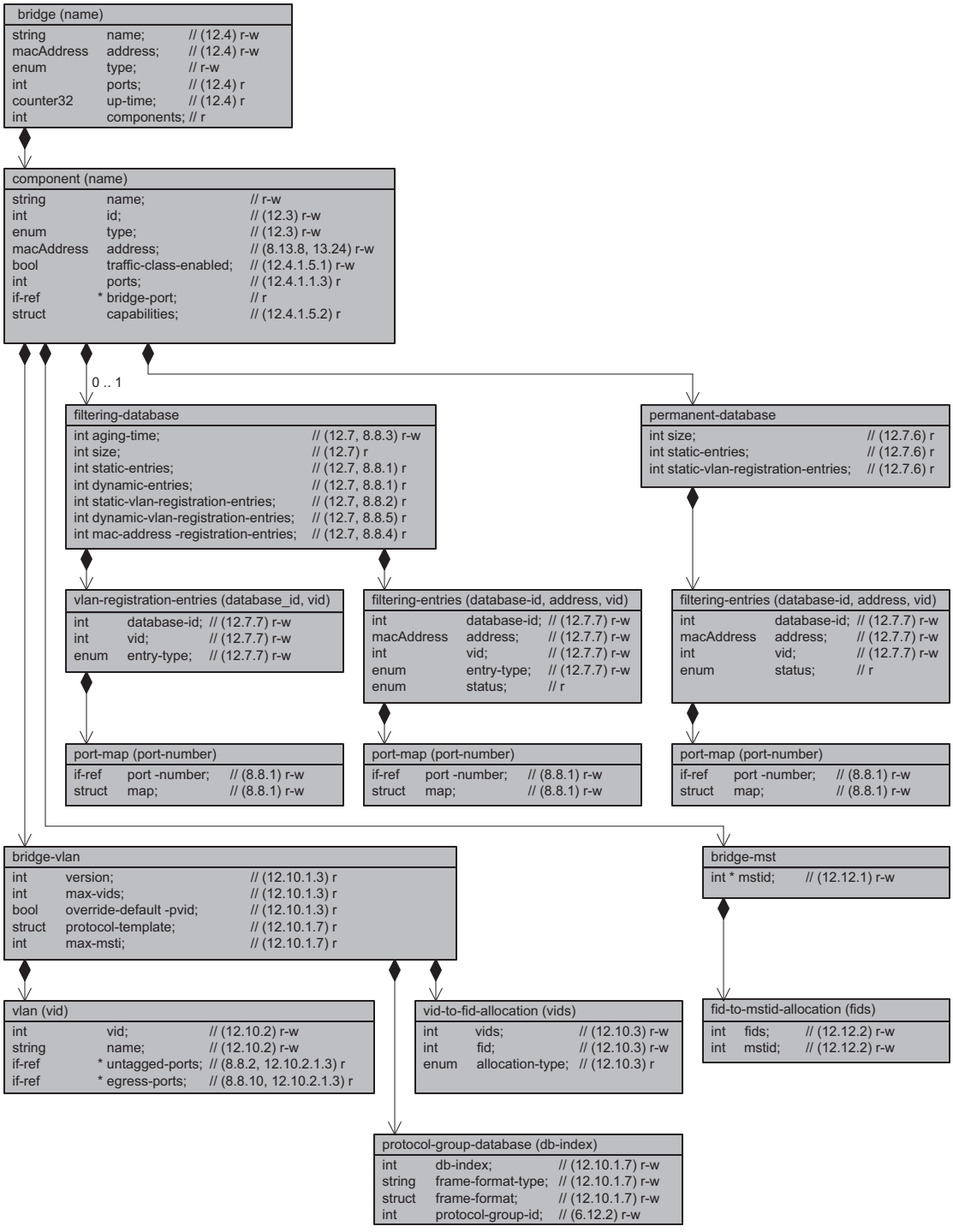


Figure 48-4—VLAN Bridge components model (MAC Relay Entities)

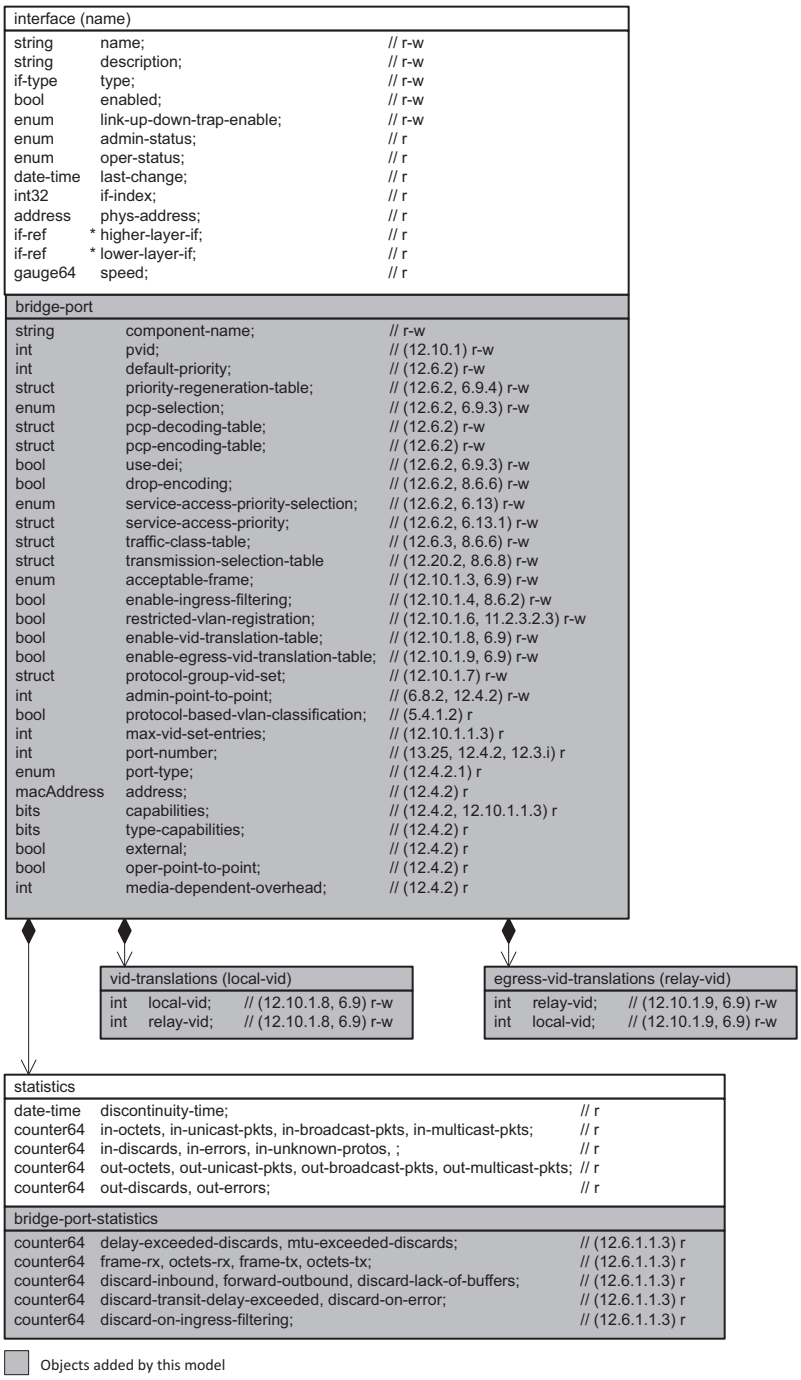


Figure 48-5—Bridge Port model

48.2.2 Two-Port MAC Relay (TPMR) model

A TPMR (5.15, 5.16) comprises a single VLAN-unaware MAC Bridge component supported by only two TPMR Ports (Clause 8, 8.5.2). The TPMR's VLAN-unaware MAC Relay Entity is modeled (Figure 48-6) as a subset of a VLAN Bridge component's MAC Relay Entity (Figure 48-4). This subset does not include the bridge-vlan, bridge-mst, and filtering-database nodes.

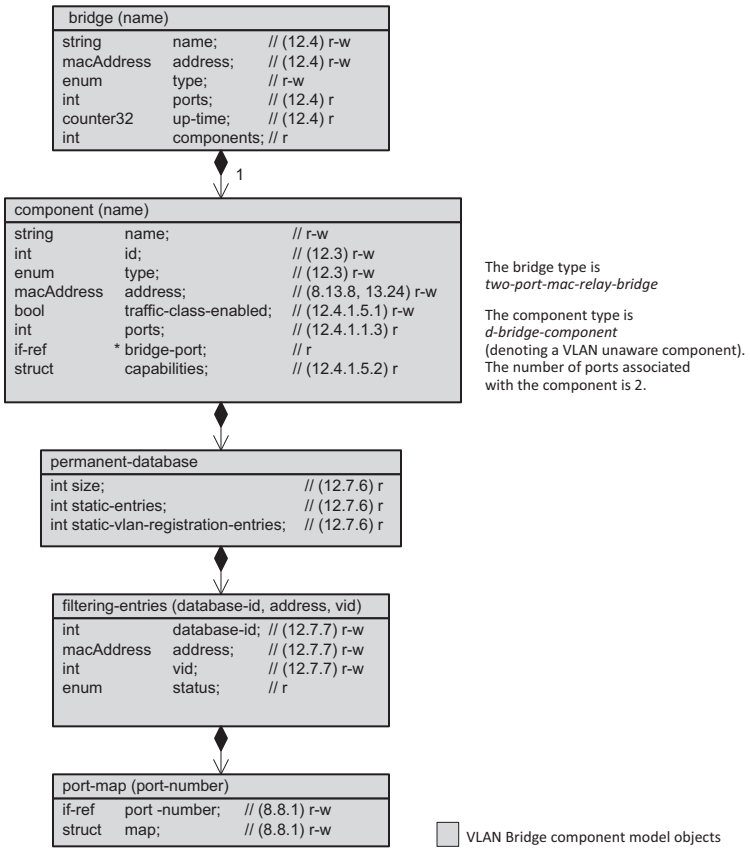


Figure 48-6—TPMR model (MAC Relay Entity)

The TPMR model extends the VLAN Bridge component's Bridge Port model as illustrated in Figure 48-7.

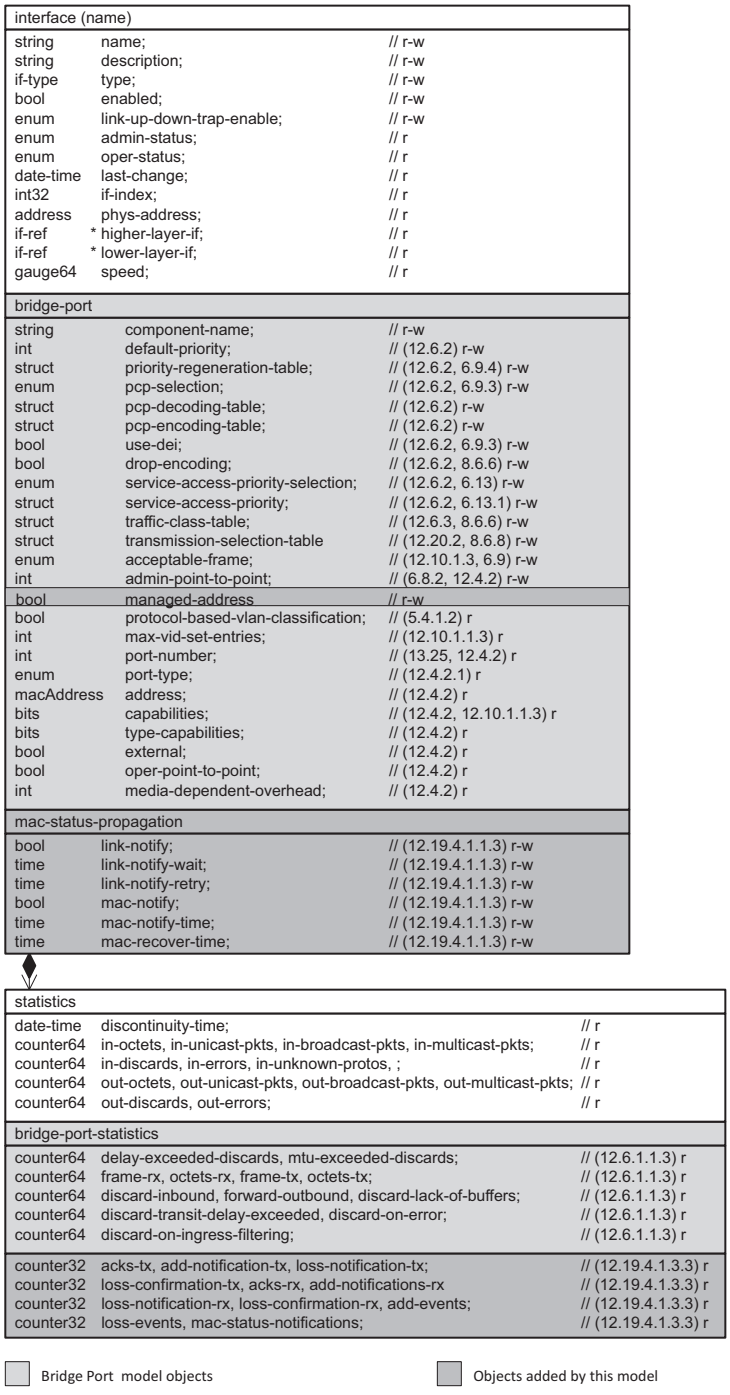


Figure 48-7—TPMR Port model

48.2.3 Customer VLAN Bridge model

A Customer VLAN Bridge (5.5) comprises a single C-VLAN Bridge component (Clause 8). The C-VLAN Bridge component's MAC Relay Entity and its Bridge Ports are modeled by the VLAN Bridge components model (48.2.1), with a single bridge component node with a type-of-bridge of customer-vlan-bridge (48.6.4) [a ComponentType of cVlanComponent in 12.3].

48.2.4 Provider Bridge model

A Provider Bridge (5.10, Clause 16) can be an S-VLAN Bridge with a single S-VLAN component or a Provider Edge Bridge with an S-VLAN component and multiple C-VLAN components. A Provider Bridge's MAC Relay Entities and its Bridge Ports (S-VLAN and C-VLAN Interfaces) are modeled (Figure 48-8, Figure 48-9, Figure 48-10) by extending the VLAN Bridge components model (48.2.1).

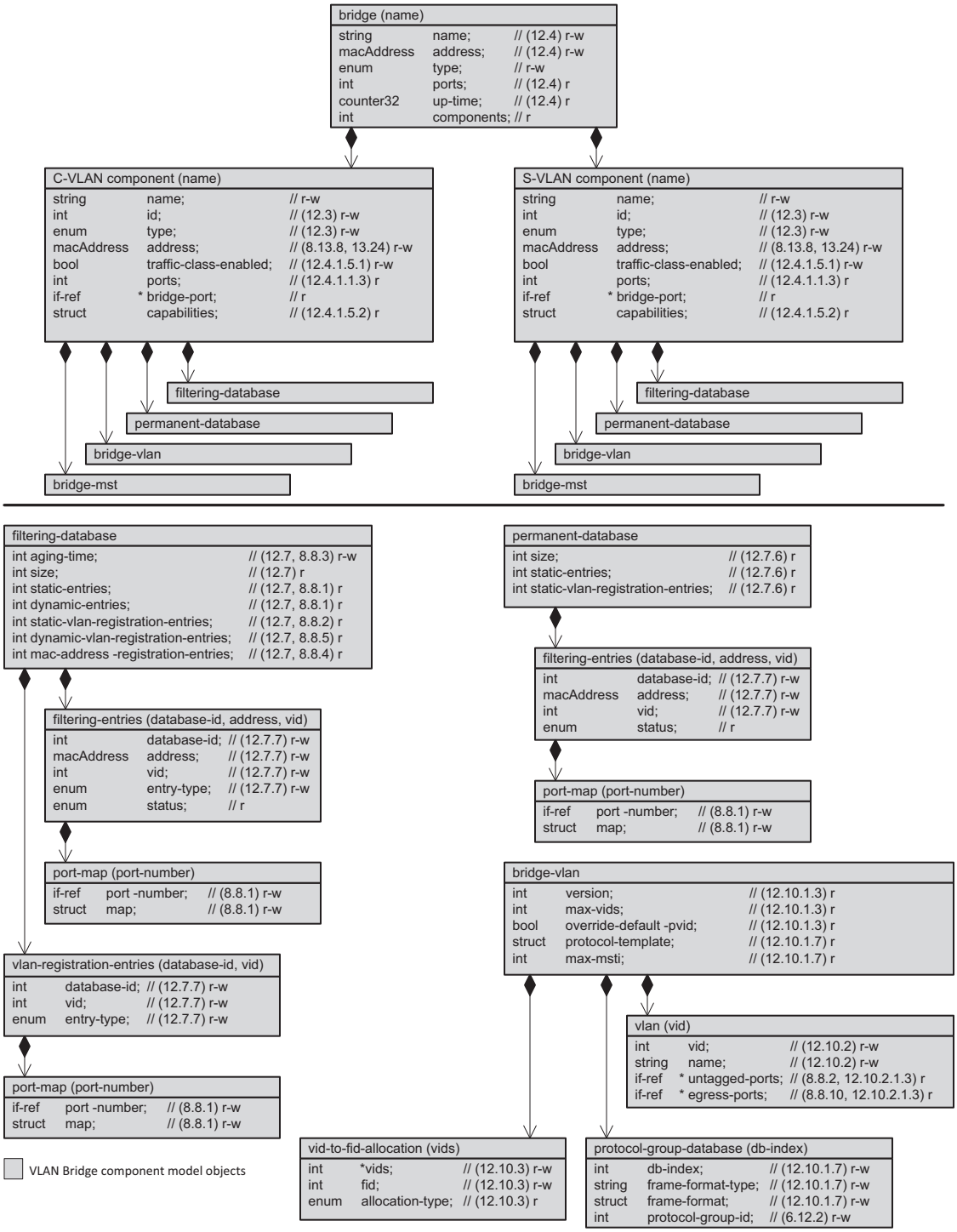


Figure 48-8—Provider Bridge model (MAC Relay Entities)

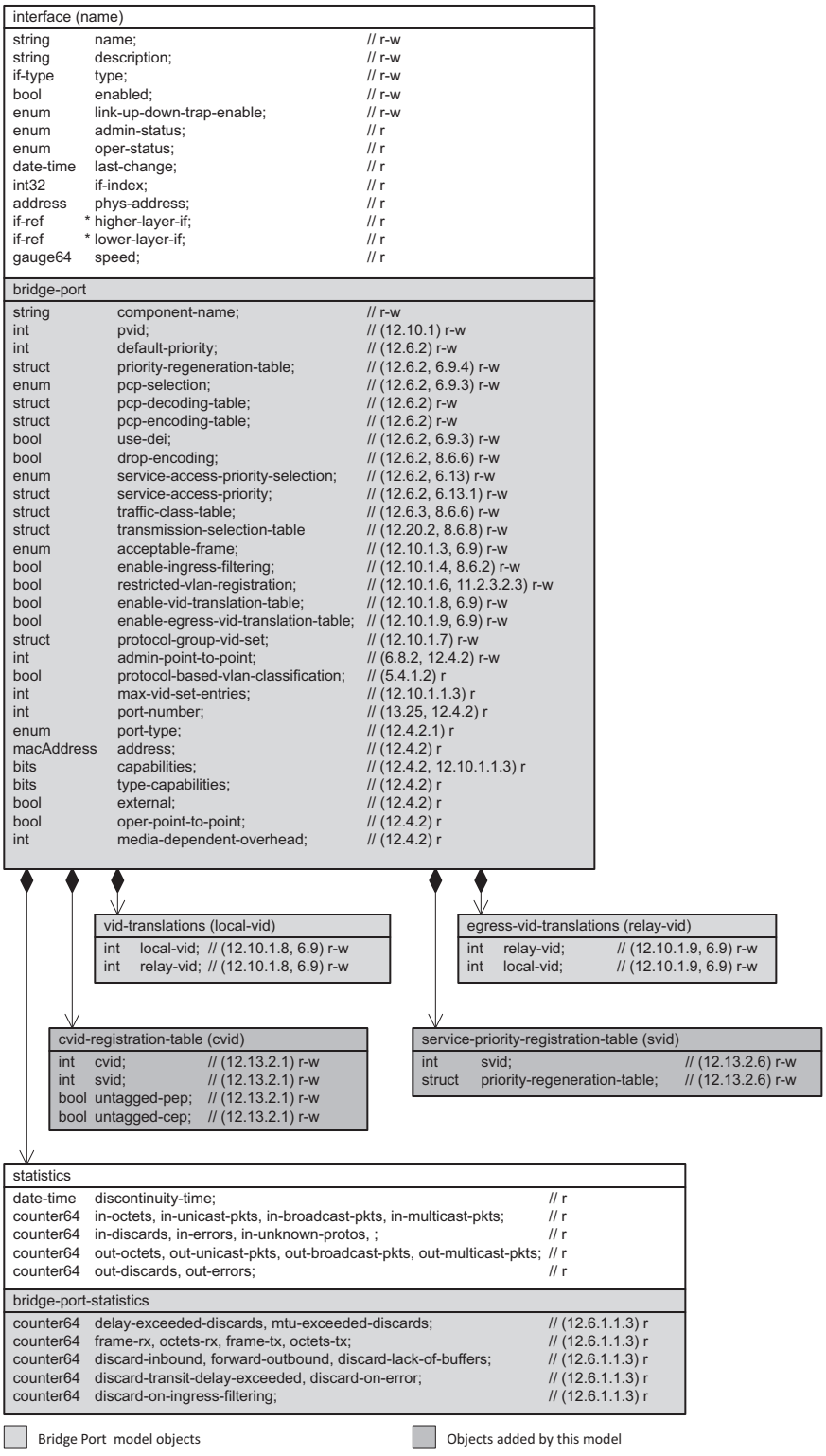


Figure 48-9—Provider Edge Bridge C-VLAN Interface model

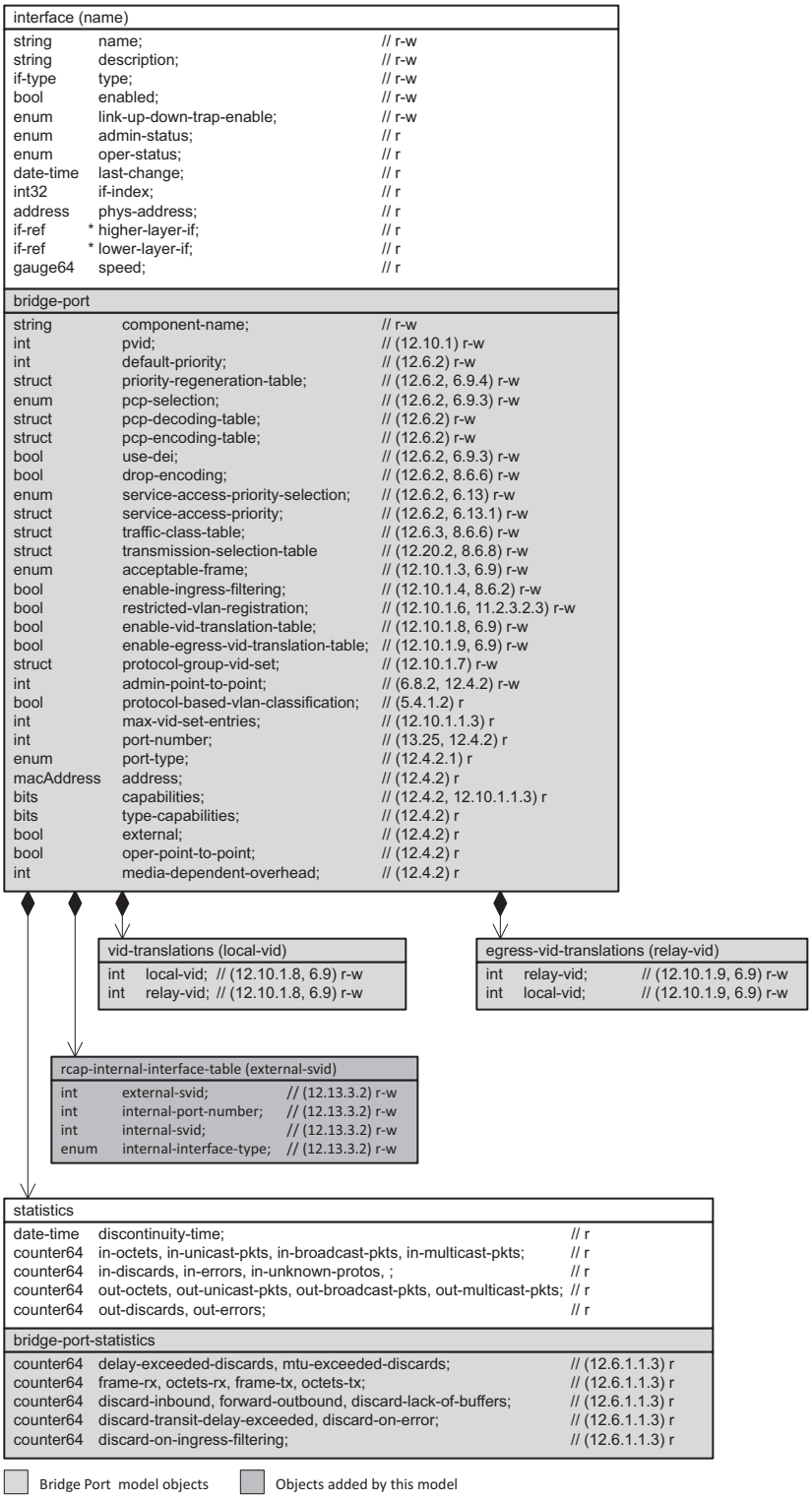


Figure 48-10—Provider Edge Bridge S-VLAN Interface model

48.2.5 CFM Model

The CFM UML data model is composed of the following set of major objects:

— The **Maintenance Domain** object is associated with a device (e.g., Bridge). It contains information used to identify the maintenance domain used to bind/contain Maintenance Association objects.

— The **Maintenance Association** objects are contained within a Maintenance Domain object. They contain maintenance point information related to the service instance being monitored.

— The **Maintenance Group** objects provide a convenient binding of a Maintenance Association object with a Maintenance Domain object.

— The **Maintenance association Endpoint** (MEP) object is associated with an Interface (e.g., Bridge Port) and a Maintenance Association Group object. It contains all information to manage a CFM entity, associated with a specific DoSAP of a service instance, which can generate and receive CFM PDUs and track any responses.

— The **Maintenance domain Intermediate Point** (MIP) object is associated with an Interface (e.g., Bridge Port) and a service (e.g., VID) to allow the explicit creation of an MHF.

— The **CFM Stack** object is associated with a device (e.g., Bridge). It contains information about maintenance points on a particular device Interface (e.g., Bridge Port or Aggregation Port).

— The **Default MD Level** object is associated with a device (e.g., Bridge) component. It contains MHF information needed for the creation of these functions on the services (e.g., VIDs) that are not attached to any Maintenance Association.

The **Configuration Error List** is associated with a device (e.g., Bridge). It contains configuration error information that is identifiable on a per-Interface (e.g., Bridge Port) and per-service (e.g., VID) basis.

The UML model representing the relationship between relevant Bridge objects to CFM objects is illustrated in Figure 48-11.

The CFM objects (e.g., cfm-stack, configuration-error-list, default-md-level, maintenance-domain) reference the device (i.e., Bridge and/or Bridge Component) to which they belong. This reference allows CFM objects to be associated with other types of devices (e.g., non-Bridges, end stations) where appropriate.

The Maintenance Group is modeled as a list that contains a convenient reference to a Maintenance Association object and its corresponding Maintenance Domain object. The identification of this collection of objects allows other CFM objects to more easily attach to a maintenance group and, in turn, simplifies configuration and operation retrieval procedures supported by the data model.

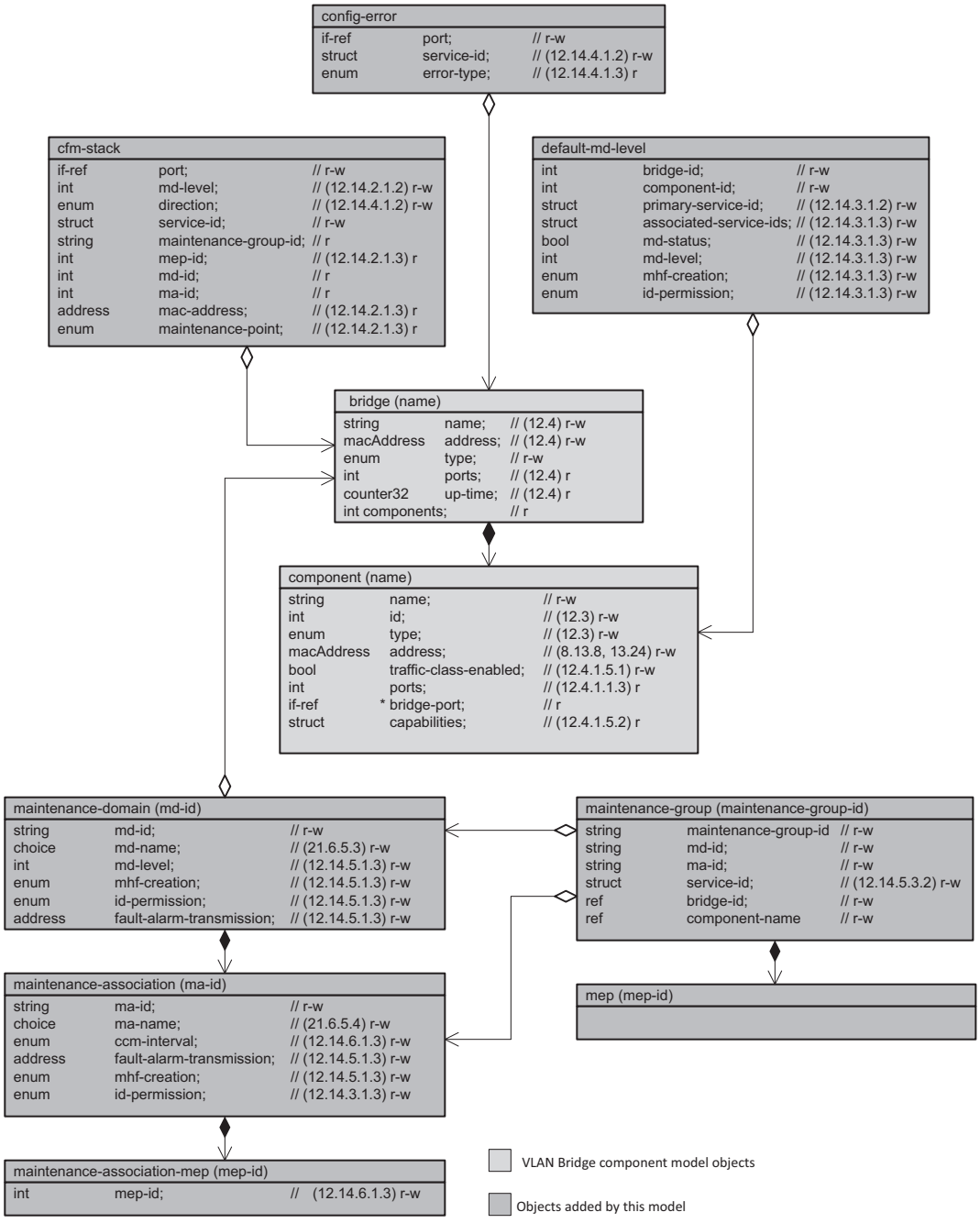


Figure 48-11—Bridge to CFM YANG model

As illustrated in Figure 48-12, MEP objects reference an Interface and are associated with a Maintenance Group. The interface relationship allows a MEP to be associated with a Bridge Port, as specified by this standard. This model also allows MEPs to be associated with other Interface types (for other devices).

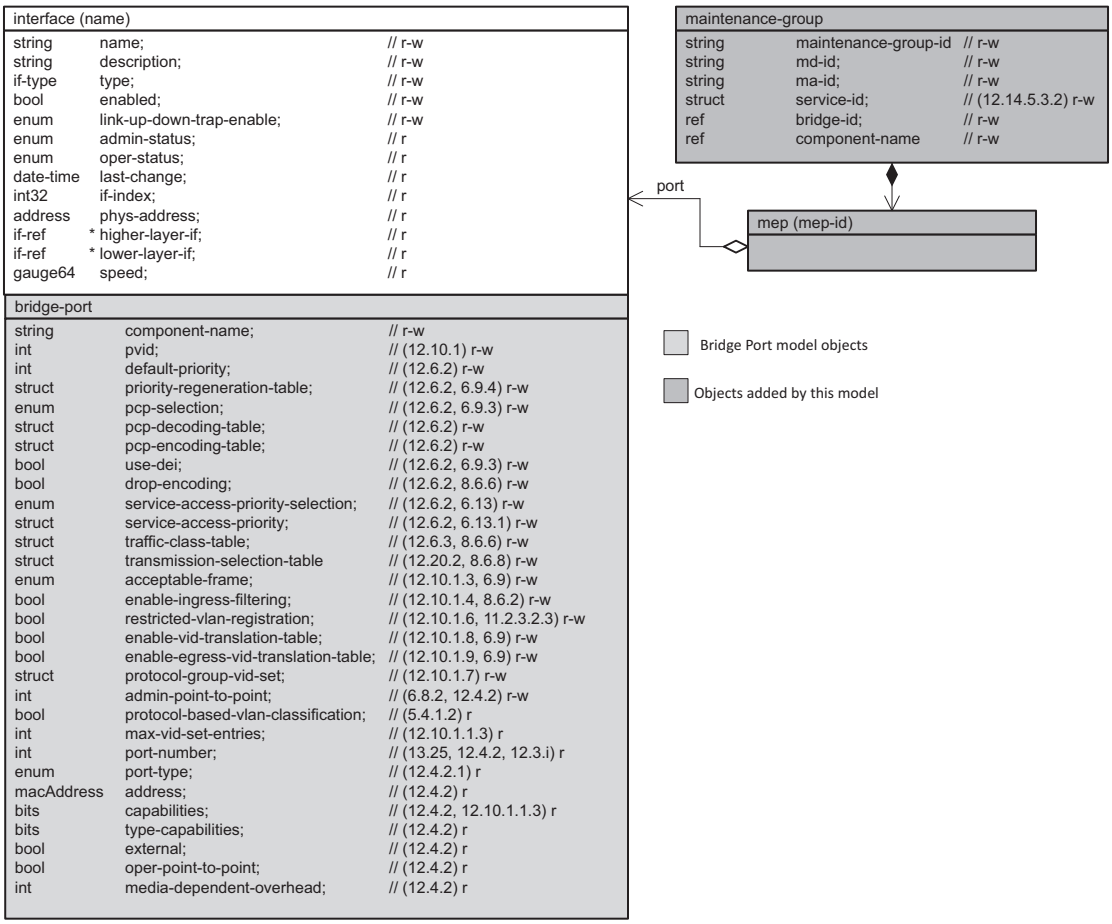


Figure 48-12—CFM MEP model relationships

The MEP object has relationships with other MEP-related objects. As illustrated in Figure 48-13, the CFM continuity check protocol suite-specific data needed to initiate protocol-specific sessions or maintain protocol-specific state information are grouped together. In addition, the MEP object will also reference the MEP CCM database and Stats objects.

48.2.5.1 CFM model support of CFM Operations

The CFM model also supports the initiation of Continuity Check, Loopback, and Linktrace protocol sessions. The general structure of the CFM session action data model is illustrated in Figure 48-14.

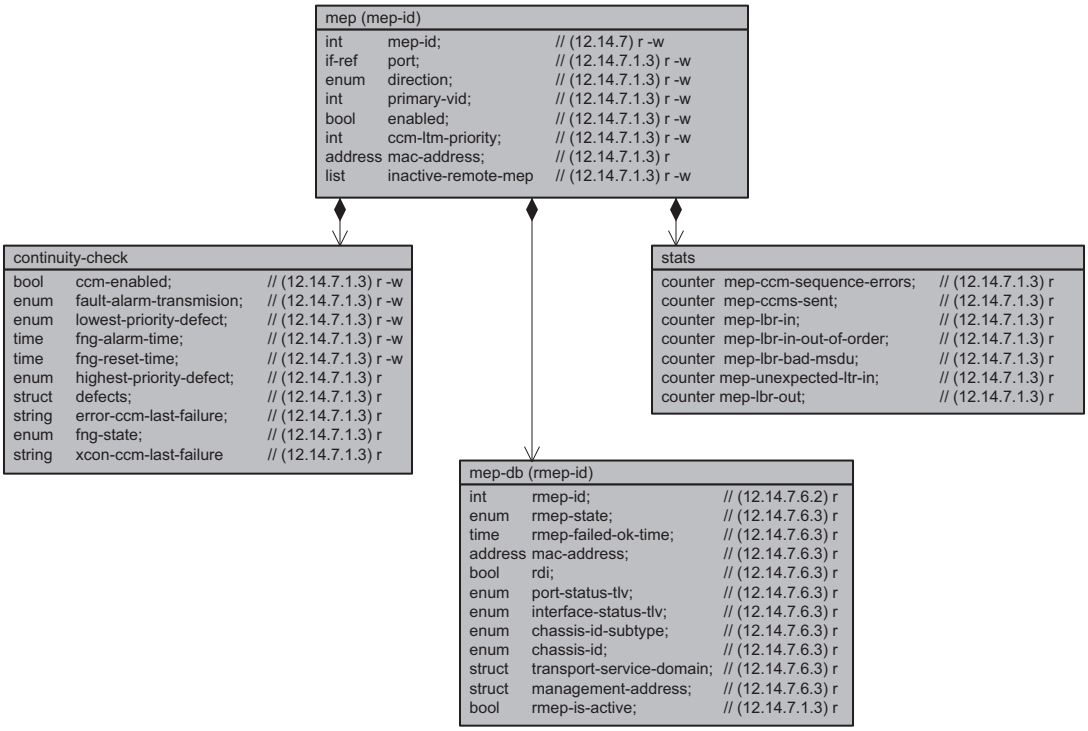


Figure 48-13—CFM MEP model

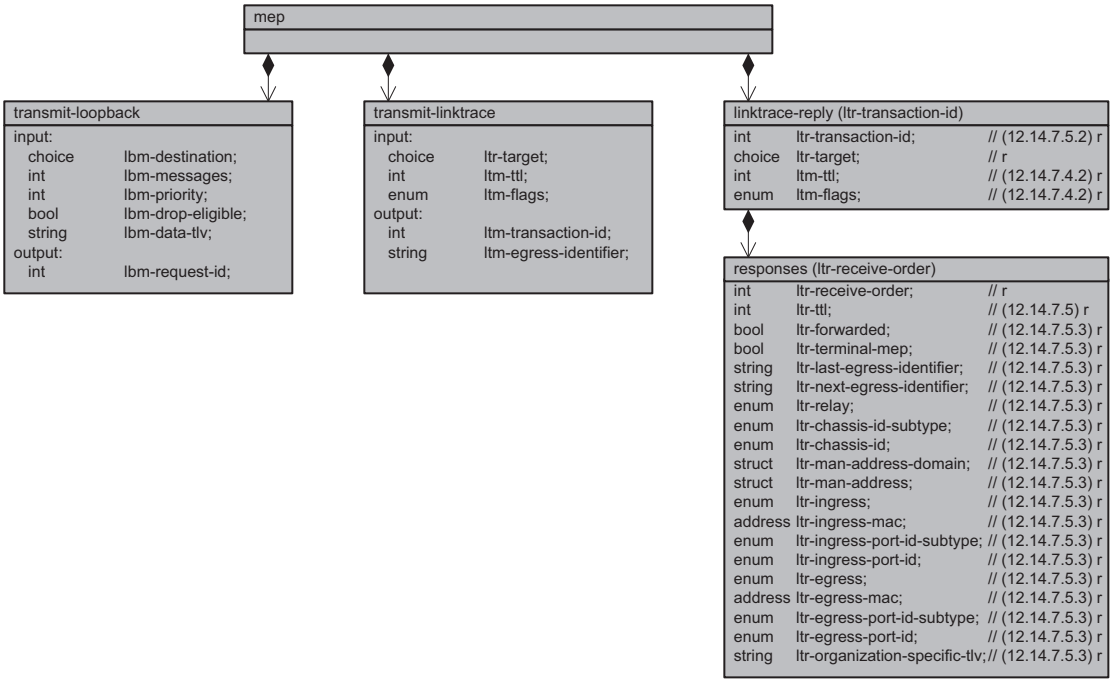


Figure 48-14—CFM operations structure

48.2.6 Stream filters and stream gates model

The stream filters and stream gates model augments the Bridge component model (48.3.1) by nodes that represent the following managed objects:

a) Stream Filter Instance Table (12.31.2)
b) Stream Gate Instance Table (12.31.3)

The UML representation of the stream filters and stream gates model is illustrated in Figure 48-15.

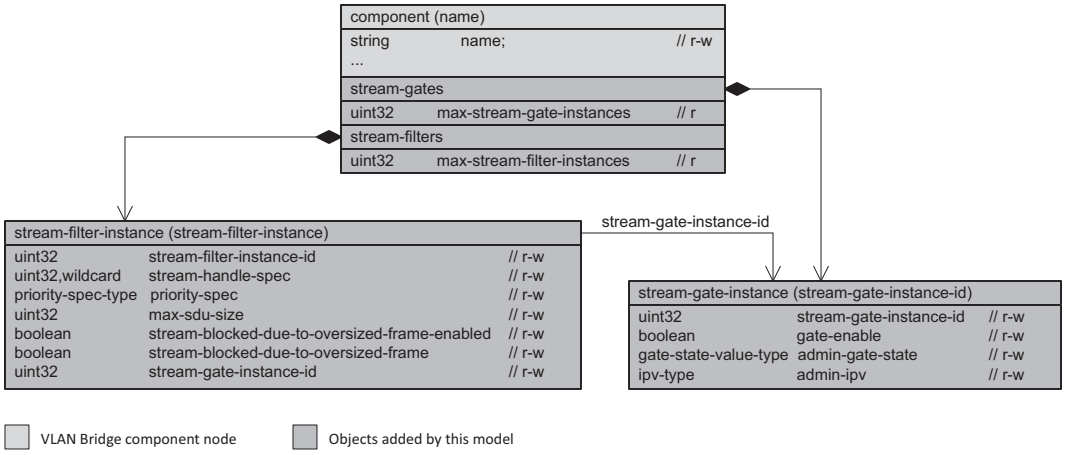


Figure 48-15—Stream filters and stream gates model

48.2.7 Asynchronous Traffic Shaping (ATS) model

The ATS model augments the Bridge component model (48.3.1) and the stream filters and stream gates model (48.3.6) by nodes that represent to following managed objects:

a) The Scheduler Instance Table (12.31.5)
b) The Scheduler Group Instance Table (12.31.6)
c) The Scheduler Port Parameter Table (12.31.7)
d) The Scheduler Timing Characteristics Table (12.31.8)
e) A Stream Filter specification type representing an ATS scheduler instance identifier (12.31.2.5)

The UML representation of the ATS model is illustrated in Figure 48-16.

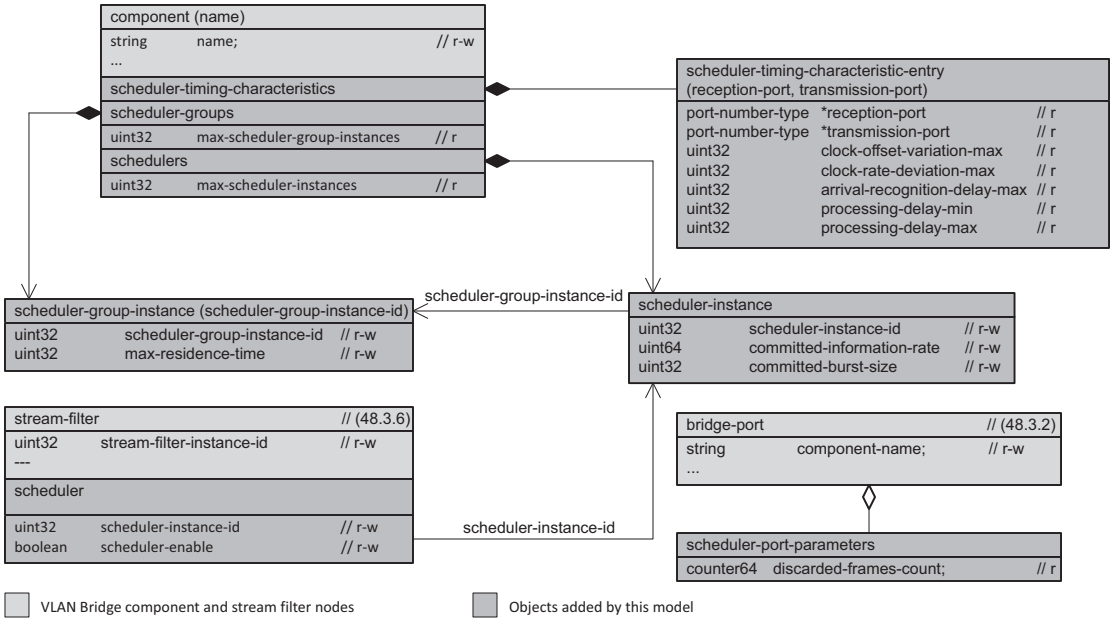


Figure 48-16—Asynchronous Traffic Shaping model

48.3 Structure of the YANG models

The YANG models specified by this standard use the YANG modules summarized in Table 48-1.[51]

In the YANG module definitions, if any discrepancy between the DESCRIPTION text and the corresponding definition in any other part of this standard occur, the definitions outside this clause (Clause 48) take precedence.

Table 48-1—Summary of the YANG modules

Module	References	Managed functionality	Initial YANG specification Notes
ieee802-types	48.6.1	Type definitions	IEEE Std 802.1Qcp General type definitions for IEEE 802 standards.
ieee802-dot1q-types	48.6.2	Type definitions	IEEE Std 802.1Qcp General type definitions used by IEEE Std 802.1Q.
ieee-802-dot1q-tsn-types	48.6.3	Type definitions	IEEE Std 802.1Qcp Type definitions and groupings for TSN user/network components.
ieee802-dot1q-bridge	48.5.4, 48.6.4	Clause 8	IEEE Std 802.1Qcp VLAN bridge component capabilities.
ieee802-dot1q-tpmr	48.5.5, 48.6.5	5.13, 5.15	IEEE Std 802.1Qcp TPMR augmentation of ieee802-dot1q-bridge.
ieee802-dot1q-pb	48.5.6, 48.6.6	Clause 20	IEEE Std 802.1Qcp Provider Bridge augmentation of ieee802-dot1q-bridge.
ieee802-dot1q-cfm-types	48.5.7, 48.6.7	Clause 20	IEEE Std 802.1Qcx General type definitions for CFM modules.
ieee802-dot1q-cfm	48.5.8, 48.6.8	Clause 20	IEEE Std 802.1Qcx Base CFM module defining Maintenance Domains, Maintenance Associations, Maintenance Groups, MEPs, and CFM session actions.
ieee802-dot1q-cfm-bridge	48.5.9, 48.6.9	Clause 20	IEEE Std 802.1Qcx Bridge and Bridge Port extension/ augmentation of ieee802-dot1q-cfm including CFM Stack, Default MD Levels, and Configuration Error Lists.
ieee802-dot1q-cfm-alarm	48.5.10, 48.6.10	Clause 20	IEEE Std 802.1Qcx Common CFM alarms, also supports alarms based on different frameworks (e.g., ietf-alarms).
ieee802-dot1q-stream-filters-gates	48.5.11, 48.6.11	8.6, 8.6.5.3, 8.6.5.4	IEEE Std 802.1Qcr Basic stream filtering and stream gating capabilities.
ieee802-dot1q-ats	48.5.12, 48.6.12	8.6	IEEE Std 802.1Qcr ATS extensions to ieee802-dot1q-stream-filters-gates and ieee802-dot1q-bridge modules.

The relationship between the models listed in 48.3 and the YANG modules listed in Table 48-1 is described in 48.4.1 through 48.4.5.

[51] An amendment's designation is often used to refer to functionality in an IEEE standard after the amendment has been incorporated in a revision of the standard, even if the functionality has been revised. The amendment that added each YANG module is identified to help locate the relevant provisions of this standard.

48.3.1 VLAN Bridge components model

This model provides basic bridging capabilities and allows for augmentation by specific YANG models (e.g., Two-Port MAC Relay model, Customer VLAN Bridge model, Provider Bridge model).

A system implementing the VLAN Bridge components model implements the YANG modules listed in Table 48-2.

48.3.2 Two-Port MAC Relay model

A system implementing the TPMR YANG model (48.3.2) implements the YANG modules listed in Table 48-3.

48.3.3 Customer VLAN Bridge model

A system implementing the Customer VLAN Bridge model (48.3.3) implements the YANG modules listed in Table 48-4.

48.3.4 Provider Bridge model

A system implementing the Provider Bridge model (48.3.4) implements the YANG modules listed in Table 48-5.

Table 48-2—VLAN Bridge component model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge

Table 48-3—Two-Port MAC Relay (TPMR) model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge
ieee802-dot1q-tpmr

Table 48-4—Customer VLAN Bridge model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge

Table 48-5—Provider Bridge model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge
ieee802-dot1q-pb

48.3.5 CFM model

A system implementing the CFM models (48.3.5) implements the YANG modules listed in Table 48-6.

48.3.6 Stream filters and stream gates model

The Stream filters and stream gates model (48.3.6) provides basic stream filter (8.6.5.3) and stream gate (8.6.5.4) capabilities and allows for augmentation by specific YANG models (e.g., the ATS model).A system implementing the stream filters and stream gates model implements the YANG modules as described in Table 48-7.

48.3.7 Asynchronous Traffic Shaping (ATS) model

A system implementing the ATS model (48.3.7) implements the YANG modules as described in Table 48-8.

Table 48-6—CFM model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-cfm-types
ieee802-dot1q-bridge
ieee802-dot1q-cfm
ieee802-dot1q-cfm-bridge
ieee802-dot1q-cfm-alarm

Table 48-7—Stream filters and stream gates model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge
ieee802-dot1q-stream-filters-gates

Table 48-8—ATS model YANG modules

YANG module
ieee802-types
ieee802-dot1q-types
ieee802-dot1q-bridge
ieee802-dot1q-stream-filters-gates
ieee802-dot1q-ats

48.4 Security considerations

The YANG modules defined in this clause are designed to be accessed via a network configuration protocol, e.g., NETCONF protocol (IETF RFC 6241 [B39]). In the case of NETCONF, the lowest NETCONF layer is the secure transport layer and the mandatory to implement secure transport is SSH (IETF RFC 6242 [B40]). The NETCONF access control model (IETF RFC 6536 [B41]) provides the means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operations and content.

It is the responsibility of a system's implementor and administrator to ensure that the protocol entities in the system that support NETCONF, and any other remote configuration protocols that make use of these YANG modules, are properly configured to allow access only to those principals (users) that have legitimate rights to read or write data nodes. This standard does not specify how the credentials of those users are to be stored or validated.

48.4.1 Security considerations of the VLAN Bridge components model

There are a number of management objects defined in the ieee802-dot1q-bridge YANG module that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF, can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation are possible.

The following objects in the ieee802-dot1q-bridge YANG module can be manipulated to interfere with the operation of VLANs and priority classes. This could, for example, be used to force a reinitialization of state machines, thus causing network instability, or to change the forwarding and filtering policies. Another possibility would be for an attacker to override established policy on Port priorities, thus giving a user (or an attacker) unauthorized preferential treatment.

interfaces/interface/bridge-port

interfaces/interface/bridge-port/priority-regeneration

interfaces/interface/bridge-port/transmission-selection-table

bridges/bridge/component/traffic-class-enabled

bridges/bridge/component/bridge-vlan/protocol-group-database

interfaces/interface/bridge-port/traffic-class

interfaces/interface/bridge-port/protocol-group-vid-set

a) The configurable object bridges/bridge/component/filtering-database/aging-time controls how fast dynamically learned forwarding information is aged out. Setting this object to a large value may simplify FDB overflow attacks. Setting this object to too small a value may compromise the throughput of the network by causing excessive flooding.
b) The configurable object bridges/bridge/component/filtering-database/filtering-entries/entry-type provides a filtering mechanism controlling which Ports frames originating from a specific source may be forwarded to. Write access to this table can be used to turn provisioned filtering off or to add filters to prevent rightful use of the network.

Some of the readable data in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control all types of access (e.g., including NETCONF get, get-config operations) to these objects and possibly to even encrypt the values of these objects when sending them over the network. These tables and objects and their sensitivity/vulnerability are described as follows:

— The object bridges/bridge/component/capabilities could be used by an attacker to determine which attacks might be useful to attempt against a given device.

— The readable objects defined in the ieee802-dot1q-bridge module provide information about the topology of a bridged network and the attached active stations. The addresses listed in the bridges/bridge/component/filtering-database/filtering-entries usually reveal information about the manufacturer of the MAC hardware, which can be useful information for mounting other specific attacks. In some networks, information about attached active stations can be considered personal identifying information about the user of the station. Unauthorized use of these objects can be considered a privacy threat.

48.4.2 Security considerations of the Two-Port MAC Relay model

There are a number of management objects defined in the ieee802-dot1q-tpmr YANG module that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF (IETF RFC 6241 [B39]), can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation are possible.

The following objects in the ieee802-dot1q-tpmr YANG module could be manipulated to interfere with the operation of MAC status propagation on a TPMR port and, for example, be used to cause network instability:

interfaces/interface/bridge-port/mac-status-propagation/link-notify

interfaces/interface/bridge-port/mac-status-propagation/link-notify-wait

interfaces/interface/bridge-port/mac-status-propagation/link-notify-retry

interfaces/interface/bridge-port/mac-status-propagation/mac-notify

interfaces/interface/bridge-port/mac-status-propagation/mac-notify-time

interfaces/interface/bridge-port/mac-status-propagation/mac-recover-time

48.4.3 Security considerations of the Customer VLAN Bridge model

The Customer VLAN Bridge YANG model is based on, and has the same security considerations as, the VLAN Bridge components model. See 48.4.1.

48.4.4 Security considerations of the Provider Bridge model

There are a number of management objects defined in the ieee802-dot1q-pb YANG module that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF (IETF RFC 6241 [B39]), can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation are possible.

The following objects in the ieee802-dot1q-pb YANG module can be manipulated to interfere with the operation of VLANs. This could, for example, be used to force a reinitialization of state machines, thus causing network instability, or to change the forwarding and filtering policies.

interfaces/interface/bridge-port

interfaces/interface/bridge-port/cvid-registration

interfaces/interface/bridge-port/service-priority-regeneration

48.4.5 Security considerations of the CFM model

There are a number of management objects defined in the ieee802-dot1q-cfm, ieee802-dot1q-cfm-bridge, and ieee802-dot1q-cfm-alarm YANG modules that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF (IETF RFC 6241 [B39]), can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation are possible.

The following objects in the ieee802-dot1q-cfm YANG module could be manipulated to interfere with the operation of a CFM port. This could, for example, be used to force a reinitialization of CFM state machines, thus causing network instability, or to change the management policies.

cfm/maintenance-domain

cfm/maintenance-group

See 48.4.1 for related ieee802-dot1q-bridge YANG model security considerations.

48.4.6 Security considerations of the Stream filters and stream gates model

There are a number of management objects defined in the ieee802-dot1q-stream-filters-gates YANG module that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF (IETF RFC 6241 [B39]), can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation are possible.

The following objects in the ieee802-dot1q-stream-filters-gates YANG module could be manipulated to interfere with the operation of stream filtering and gating. This could, for example, be used to force a reinitialization of PSFP or ATS state machines, thus causing network instability.

bridges/bridge/component/stream-filters

bridges/bridge/component/stream-gates

See 48.4.1 for related ieee802-dot1q-bridge YANG model security considerations.

48.4.7 Security considerations of the Asynchronous Traffic Shaping model

.There are a number of management objects defined in the ieee802-dot1q-ats YANG module that are configurable (i.e., read-write) and/or operational (i.e., read-only). Such objects may be considered sensitive or vulnerable in some network environments. A network configuration protocol, such as NETCONF (IETF RFC 6241 [B39]), can support protocol operations that can edit or delete YANG module configuration data (e.g., edit-config, delete-config, copy-config). If this is done in a non-secure environment without proper protection, then negative effects on the network operation is possible.

The following objects in the ieee802-dot1q-ats YANG module could be manipulated to interfere with the operation of stream filtering. This could, for example, be used to force a reinitialization of ATS state machines, thus causing network instability.

bridges/bridge/component/stream-filters

interfaces/interface/bridge-port/ats-port-parameters

bridges/bridge/component/schedulers

bridges/bridge/component/scheduler-groups

See 48.4.1 and 48.4.6 for related ieee802-dot1q-bridge and ieee802-dot1q-stream-filters-gates YANG model security considerations.

48.5 YANG schema tree definitions

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in these diagrams is as follows:

— Brackets “[“ and “]” enclose list keys.
— Abbreviations before data node names: “rw” means configuration (read-write), and “ro” means state data (read-only).
— Symbols after data node names: “?” means an optional node, “!” means a presence container, and “*” denotes a list and leaf-list.
— Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (“:”).
— Ellipsis (“...”) stands for contents of subtrees that are not shown.

48.5.1 Schema for the ieee802-types YANG module

This YANG module does not have a YANG schema tree.

48.5.2 Schema for the ieee802-dot1q-types YANG module

This YANG module does not have a YANG schema tree.

48.5.3 Schema for the ieee802-dot1q-tsn-types YANG module

This YANG module does not have a YANG schema tree.

48.5.4 Schema for the ieee802-dot1q-bridge YANG module

```
module: ieee802-dot1q-bridge
  +--rw bridges
     +--rw bridge* [name]
        +--rw name           dot1qtypes:name-type
        +--rw address        ieee:mac-address
        +--rw bridge-type    identityref
        +--ro ports?         uint16
        +--ro up-time?       yang:zero-based-counter32
        +--ro components?    uint32
        +--rw component* [name]
           +--rw name                      string
           +--rw id?                       uint32
           +--rw type                      identityref
           +--rw address?                  ieee:mac-address
           +--rw traffic-class-enabled?    boolean
           +--ro ports?                    uint16
           +--ro bridge-port*              if:interface-ref
           +--ro capabilities
           |  +--ro extended-filtering?             boolean
           |  +--ro traffic-classes?                boolean
           |  +--ro static-entry-individual-port?   boolean
           |  +--ro ivl-capable?                    boolean
           |  +--ro svl-capable?                    boolean
           |  +--ro hybrid-capable?                 boolean
           |  +--ro configurable-pvid-tagging?      boolean
           |  +--ro local-vlan-capable?             boolean
           +--rw filtering-database
           |  +--rw aging-time?                          uint32
           |  +--ro size?                                yang:gauge32
           |  +--ro static-entries?                      yang:gauge32
           |  +--ro dynamic-entries?                     yang:gauge32
           |  +--ro static-vlan-registration-entries?    yang:gauge32
           |  +--ro dynamic-vlan-registration-entries?   yang:gauge32
           |  +--ro mac-address-registration-entries?    yang:gauge32
{extended-filtering-services}?
           |  +--rw filtering-entry* [database-id vids address]
           |  |  +--rw database-id    uint32
```

```
|  |  +--rw address        ieee:mac-address
|  |  +--rw vids           dot1qtypes:vid-range-type
|  |  +--rw entry-type?    enumeration
|  |  +--rw port-map* [port-ref]
|  |  |  +--rw port-ref                                  port-number-type
|  |  |  +--rw (map-type)?
|  |  |     +--:(static-filtering-entries)
|  |  |     |  +--rw static-filtering-entries
|  |  |     |     +--rw control-element?         enumeration
|  |  |     |     +--rw connection-identifier?   port-number-type
|  |  |     +--:(static-vlan-registration-entries)
|  |  |     |  +--rw static-vlan-registration-entries
|  |  |     |     +--rw registrar-admin-control?   enumeration
|  |  |     |     +--rw vlan-transmitted?          enumeration
|  |  |     +--:(mac-address-registration-entries)
|  |  |     |  +--rw mac-address-registration-entries
|  |  |     |     +--rw control-element?   enumeration
|  |  |     +--:(dynamic-vlan-registration-entries)
|  |  |     |  +--rw dynamic-vlan-registration-entries
|  |  |     |     +--rw control-element?   enumeration
|  |  |     +--:(dynamic-reservation-entries)
|  |  |     |  +--rw dynamic-reservation-entries
|  |  |     |     +--rw control-element?   enumeration
|  |  |     +--:(dynamic-filtering-entries)
|  |  |        +--rw dynamic-filtering-entries
|  |  |           +--rw control-element?   enumeration
|  |  +--ro status?        enumeration
|  +--rw vlan-registration-entry* [database-id vids]
|     +--rw database-id    uint32
|     +--rw vids           dot1qtypes:vid-range-type
|     +--rw entry-type?    enumeration
|     +--rw port-map* [port-ref]
|        +--rw port-ref                                  port-number-type
|        +--rw (map-type)?
|           +--:(static-filtering-entries)
|           |  +--rw static-filtering-entries
|           |     +--rw control-element?         enumeration
|           |     +--rw connection-identifier?   port-number-type
|           +--:(static-vlan-registration-entries)
|           |  +--rw static-vlan-registration-entries
|           |     +--rw registrar-admin-control?   enumeration
|           |     +--rw vlan-transmitted?          enumeration
|           +--:(mac-address-registration-entries)
|           |  +--rw mac-address-registration-entries
|           |     +--rw control-element?   enumeration
|           +--:(dynamic-vlan-registration-entries)
|           |  +--rw dynamic-vlan-registration-entries
|           |     +--rw control-element?   enumeration
|           +--:(dynamic-reservation-entries)
|           |  +--rw dynamic-reservation-entries
|           |     +--rw control-element?   enumeration
|           +--:(dynamic-filtering-entries)
|              +--rw dynamic-filtering-entries
|                 +--rw control-element?   enumeration
+--rw permanent-database
|  +--ro size?                              yang:gauge32
|  +--ro static-entries?                    yang:gauge32
|  +--ro static-vlan-registration-entries?  yang:gauge32
|  +--rw filtering-entry* [database-id vids address]
|     +--rw database-id    uint32
|     +--rw address        ieee:mac-address
|     +--rw vids           dot1qtypes:vid-range-type
|     +--ro status?        enumeration
|     +--rw port-map* [port-ref]
|        +--rw port-ref                                  port-number-type
|        +--rw (map-type)?
|           +--:(static-filtering-entries)
|           |  +--rw static-filtering-entries
|           |     +--rw control-element?         enumeration
|           |     +--rw connection-identifier?   port-number-type
|           +--:(static-vlan-registration-entries)
|           |  +--rw static-vlan-registration-entries
```

```
            |           |     +--rw registrar-admin-control?   enumeration
            |           |     +--rw vlan-transmitted?          enumeration
            |           +--:(mac-address-registration-entries)
            |           |  +--rw mac-address-registration-entries
            |           |     +--rw control-element?   enumeration
            |           +--:(dynamic-vlan-registration-entries)
            |           |  +--rw dynamic-vlan-registration-entries
            |           |     +--rw control-element?   enumeration
            |           +--:(dynamic-reservation-entries)
            |           |  +--rw dynamic-reservation-entries
            |           |     +--rw control-element?   enumeration
            |           +--:(dynamic-filtering-entries)
            |              +--rw dynamic-filtering-entries
            |                 +--rw control-element?   enumeration
            +--rw bridge-vlan
            |  +--ro version?                   uint16
            |  +--ro max-vids?                  uint16
            |  +--ro override-default-pvid?     boolean
            |  +--ro protocol-template?         dot1qtypes:protocol-frame-format-type
{port-and-protocol-based-vlan}?
            |  +--ro max-msti?                  uint16
            |  +--rw vlan* [vid]
            |  |  +--rw vid               dot1qtypes:vlan-index-type
            |  |  +--rw name?             dot1qtypes:name-type
            |  |  +--ro untagged-ports*   if:interface-ref
            |  |  +--ro egress-ports*     if:interface-ref
            |  +--rw protocol-group-database* [db-index] {port-and-protocol-based-vlan}?
            |  |  +--rw db-index                uint16
            |  |  +--rw frame-format-type?      dot1qtypes:protocol-frame-format-type
            |  |  +--rw (frame-format)?
            |  |  |  +--:(ethernet-rfc1042-snap8021H)
            |  |  |  |  +--rw ethertype?         dot1qtypes:ethertype-type
            |  |  |  +--:(snap-other)
            |  |  |  |  +--rw protocol-id?       string
            |  |  |  +--:(llc-other)
            |  |  |     +--rw dsap-ssap-pairs
            |  |  |        +--rw llc-address?   string
            |  |  +--rw group-id?                uint32
            |  +--rw vid-to-fid-allocation* [vids]
            |  |  +--rw vids              dot1qtypes:vid-range-type
            |  |  +--ro fid?              uint32
            |  |  +--ro allocation-type?   enumeration
            |  +--rw fid-to-vid-allocation* [fid]
            |  |  +--rw fid                uint32
            |  |  +--ro allocation-type?   enumeration
            |  |  +--ro vid*               dot1qtypes:vlan-index-type
            |  +--rw vid-to-fid* [vid]
            |     +--rw vid    dot1qtypes:vlan-index-type
            |     +--rw fid?   uint32
            +--rw bridge-mst
               +--rw mstid*                     dot1qtypes:mstid-type
               +--rw fid-to-mstid* [fid]
               |  +--rw fid      uint32
               |  +--rw mstid?   dot1qtypes:mstid-type
               +--rw fid-to-mstid-allocation* [fids]
                  +--rw fids     dot1qtypes:vid-range-type
                  +--rw mstid?   dot1qtypes:mstid-type

  augment /if:interfaces/if:interface:
    +--rw bridge-port
       +--rw component-name?                          string
       +--rw port-type?                               identityref
       +--rw pvid?                                    dot1qtypes:vlan-index-type
       +--rw default-priority?                        dot1qtypes:priority-type
       +--rw priority-regeneration
       |  +--rw priority0?   priority-type
       |  +--rw priority1?   priority-type
       |  +--rw priority2?   priority-type
       |  +--rw priority3?   priority-type
       |  +--rw priority4?   priority-type
       |  +--rw priority5?   priority-type
       |  +--rw priority6?   priority-type
```

```
       |  +--rw priority7?   priority-type
       +--rw pcp-selection?                              dot1qtypes:pcp-selection-type
       +--rw pcp-decoding-table
       |  +--rw pcp-decoding-map* [pcp]
       |     +--rw pcp             pcp-selection-type
       |     +--rw priority-map* [priority-code-point]
       |        +--rw priority-code-point    priority-type
       |        +--rw priority?              priority-type
       |        +--rw drop-eligible?         boolean
       +--rw pcp-encoding-table
       |  +--rw pcp-encoding-map* [pcp]
       |     +--rw pcp             pcp-selection-type
       |     +--rw priority-map* [priority dei]
       |        +--rw priority               priority-type
       |        +--rw dei                    boolean
       |        +--rw priority-code-point?   priority-type
       +--rw use-dei?                                    boolean
       +--rw drop-encoding?                              boolean
       +--rw service-access-priority-selection?          boolean
       +--rw service-access-priority
       |  +--rw priority0?   priority-type
       |  +--rw priority1?   priority-type
       |  +--rw priority2?   priority-type
       |  +--rw priority3?   priority-type
       |  +--rw priority4?   priority-type
       |  +--rw priority5?   priority-type
       |  +--rw priority6?   priority-type
       |  +--rw priority7?   priority-type
       +--rw traffic-class
       |  +--rw traffic-class-map* [priority]
       |     +--rw priority                   priority-type
       |     +--rw available-traffic-class* [num-traffic-class]
       |        +--rw num-traffic-class    uint8
       |        +--rw traffic-class?       traffic-class-type
       +--rw transmission-selection-algorithm-table
       |  +--rw transmission-selection-algorithm-map* [traffic-class]
       |     +--rw traffic-class                    traffic-class-type
       |     +--rw transmission-selection-algorithm?   identityref
       +--rw acceptable-frame?                           enumeration
       +--rw enable-ingress-filtering?                   boolean
       +--rw enable-restricted-vlan-registration?        boolean
       +--rw enable-vid-translation-table?               boolean
       +--rw enable-egress-vid-translation-table?        boolean
       +--rw protocol-group-vid-set* [group-id] {port-and-protocol-based-vlan}?
       |  +--rw group-id    uint32
       |  +--rw vid*        dot1qtypes:vlanid
       +--rw admin-point-to-point?                       enumeration
       +--ro protocol-based-vlan-classification?         boolean
{port-and-protocol-based-vlan}?
      +--ro max-vid-set-entries?                      uint16 {port-and-protocol-based-vlan}?
       +--ro port-number?                                dot1qtypes:port-number-type
       +--ro address?                                    ieee:mac-address
       +--ro capabilities?                               bits
       +--ro type-capabilties?                           bits
       +--ro external?                                   boolean
       +--ro oper-point-to-point?                        boolean
       +--ro media-dependent-overhead?                   uint8
       +--ro statistics
       |  +--ro delay-exceeded-discards?          yang:counter64
       |  +--ro mtu-exceeded-discards?            yang:counter64
       |  +--ro frame-rx?                         yang:counter64
       |  +--ro octets-rx?                        yang:counter64
       |  +--ro frame-tx?                         yang:counter64
       |  +--ro octets-tx?                        yang:counter64
       |  +--ro discard-inbound?                  yang:counter64
       |  +--ro forward-outbound?                 yang:counter64
       |  +--ro discard-lack-of-buffers?          yang:counter64
       |  +--ro discard-transit-delay-exceeded?   yang:counter64
       |  +--ro discard-on-error?                 yang:counter64
       |  +--ro discard-on-ingress-filtering?     yang:counter64 {ingress-filtering}?
       +--rw vid-translations* [local-vid]
       |  +--rw local-vid    dot1qtypes:vlanid
```

```
      |  +--rw relay-vid?   dot1qtypes:vlanid
      +--rw egress-vid-translations* [relay-vid]
         +--rw relay-vid    dot1qtypes:vlanid
         +--rw local-vid?   dot1qtypes:vlanid
```

48.5.5 Schema for the ieee802-dot1q-tpmr YANG module

```
module: ieee802-dot1q-tpmr

  augment /if:interfaces/if:interface/dot1q:bridge-port:
    +--rw managed-address?          boolean
    +--rw mac-status-propagation
       +--rw link-notify?         boolean
       +--rw link-notify-wait?    yang:timeticks
       +--rw link-notify-retry?   yang:timeticks
       +--rw mac-notify?          boolean
       +--rw mac-notify-time?     yang:timeticks
       +--rw mac-recover-time?    yang:timeticks
  augment /if:interfaces/if:interface/dot1q:bridge-port/dot1q:statistics:
    +--ro acks-tx?                     yang:counter64
    +--ro add-notificatons-tx?         yang:counter64
    +--ro add-confirmations-tx?        yang:counter64
    +--ro loss-notification-tx?        yang:counter64
    +--ro loss-confirmation-tx?        yang:counter64
    +--ro acks-rx?                     yang:counter64
    +--ro add-notificatons-rx?         yang:counter64
    +--ro add-confirmations-rx?        yang:counter64
    +--ro loss-notification-rx?        yang:counter64
    +--ro loss-confirmation-rx?        yang:counter64
    +--ro add-events?                  yang:counter64
    +--ro loss-events?                 yang:counter64
    +--ro mac-status-notifications?    yang:counter64
```

48.5.6 Schema for the ieee802-dot1q-pb YANG module

```
module: ieee802-dot1q-pb

  augment /if:interfaces/if:interface/dot1q:bridge-port:
    +--rw svid?                              dot1qtypes:vlanid
    +--rw cvid-registration* [cvid]
    |  +--rw cvid            dot1qtypes:vlanid
    |  +--rw svid?           dot1qtypes:vlanid
    |  +--rw untagged-pep?   boolean
    |  +--rw untagged-cep?   boolean
    +--rw service-priority-regeneration* [svid]
    |  +--rw svid                      dot1qtypes:vlanid
    |  +--rw priority-regeneration
    |     +--rw priority0?   priority-type
    |     +--rw priority1?   priority-type
    |     +--rw priority2?   priority-type
    |     +--rw priority3?   priority-type
    |     +--rw priority4?   priority-type
    |     +--rw priority5?   priority-type
    |     +--rw priority6?   priority-type
    |     +--rw priority7?   priority-type
    +--rw rcap-internal-interface* [external-svid]
       +--rw external-svid              dot1qtypes:vlanid
       +--rw internal-port-number?      dot1qtypes:port-number-type
       +--rw internal-svid?             dot1qtypes:vlanid
       +--rw internal-interface-type?   enumeration
```

48.5.7 Schema for the ieee802-dot1q-cfm-types YANG module

This YANG module does not have a YANG schema tree.

48.5.8 Schema for the ieee802-dot1q-cfm YANG module

```
module: ieee802-dot1q-cfm
  +--rw cfm
     +--rw maintenance-domain* [md-id]
     |  +--rw md-id                                cfm-types:name-key-type
     |  +--rw (md-name)?
     |  |  +--:(none)
     |  |  |  +--rw none?                          empty
     |  |  +--:(dns-like-name)
     |  |  |  +--rw dns-like-name?                 string
     |  |  +--:(mac-address-and-uint)
     |  |  |  +--rw mac-address-and-uint-type
     |  |  |     +--rw address    ieee:mac-address
     |  |  |     +--rw int        uint16
     |  |  +--:(char-string)
     |  |     +--rw char-string?                   string
     |  +--rw md-level?                            cfm-types:md-level-type
     |  +--rw mhf-creation?                        cfm-types:mhf-creation-type
     |  +--rw id-permission?                       cfm-types:sender-id-permission-type
     |  +--rw fault-alarm-transmission?            cfm-types:fault-alarm-type
     |  +--rw maintenance-association* [ma-id]
     |     +--rw ma-id                            cfm-types:name-key-type
     |     +--rw (ma-name)
     |     |  +--:(primary-vid)
     |     |  |  +--rw primary-vid?                dot1q-types:vlanid
     |     |  +--:(char-string)
     |     |  |  +--rw char-string?                string
     |     |  +--:(unsigned-int16)
     |     |  |  +--rw unsigned-int16?             uint16
     |     |  +--:(rfc2865-vpn-id)
     |     |     +--rw vpn-id
     |     |        +--rw vpn-oui      uint32
     |     |        +--rw vpn-index    uint32
     |     +--rw ccm-interval?                    cfm-types:ccm-interval-type
     |     +--rw fault-alarm-transmission?        cfm-types:fault-alarm-type
     |     +--rw mhf-creation?                    cfm-types:mhf-creation-type
     |     +--rw id-permission?                   cfm-types:sender-id-permission-type
     |     +--rw maintenance-association-mep* [mep-id]
     |        +--rw mep-id    cfm-types:mep-id-type
     +--rw maintenance-group* [maintenance-group-id]
        +--rw maintenance-group-id    cfm-types:name-key-type
        +--rw md-id                   -> /cfm/maintenance-domain/md-id
        +--rw ma-id                   -> /cfm/maintenance-domain[md-id =
current()/../md-id]/maintenance-association/ma-id
        +--rw mep* [mep-id]
           +--rw mep-id                 -> /cfm/maintenance-domain[md-id =
current()/../../md-id]/maintenance-association[ma-id =
current()/../../ma-id]/maintenance-association-mep/mep-id
           +--rw direction              cfm-types:mp-direction-type
           +--rw enabled?               boolean
           +--rw ccm-ltm-priority?      dot1q-types:priority-type
           +--ro mac-address            ieee:mac-address
           +--rw inactive-remote-mep* [inactive-rmep-id]
           |  +--rw inactive-rmep-id    -> /cfm/maintenance-domain[md-id =
current()/../../../md-id]/maintenance-association[ma-id =
current()/../../../ma-id]/maintenance-association-mep/mep-id
           +--ro mep-db* [rmep-id]
           |  +--ro rmep-id                     cfm-types:mep-id-type
           |  +--ro rmep-state                  cfm-types:remote-mep-state-type
           |  +--ro rmep-failed-ok-time         yang:timeticks
           |  +--ro mac-address                 ieee:mac-address
           |  +--ro rdi                         boolean
           |  +--ro port-status-tlv?            cfm-types:port-status-tlv-value-type
           |  +--ro interface-status-tlv?       cfm-types:interface-status-tlv-value-type
           |  +--ro chassis-id-subtype?         ieee:chassis-id-subtype-type
           |  +--ro chassis-id?                 ieee:chassis-id-type
           |  +--ro transport-service-domain
           |  |  +--ro domain?                  yang:object-identifier-128
           |  |  +--ro (management-address)
           |  |     +--:(ip)
           |  |     |  +--ro ip-address         inet:ip-address
```

```
           |  |     |  +--ro ip-port            inet:port-number
           |  |     +--:(local)
           |  |     |  +--ro local-address      string
           |  |     +--:(dns)
           |  |     |  +--ro dns-address        string
           |  |     +--:(other)
           |  |        +--ro unknown-address?   binary
           |  +--ro rmep-is-active?             boolean
           +--rw continuity-check
           |  +--rw ccm-enabled?                boolean
           |  +--ro fng-state?                  cfm-types:fng-state-type
           |  +--rw fault-alarm-transmission?   cfm-types:fault-alarm-type
           |  +--rw lowest-priority-defect?     cfm-types:lowest-alarm-priority-type
           |  +--rw fng-alarm-time?             uint16
           |  +--rw fng-reset-time?             uint16
           |  +--ro highest-priority-defect     cfm-types:highest-defect-priority-type
           |  +--ro defects                     cfm-types:mep-defects-type
           |  +--ro error-ccm-last-failure?     binary
           |  +--ro xcon-ccm-last-failure?      binary
           +--ro stats
           |  +--ro mep-ccm-sequence-errors    yang:counter64
           |  +--ro mep-ccms-sent              yang:counter64
           |  +--ro mep-lbr-in                 yang:counter64
           |  +--ro mep-lbr-in-out-of-order    yang:counter64
           |  +--ro mep-lbr-bad-msdu           yang:counter64
           |  +--ro mep-unexpected-ltr-in      yang:counter64
           |  +--ro mep-lbr-out                yang:counter64
           +--ro linktrace-reply* [ltr-transaction-id]
           |  +--ro ltr-transaction-id    cfm-types:seq-number-type
           |  +--ro linktrace-input
           |  |  +--ro (ltr-target)
           |  |  |  +--:(target-ucast-mac-address)
           |  |  |  |  +--ro ltm-target-mac-address?   cfm-types:unicast-mac-address-type
           |  |  |  +--:(target-mep-id)
           |  |  |     +--ro ltm-target-mep-id?        cfm-types:mep-id-type
           |  |  +--ro ltm-ttl?                        uint8
           |  |  +--ro ltm-flags?                      cfm-types:mep-tx-ltm-flags-type
           |  +--ro responses* [ltr-receive-order]
           |     +--ro ltr-receive-order                uint32
           |     +--ro ltr-ttl                          uint8
           |     +--ro ltr-forwarded                    boolean
           |     +--ro ltr-terminal-mep                 boolean
           |     +--ro ltr-last-egress-identifier
           |     |  +--ro int        uint16
           |     |  +--ro address    ieee:mac-address
           |     +--ro ltr-next-egress-identifier
           |     |  +--ro int        uint16
           |     |  +--ro address    ieee:mac-address
           |     +--ro ltr-relay
cfm-types:relay-action-field-value-type
           |     +--ro ltr-chassis-id-subtype?          ieee:chassis-id-subtype-type
           |     +--ro ltr-chassis-id                   ieee:chassis-id-type
           |     +--ro ltr-transport-service-domain
           |     |  +--ro domain?                  yang:object-identifier-128
           |     |  +--ro (management-address)
           |     |     +--:(ip)
           |     |     |  +--ro ip-address         inet:ip-address
           |     |     |  +--ro ip-port            inet:port-number
           |     |     +--:(local)
           |     |     |  +--ro local-address      string
           |     |     +--:(dns)
           |     |     |  +--ro dns-address        string
           |     |     +--:(other)
           |     |        +--ro unknown-address?   binary
           |     +--ro ltr-ingress?
cfm-types:ingress-action-field-value-type
           |     +--ro ltr-ingress-mac                  ieee:mac-address
           |     +--ro ltr-ingress-port-id-subtype?     ieee:port-id-subtype-type
           |     +--ro ltr-ingress-port-id              ieee:port-id-type
           |     +--ro ltr-egress?
cfm-types:egress-action-field-value-type
           |     +--ro ltr-egress-mac                   ieee:mac-address
```

```
           |     +--ro ltr-egress-port-id-subtype?      ieee:port-id-subtype-type
           |     +--ro ltr-egress-port-id               ieee:port-id-type
           |     +--ro ltr-organization-specific-tlv?   binary
           +---x transmit-loopback
           |  +---w input
           |  |  +---w (lbm-destination)
           |  |  |  +--:(dest-ucast-mac-address)
           |  |  |  |  +---w lbm-dest-ucast-mac-address?
cfm-types:unicast-mac-address-type
           |  |  |  +--:(dest-mcast-class1-mac-address)
           |  |  |  |  +---w lbm-dest-mcast-class1-mac-address?
cfm-types:multicast-class1-mac-address-type
           |  |  |  +--:(dest-mep-id)
           |  |  |     +---w lbm-dest-mep-id?                    cfm-types:mep-id-type
           |  |  +---w lbm-messages?                             uint16
           |  |  +---w lbm-priority?                            dot1q-types:priority-type
           |  |  +---w lbm-drop-eligible?                        boolean
           |  |  +---w lbm-data-tlv?                           cfm-types:lbm-data-tlv-type
           |  +--ro output
           |     +--ro lbm-request-id    cfm-types:seq-number-type
           +---x transmit-linktrace
              +---w input
              |  +---w (ltr-target)
              |  |  +--:(target-ucast-mac-address)
              |  |  |  +---w ltm-target-mac-address?   cfm-types:unicast-mac-address-type
              |  |  +--:(target-mep-id)
              |  |     +---w ltm-target-mep-id?        cfm-types:mep-id-type
              |  +---w ltm-ttl?                         uint8
              |  +---w ltm-flags?                       cfm-types:mep-tx-ltm-flags-type
              +--ro output
                 +--ro ltm-transaction-id       cfm-types:seq-number-type
                 +--ro ltm-egress-identifier
                    +--ro int        uint16
                    +--ro address    ieee:mac-address
```

48.5.9 Schema for the ieee802-dot1q-cfm-bridge YANG module

```
module: ieee802-dot1q-cfm-bridge

  augment /dot1q-cfm:cfm:
    +--ro cfm-stack* [port service-selector service-id md-level direction]
    |  +--ro port                   port-ref
    |  +--ro md-level               cfm-types:md-level-type
    |  +--ro direction              cfm-types:mp-direction-type
    |  +--ro service-selector       cfm-types:service-selector-type
    |  +--ro service-id             cfm-types:service-selector-value-type
    |  +--ro maintenance-group-id    ->
/dot1q-cfm:cfm/maintenance-group/maintenance-group-id
    |  +--ro mep-id                 ->
/dot1q-cfm:cfm/maintenance-group[dot1q-cfm:maintenance-group-id =
current()/../maintenance-group-id]/mep/mep-id
    |  +--ro md-id?                 -> /dot1q-cfm:cfm/maintenance-domain/md-id
    |  +--ro ma-id?                -> /dot1q-cfm:cfm/maintenance-domain[dot1q-cfm:md-id =
current()/../md-id]/maintenance-association/ma-id
    |  +--ro mac-address            ieee:mac-address
    |  +--ro maintenance-point      cfm-types:mp-type
    +--rw default-md-level* [bridge-id component-id service-selector primary-service-id]
    |  +--rw bridge-id                bridge-ref
    |  +--rw component-id             -> /dot1q:bridges/bridge[dot1q:name =
current()/../bridge-id]/component/name
    |  +--rw service-selector         cfm-types:service-selector-type
    |  +--rw primary-service-id       cfm-types:service-selector-value-type
    |  +--rw associated-service-ids
    |  |  +--rw (service-id)?
    |  |     +--:(vids)
    |  |     |  +--rw vid* [vlan-id]
    |  |     |     +--rw vlan-id    dot1q-types:vlanid
    |  |     +--:(isid)
    |  |     |  +--rw isid?         uint32
    |  |     +--:(tesid)
    |  |     |  +--rw tesid?        uint32
```

```
    |  |     +--:(segid)
    |  |     |  +--rw segid?        uint32
    |  |     +--:(path-tesid)
    |  |     |  +--rw path-tesid?   uint32
    |  |     +--:(group-isid)
    |  |        +--rw group-isid?   uint32
    |  +--ro md-status                boolean
    |  +--rw md-level                 cfm-types:md-level-type
    |  +--rw mhf-creation?            cfm-types:mhf-creation-type
    |  +--rw id-permission?           cfm-types:sender-id-permission-type
    +--ro config-error* [port service-selector service-id]
       +--ro port               port-ref
       +--ro service-selector   cfm-types:service-selector-type
       +--ro service-id         cfm-types:service-selector-value-type
       +--ro error-type         cfm-types:config-error-type
  augment /dot1q-cfm:cfm/dot1q-cfm:maintenance-group:
    +--rw bridge-id?        bridge-ref
    +--rw component-name    -> /dot1q:bridges/bridge[dot1q:name =
current()/../cfm-bridge:bridge-id]/dot1q:component/name
    +--rw service-id
       +--rw (service-id)?
          +--:(vids)
          |  +--rw vid* [vlan-id]
          |     +--rw vlan-id    dot1q-types:vlanid
          +--:(isid)
          |  +--rw isid?         uint32
          +--:(tesid)
          |  +--rw tesid?        uint32
          +--:(segid)
          |  +--rw segid?        uint32
          +--:(path-tesid)
          |  +--rw path-tesid?   uint32
          +--:(group-isid)
             +--rw group-isid?   uint32
  augment /dot1q-cfm:cfm/dot1q-cfm:maintenance-group/dot1q-cfm:mep:
    +--rw port           port-ref
    +--rw primary-vid?   -> ../../service-id/vid/vlan-id
```

48.5.10 Schema for the ieee802-dot1q-cfm-alarm YANG module

```
module: ieee802-dot1q-cfm-alarm

  augment /dot1q-cfm:cfm/dot1q-cfm:maintenance-group/dot1q-cfm:mep:
    +---n mep-fault-alarm
       +--ro mep-priority-defect    ->
../../dot1q-cfm:continuity-check/highest-priority-defect
```

48.5.11 Schema for the ieee802-dot1q-stream-filters-gates YANG module

```
module: ieee802-dot1q-stream-filters-gates

  augment /dot1q:bridges/dot1q:bridge/dot1q:component:
    +--rw stream-filters
    |  +--rw stream-filter-instance-table* [stream-filter-instance-id]
    |  |  +--rw stream-filter-instance-id                       uint32
    |  |  +--rw (stream-handle-spec)?
    |  |  |  +--:(wildcard)
    |  |  |  |  +--rw wildcard?                                 empty
    |  |  |  +--:(stream-handle)
    |  |  |     +--rw stream-handle                             uint32
    |  |  +--rw priority-spec                                   priority-spec-type
    |  |  +--rw max-sdu-size                                    uint32
    |  |  +--rw stream-blocked-due-to-oversize-frame-enabled?   boolean
    |  |  +--rw stream-blocked-due-to-oversize-frame?           boolean
    |  |  +--rw stream-gate-ref                                 stream-gate-ref
    |  +--ro max-stream-filter-instances?    uint32
    +--rw stream-gates
       +--rw stream-gate-instance-table* [stream-gate-instance-id]
       |  +--rw stream-gate-instance-id    uint32
       |  +--rw gate-enable?               boolean
```

```
       |  +--rw admin-gate-states?         gate-state-value-type
       |  +--rw admin-ipv?                 ipv-spec-type
       +--ro max-stream-gate-instances?    uint32
```

48.5.12 Schema for the ieee802-dot1q-ats YANG module

```
module: ieee802-dot1q-ats

  augment
/dot1q:bridges/dot1q:bridge/dot1q:component/sfsg:stream-filters/sfsg:stream-filter-instanc
e-table:
    +--rw scheduler
       +--rw scheduler-ref?      ats:scheduler-ref-type
       +--rw scheduler-enable?   boolean
  augment /if:interfaces/if:interface/dot1q:bridge-port:
    +--rw ats-port-parameters
       +--ro discarded-frames-count?   yang:counter64
  augment /dot1q:bridges/dot1q:bridge/dot1q:component:
    +--rw schedulers
    |  +--rw scheduler-instance-table* [scheduler-instance-id]
    |  |  +--rw scheduler-instance-id         uint32
    |  |  +--rw committed-information-rate    uint64
    |  |  +--rw committed-burst-size          uint32
    |  |  +--rw scheduler-group-ref           ats:scheduler-group-ref-type
    |  +--ro max-scheduler-instances?    uint32
    +--rw scheduler-groups
       +--rw scheduler-group-instance-table* [scheduler-group-instance-id]
       |  +--rw scheduler-group-instance-id    uint32
       |  +--rw max-residence-time             uint32
       +--ro max-scheduler-group-instances?      uint32
       +--rw scheduler-timing-characteristics
          +--ro scheduler-timing-characteristics-table* [reception-port transmission-port]
             +--ro reception-port                  dot1qtypes:port-number-type
             +--ro transmission-port               dot1qtypes:port-number-type
             +--ro clock-offset-variation-max      uint32
             +--ro clock-rate-deviation-max        uint32
             +--ro arrival-recognition-delay-max   uint32
             +--ro processing-delay-min            uint32
             +--ro processing-delay-max            uint32
```

48.6 YANG modules[52] [53] [54]

48.6.1 The ieee802-types YANG module

```
module ieee802-types {
  namespace urn:ieee:std:802.1Q:yang:ieee802-types;
  prefix ieee;
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This module contains a collection of generally useful derived data
    types for IEEE YANG models.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-05-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2021-08-25 {
    description
      "Published as part of IEEE Std 802.1ABcu";
    reference
      "IEEE Std 802.1AB-2016";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Second version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  revision 2018-03-07 {
    description
      "Published as part of IEEE Std 802.1Q-2018. Initial version.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
  }
  typedef mac-address {
    type string {
      pattern "[0-9a-fA-F]{2}(-[0-9a-fA-F]{2}){5}";
    }
    description
      "The mac-address type represents a MAC address in the canonical
      format and hexadecimal format specified by IEEE Std 802. The
      hexidecimal representation uses uppercase characters.";
```

[52] Copyright release for YANG: Users of this standard may freely reproduce the YANG modules contained in this standard so that they can be used for their intended purpose.

[53] An ASCII version of each YANG module is attached to the PDF of this standard and can also be obtained from the IEEE 802.1 Website at https://1.ieee802.org/yang-modules/.

[54] References in this standard's YANG module definitions are not clickable, as each module has been incorporated unchanged after development and verification using YANG tools.

```
    reference
      "3.1, 8.1 of IEEE Std 802-2014";
  }
  typedef chassis-id-subtype-type {
    type enumeration {
      enum chassis-component {
        value 1;
        description
          "Represents a chassis identifier based on the value of
          entPhysicalAlias object (defined in IETF RFC 2737) for a
          chassis component (i.e., an entPhysicalClass value of
          chassis(3))";
      }
      enum interface-alias {
        value 2;
        description
          "Represents a chassis identifier based on the value of ifAlias
          object (defined in IETF RFC 2863) for an interface on the
          containing chassis.";
      }
      enum port-component {
        value 3;
        description
          "Represents a chassis identifier based on the value of
          entPhysicalAlias object (defined in IETF RFC 2737) for a port
          or backplane component (i.e., entPhysicalClass value of
          port(10) or backplane(4)), within the containing chassis.";
      }
      enum mac-address {
        value 4;
        description
          "Represents a chassis identifier based on the value of a
          unicast source address (encoded in network byte order and IEEE
          802.3 canonical bit order), of a port on the containing
          chassis as defined in IEEE Std 802-2001.";
      }
      enum network-address {
        value 5;
        description
          "Represents a chassis identifier based on a network address,
          associated with a particular chassis. The encoded address is
          actually composed of two fields. The first field is a single
          octet, representing the IANA AddressFamilyNumbers value for
          the specific address type, and the second field is the network
          address value.";
      }
      enum interface-name {
        value 6;
        description
          "Represents a chassis identifier based on the value of ifName
          object (defined in IETF RFC 2863) for an interface on the
          containing chassis.";
      }
      enum local {
        value 7;
        description
          "Represents a chassis identifier based on a locally defined
          value.";
      }
    }
    description
      "The source of a chassis identifier.";
    reference
      "IEEE Std 802-2014;" +
      "IETF RFC 2737;" +
      "IETF RFC 2863";
  }
  typedef chassis-id-type {
    type string {
      length "1..255";
    }
    description
```

```
    "The format of a chassis identifier string. Objects of this type
    are always used with an associated lldp-chassis-is-subtype object,
    which identifies the format of the particular lldp-chassis-id
    object instance.

    If the associated lldp-chassis-id-subtype object has a value of
    chassis-component, then the octet string identifies a particular
    instance of the entPhysicalAlias object (defined in IETF RFC 2737)
    for a chassis component (i.e., an entPhysicalClass value of
    chassis(3)).

    If the associated lldp-chassis-id-subtype object has a value of
    interface-alias, then the octet string identifies a particular
    instance of the ifAlias object (defined in IETF RFC 2863) for an
    interface on the containing chassis. If the particular ifAlias
    object does not contain any values, another chassis identifier
    type should be used.

    If the associated lldp-chassis-id-subtype object has a value of
    port-component, then the octet string identifies a particular
    instance of the entPhysicalAlias object (defined in IETF RFC 2737)
    for a port or backplane component within the containing chassis.

    If the associated lldp-chassis-id-subtype object has a value of
    mac-address, then this string identifies a particular unicast
    source address (encoded in network byte order and IEEE 802.3
    canonical bit order), of a port on the containing chassis as
    defined in IEEE Std 802-2001.

    If the associated lldp-chassis-id-subtype object has a value of
    network-address, then this string identifies a particular network
    address, encoded in network byte order, associated with one or
    more ports on the containing chassis. The first octet contains the
    IANA Address Family Numbers enumeration value for the specific
    address type, and octets 2 through N contain the network address
    value in network byte order.

    If the associated lldp-chassis-id-subtype object has a value of
    interface-name, then the octet string identifies a particular
    instance of the ifName object (defined in IETF RFC 2863) for an
    interface on the containing chassis. If the particular ifName
    object does not contain any values, another chassis identifier
    type should be used.

    If the associated lldp-chassis-id-subtype object has a value of
    local, then this string identifies a locally assigned Chassis ID.";
  reference
    "IEEE Std 802-2014;" +
    "IETF RFC 2737;" +
    "IETF RFC 2863";
}
typedef port-id-subtype-type {
  type enumeration {
    enum interface-alias {
      value 1;
      description
        "Represents a port identifier based on the ifAlias MIB object,
        defined in IETF RFC 2863.";
    }
    enum port-component {
      value 2;
      description
        "Represents a port identifier based on the value of
        entPhysicalAlias (defined in IETF RFC 2737) for a port
        component (i.e., entPhysicalClass value of port(10)), within
        the containing chassis.";
    }
    enum mac-address {
      value 3;
      description
        "Represents a port identifier based on a unicast source
        address (encoded in network byte order and IEEE 802.3
```

```
          canonical bit order), which has been detected by the agent and
          associated with a particular port (IEEE Std 802-2001).";
      }
      enum network-address {
        value 4;
        description
          "Represents a port identifier based on a network address,
          detected by the agent and associated with a particular port.";
      }
      enum interface-name {
        value 5;
        description
          "Represents a port identifier based on the ifName MIB object,
          defined in IETF RFC 2863.";
      }
      enum agent-circuit-id {
        value 6;
        description
          "Represents a port identifier based on the agent-local
          identifier of the circuit (defined in RFC 3046), detected by
          the agent and associated with a particular port.";
      }
      enum local {
        value 7;
        description
          "Represents a port identifier based on a value locally
          assigned.";
      }
    }
    description
      "The source of a particular type of port identifier used in the
      LLDP YANG module.";
  }
  typedef port-id-type {
    type string {
      length "1..255";
    }
    description
      "The format of a port identifier string. Objects of this type are
      always used with an associated port-id-subtype object, which
      identifies the format of the particular lldp-port-id object
      instance.

      If the associated port-id-subtype object has a value of
      interface-alias, then the octet string identifies a particular
      instance of the ifAlias object (defined in IETF RFC 2863). If the
      particular ifAlias object does not contain any values, another
      port identifier type should be used.

      If the associated port-id-subtype object has a value of
      port-component, then the octet string identifies a particular
      instance of the entPhysicalAlias object (defined in IETF RFC 2737)
      for a port or backplane component.

      If the associated port-id-subtype object has a value of
      mac-address, then this string identifies a particular unicast
      source address (encoded in network byte order and IEEE 802.3
      canonical bit order) associated with the port (IEEE Std 802-2001).

      If the associated port-id-subtype object has a value of
      network-address, then this string identifies a network address
      associated with the port. The first octet contains the IANA
      AddressFamilyNumbers enumeration value for the specific address
      type, and octets 2 through N contain the networkAddress address
      value in network byte order.

      If the associated port-id-subtype object has a value of
      interface-name, then the octet string identifies a particular
      instance of the ifName object (defined in IETF RFC 2863). If the
      particular ifName object does not contain any values, another port
      identifier type should be used.
```

```
      If the associated port-id-subtype object has a value of
      agent-circuit-id, then this string identifies a agent-local
      identifier of the circuit (defined in RFC 3046).

      If the associated port-id-subtype object has a value of
      local, then this string identifies a locally assigned port ID.";
    reference
      "IEEE Std 802-2014;" +
      "IETF RFC 2737;" +
      "IETF RFC 2863," +
      "IETF RFC 3046";
  }
}
```

48.6.2 The ieee802-dot1q-types YANG module

```
module ieee802-dot1q-types {
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-types;
  prefix dot1q-types;
  import ietf-yang-types {
    prefix yang;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "Common types used within dot1Q-bridge modules.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Second version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  revision 2018-03-07 {
    description
      "Published as part of IEEE Std 802.1Q-2018. Initial version.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
  }
  identity dot1q-vlan-type {
    description
      "Base identity from which all 802.1Q VLAN tag types are derived
      from.";
  }
  identity c-vlan {
    base dot1q-vlan-type;
    description
      "An 802.1Q Customer VLAN, using the 81-00 EtherType";
    reference
      "5.5 of IEEE Std 802.1Q-2022";
  }
  identity s-vlan {
    base dot1q-vlan-type;
    description
      "An 802.1Q Service VLAN, using the 88-A8 EtherType originally
      introduced in 802.1ad, and incorporated into 802.1Q (2011)";
    reference
      "5.6 of IEEE Std 802.1Q-2022";
  }
  identity transmission-selection-algorithm {
    description
      "Specify the transmission selection algorithms of IEEE Std
```

```
    802.1Q-2022 Table 8-6";
}
identity strict-priority {
  base transmission-selection-algorithm;
  description
    "Indicates the strict priority transmission selection algorithm.";
  reference
    "Table 8-6 of IEEE Std 802.1Q-2022";
}
identity credit-based-shaper {
  base transmission-selection-algorithm;
  description
    "Indicates the credit based shaper transmission selection
    algorithm.";
  reference
    "Table 8-6 of IEEE Std 802.1Q-2022";
}
identity enhanced-transmission-selection {
  base transmission-selection-algorithm;
  description
    "Indicates the enhanced transmission selection algorithm.";
  reference
    "Table 8-6 of IEEE Std 802.1Q-2022";
}
identity asynchronous-traffic-shaping {
  base transmission-selection-algorithm;
  description
    "Indicates the asynchronous transmission selection algorithm.";
  reference
    "Table 8-6 of IEEE Std 802.1Q-2022";
}
identity vendor-specific {
  base transmission-selection-algorithm;
  description
    "Indicates a vendor specific transmission selection algorithm.";
  reference
    "Table 8-6 of IEEE Std 802.1Q-2022";
}
typedef name-type {
  type string {
    length "0..32";
  }
  description
    "A text string of up to 32 characters, of locally determined
    significance.";
}
typedef port-number-type {
  type uint32 {
    range "1..4095";
  }
  description
    "The port number of the Bridge port for which this entry contains
    Bridge management information.";
}
typedef priority-type {
  type uint8 {
    range "0..7";
  }
  description
    "A range of priorities from 0 to 7 (inclusive). The Priority Code
    Point (PCP) is a 3-bit field that refers to the class of service
    associated with an 802.1Q VLAN tagged frame. The field specifies a
    priority value between 0 and 7, these values can be used by
    quality of service (QoS) to prioritize different classes of
    traffic.";
}
typedef vid-range-type {
  type string {
    pattern
      "([1-9]"+
      "[0-9]{0,3}"+
      "(-[1-9][0-9]{0,3})?"+
```

```
      "(,[1-9][0-9]{0,3}(-[1-9][0-9]{0,3})?)*)";
  }
  description
    "A list of VLAN Ids, or non overlapping VLAN ranges, in ascending
    order, between 1 and 4094.

    This type is used to match an ordered list of VLAN Ids, or
    contiguous ranges of VLAN Ids. Valid VLAN Ids must be in the range
    1 to 4094, and included in the list in non overlapping ascending
    order.

    For example: 1,10-100,250,500-1000";
}
typedef vlanid {
  type uint16 {
    range "1..4094";
  }
  description
    "The vlanid type uniquely identifies a VLAN. This is the 12-bit
    VLAN-ID used in the VLAN Tag header. The range is defined by the
    referenced specification. This type is in the value set and its
    semantics equivalent to the VlanId textual convention of the
    SMIv2.";
}
typedef vlan-index-type {
  type uint32 {
    range "1..4094 | 4096..4294967295";
  }
  description
    "A value used to index per-VLAN tables. Values of 0 and 4095 are
    not permitted. The range of valid VLAN indices. If the value is
    greater than 4095, then it represents a VLAN with scope local to
    the particular agent, i.e., one without a global VLAN-ID assigned
    to it. Such VLANs are outside the scope of IEEE 802.1Q, but it is
    convenient to be able to manage them in the same way using this
    YANG module.";
  reference
    "9.6 of IEEE Std 802.1Q-2022";
}
typedef mstid-type {
  type uint32 {
    range "1..4094";
  }
  description
    "In an MSTP Bridge, an MSTID, i.e., a value used to identify a
    spanning tree (or MST) instance";
  reference
    "13.8 of IEEE Std 802.1Q-2022";
}
typedef pcp-selection-type {
  type enumeration {
    enum 8P0D {
      description
        "8 priorities, 0 drop eligible";
    }
    enum 7P1D {
      description
        "7 priorities, 1 drop eligible";
    }
    enum 6P2D {
      description
        "6 priorities, 2 drop eligible";
    }
    enum 5P3D {
      description
        "5 priorities, 3 drop eligible";
    }
  }
  description
    "Priority Code Point selection types.";
  reference
    "12.6.2.5.3, 6.9.3 of IEEE Std 802.1Q-2022";
```

```
}
typedef protocol-frame-format-type {
  type enumeration {
    enum Ethernet {
      description
        "Ethernet frame format";
    }
    enum rfc1042 {
      description
        "RFC 1042 frame format";
    }
    enum snap8021H {
      description
        "SNAP 802.1H frame format";
    }
    enum snapOther {
      description
        "Other SNAP frame format";
    }
    enum llcOther {
      description
        "Other LLC frame format";
    }
  }
  description
    "A value representing the frame format to be matched.";
  reference
    "12.10.1.7.1 of IEEE Std 802.1Q-2022";
}
typedef ethertype-type {
  type string {
    pattern "[0-9a-fA-F]{2}-[0-9a-fA-F]{2}";
  }
  description
    "The EtherType value represented in the canonical order defined by
    IEEE 802. The canonical representation uses uppercase characters.";
  reference
    "9.2 of IEEE Std 802-2014";
}
typedef dot1q-tag-type {
  type identityref {
    base dot1q-vlan-type;
  }
  description
    "Identifies a specific 802.1Q tag type";
  reference
    "9.5 IEEE Std 802.1Q-2022";
}
typedef traffic-class-type {
  type uint8 {
    range "0..7";
  }
  description
    "This is the numerical value associated with a traffic class in a
    Bridge. Larger values are associated with higher priority traffic
    classes.";
  reference
    "3.273 of IEEE Std 802.1Q-2022";
}
grouping dot1q-tag-classifier-grouping {
  description
    "A grouping which represents an 802.1Q VLAN, matching both the
    EtherType and a single VLAN Id.";
  leaf tag-type {
    type dot1q-tag-type;
    mandatory true;
    description
      "VLAN type";
  }
  leaf vlan-id {
    type vlanid;
    mandatory true;
```

```
    description
      "VLAN Id";
  }
}
grouping dot1q-tag-or-any-classifier-grouping {
  description
    "A grouping which represents an 802.1Q VLAN, matching both the
    EtherType and a single VLAN Id or 'any' to match on any VLAN Id.";
  leaf tag-type {
    type dot1q-tag-type;
    mandatory true;
    description
      "VLAN type";
  }
  leaf vlan-id {
    type union {
      type vlanid;
      type enumeration {
        enum any {
          value 4095;
          description
            "Matches 'any' VLAN in the range 1 to 4094 that is not
            matched by a more specific VLAN Id match";
        }
      }
    }
    mandatory true;
    description
      "VLAN Id or any";
  }
}
grouping dot1q-tag-ranges-classifier-grouping {
  description
    "A grouping which represents an 802.1Q VLAN that matches a range
    of VLAN Ids.";
  leaf tag-type {
    type dot1q-tag-type;
    mandatory true;
    description
      "VLAN type";
  }
  leaf vlan-ids {
    type vid-range-type;
    mandatory true;
    description
      "VLAN Ids";
  }
}
grouping dot1q-tag-ranges-or-any-classifier-grouping {
  description
    "A grouping which represents an 802.1Q VLAN, matching both the
    EtherType and a single VLAN Id, ordered list of ranges, or 'any'
    to match on any VLAN Id.";
  leaf tag-type {
    type dot1q-tag-type;
    mandatory true;
    description
      "VLAN type";
  }
  leaf vlan-id {
    type union {
      type vid-range-type;
      type enumeration {
        enum any {
          value 4095;
          description
            "Matches 'any' VLAN in the range 1 to 4094.";
        }
      }
    }
    mandatory true;
    description
```

```
      "VLAN Ids or any";
  }
}
grouping priority-regeneration-table-grouping {
  description
    "The priority regeneration table provides the ability to map
    incoming priority values on a per-Port basis, under management
    control.";
  reference
    "6.9.4 of IEEE Std 802.1Q-2022";
  leaf priority0 {
    type priority-type;
    default "0";
    description
      "Priority 0";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority1 {
    type priority-type;
    default "1";
    description
      "Priority 1";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority2 {
    type priority-type;
    default "2";
    description
      "Priority 2";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority3 {
    type priority-type;
    default "3";
    description
      "Priority 3";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority4 {
    type priority-type;
    default "4";
    description
      "Priority 4";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority5 {
    type priority-type;
    default "5";
    description
      "Priority 5";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority6 {
    type priority-type;
    default "6";
    description
      "Priority 6";
    reference
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
  leaf priority7 {
    type priority-type;
    default "7";
    description
      "Priority 7";
    reference
```

```
      "12.6.2.3, 6.9.4 of IEEE Std 802.1Q-2022";
  }
}
grouping pcp-decoding-table-grouping {
  description
    "The Priority Code Point decoding table enables the decoding of
    the priority and drop-eligible parameters from the PCP.";
  reference
    "6.9.3 of IEEE Std 802.1Q-2022";
  list pcp-decoding-map {
    key "pcp";
    description
      "This map associates the priority code point field found in the
      VLAN to a priority and drop eligible value based upon the
      priority code point selection type.";
    leaf pcp {
      type pcp-selection-type;
      description
        "The priority code point selection type.";
      reference
        "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
    }
    list priority-map {
      key "priority-code-point";
      description
        "This map associated a priority code point value to priority
        and drop eligible parameters.";
      leaf priority-code-point {
        type priority-type;
        description
          "Priority associated with the pcp.";
        reference
          "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
      }
      leaf priority {
        type priority-type;
        description
          "Priority associated with the pcp.";
        reference
          "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
      }
      leaf drop-eligible {
        type boolean;
        description
          "Drop eligible value for pcp";
        reference
          "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
      }
    }
  }
}
grouping pcp-encoding-table-grouping {
  description
    "The Priority Code Point encoding table encodes the priority and
    drop-eligible parameters in the PCP field of the VLAN tag.";
  reference
    "12.6.2.9, 6.9.3 of IEEE Std 802.1Q-2022";
  list pcp-encoding-map {
    key "pcp";
    description
      "This map associated the priority and drop-eligible parameters
      to the priority used to encode the PCP of the VLAN based upon
      the priority code point selection type.";
    leaf pcp {
      type pcp-selection-type;
      description
        "The priority code point selection type.";
      reference
        "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
    }
    list priority-map {
      key "priority dei";
```

```
      description
        "This map associated the priority and drop-eligible parameters
        to the priority code point field of the VLAN tag.";
      leaf priority {
        type priority-type;
        description
          "Priority associated with the pcp.";
        reference
          "12.6.2.7, 6.9.3 of IEEE Std 802.1Q-2022";
      }
      leaf dei {
        type boolean;
        description
          "The drop eligible value.";
        reference
          "12.6.2, 8.6.6 of IEEE Std 802.1Q-2022";
      }
      leaf priority-code-point {
        type priority-type;
        description
          "PCP value for priority when DEI value";
        reference
          "12.6.2.9, 6.9.3 of IEEE Std 802.1Q-2022";
      }
    }
  }
}
grouping service-access-priority-table-grouping {
  description
    "The Service Access Priority Table associates a received priority
    with a serice access priority.";
  reference
    "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
  leaf priority0 {
    type priority-type;
    default "0";
    description
      "Service access priority value for priority 0";
    reference
      "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
  }
  leaf priority1 {
    type priority-type;
    default "1";
    description
      "Service access priority value for priority 1";
    reference
      "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
  }
  leaf priority2 {
    type priority-type;
    default "2";
    description
      "Service access priority value for priority 2";
    reference
      "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
  }
  leaf priority3 {
    type priority-type;
    default "3";
    description
      "Service access priority value for priority 3";
    reference
      "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
  }
  leaf priority4 {
    type priority-type;
    default "4";
    description
      "Service access priority value for priority 4";
    reference
      "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
```

```
    }
    leaf priority5 {
      type priority-type;
      default "5";
      description
        "Service access priority value for priority 5";
      reference
        "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
    }
    leaf priority6 {
      type priority-type;
      default "6";
      description
        "Service access priority value for priority 6";
      reference
        "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
    }
    leaf priority7 {
      type priority-type;
      default "7";
      description
        "Service access priority value for priority 7";
      reference
        "12.6.2.17, 6.13.1 of IEEE Std 802.1Q-2022";
    }
  }
  grouping traffic-class-table-grouping {
    description
      "The Traffic Class Table models the operations that can be
      performed on, or inquire about, the current contents of the
      Traffic Class Table (8.6.6) for a given Port.";
    reference
      "12.6.3, 8.6.6 of IEEE Std 802.1Q-2022";
    list traffic-class-map {
      key "priority";
      description
        "The priority index into the traffic class table.";
      leaf priority {
        type priority-type;
        description
          "The priority of the traffic class entry.";
        reference
          "8.6.6 of IEEE Std 802.1Q-2022";
      }
      list available-traffic-class {
        key "num-traffic-class";
        description
          "The traffic class index associated with a given priority
          within the traffic class table.";
        reference
          "8.6.6 of IEEE Std 802.1Q-2022";
        leaf num-traffic-class {
          type uint8 {
            range "1..8";
          }
          description
            "The available number of traffic classes.";
          reference
            "8.6.6 of IEEE Std 802.1Q-2022";
        }
        leaf traffic-class {
          type traffic-class-type;
          description
            "The traffic class index associated with a given traffic
            class entry.";
          reference
            "8.6.6 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
  grouping transmission-selection-table-grouping {
```

```
    description
      "The Transmission Selection Algorithm Table models the operations
      that can be performed on, or inquire about, the current contents
      of the Transmission Selection Algorithm Table (12.20.2) for a
      given Port.";
    reference
      "12.20.2, 8.6.8 of IEEE Std 802.1Q-2022";
    list transmission-selection-algorithm-map {
      key "traffic-class";
      description
        "The traffic class to index into the transmission selection
        table.";
      leaf traffic-class {
        type traffic-class-type;
        description
          "The traffic class of the entry.";
        reference
          "8.6.6 of IEEE Std 802.1Q-2022";
      }
      leaf transmission-selection-algorithm {
        type identityref {
          base dot1q-types:transmission-selection-algorithm;
        }
        description
          "Transmission selection algorithm";
        reference
          "8.6.8, Table 8-6 of IEEE Std 802.1Q-2022";
      }
    }
  }
  grouping port-map-grouping {
    description
      "A set of control indicators, one for each Port. A Port Map,
      containing a control element for each outbound Port";
    reference
      "8.8.1, 8.8.2 of IEEE Std 802.1Q-2022";
    list port-map {
      key "port-ref";
      description
        "The list of entries composing the port map.";
      leaf port-ref {
        type port-number-type;
        description
          "The interface port reference associated with this map.";
        reference
          "8.8.1 of IEEE Std 802.1Q-2022";
      }
      choice map-type {
        description
          "Type of port map";
        container static-filtering-entries {
          description
            "Static filtering entries attributes.";
          leaf control-element {
            type enumeration {
              enum forward {
                description
                  "Forwarded, independently of any dynamic filtering
                  information held by the FDB.";
              }
              enum filter {
                description
                  "Filtered, independently of any dynamic filtering
                  information.";
              }
              enum forward-filter {
                description
                  "Forwarded or filtered on the basis of dynamic
                  filtering information, or on the basis of the default
                  Group filtering behavior for the outbound Port (8.8.6)
                  if no dynamic filtering information is present
                  specifically for the MAC address.";
```

```
        }
      }
      description
        "containing a control element for each outbound Port,
        specifying that a frame with a destination MAC address,
        and in the case of VLAN Bridge components, VID that meets
        this specification.";
      reference
        "8.8.1 of IEEE Std 802.1Q-2022";
    }
    leaf connection-identifier {
      type port-number-type;
      description
        "A Port MAP may contain a connection identifier (8.8.12)
        for each outbound port. The connection identifier may be
        associated with the Bridge Port value maintained in a
        Dynamic Filtering Entry of the FDB for Bridge Ports.";
      reference
        "8.8.1, 8.8.12 of IEEE Std 802.1Q-2022";
    }
  }
  container static-vlan-registration-entries {
    description
      "Static VLAN registration entries.";
    leaf registrar-admin-control {
      type enumeration {
        enum fixed-new-ignored {
          description
            "Registration Fixed (New ignored).";
        }
        enum fixed-new-propagated {
          description
            "Registration Fixed (New propagated.";
        }
        enum forbidden {
          description
            "Registration Forbidden.";
        }
        enum normal {
          description
            "Normal Registration.";
        }
      }
      description
        "The Registrar Administrative Control values for MVRP and
        MIRP for the VID.";
      reference
        "8.8.2 of IEEE Std 802.1Q-2022";
    }
    leaf vlan-transmitted {
      type enumeration {
        enum tagged {
          description
            "VLAN-tagged";
        }
        enum untagged {
          description
            "VLAN-untagged";
        }
      }
      description
        "Whether frames are to be VLAN-tagged or untagged when
        transmitted.";
      reference
        "8.8.2 of IEEE Std 802.1Q-2022";
    }
  }
  container mac-address-registration-entries {
    description
      "MAC address registration entries attributes.";
    leaf control-element {
      type enumeration {
```

```
      enum registered {
        description
          "Forwarded, independently of any dynamic filtering
          information held by the FDB.";
      }
      enum not-registered {
        description
          "Filtered, independently of any dynamic filtering
          information.";
      }
    }
    description
      "containing a control element for each outbound Port,
      specifying that a frame with a destination MAC address,
      and in the case of VLAN Bridge components, VID that meets
      this specification.";
    reference
      "8.8.4 of IEEE Std 802.1Q-2022";
  }
}
container dynamic-vlan-registration-entries {
  description
    "Dynamic VLAN registration entries attributes.";
  leaf control-element {
    type enumeration {
      enum registered {
        description
          "Forwarded, independently of any dynamic filtering
          information held by the FDB.";
      }
    }
    description
      "containing a control element for each outbound Port,
      specifying that a frame with a destination MAC address,
      and in the case of VLAN Bridge components, VID that meets
      this specification.";
    reference
      "8.8.5 of IEEE Std 802.1Q-2022";
  }
}
container dynamic-reservation-entries {
  description
    "Dynamic reservation entries attributes.";
  leaf control-element {
    type enumeration {
      enum forward {
        description
          "Forwarded, independently of any dynamic filtering
          information held by the FDB.";
      }
      enum filter {
        description
          "Filtered, independently of any dynamic filtering
          information.";
      }
    }
    description
      "Containing a control element for each outbound Port,
      specifying that a frame with a destination MAC address,
      and in the case of VLAN Bridge components, VID that meets
      this specification.";
    reference
      "8.8.7 of IEEE Std 802.1Q-2022";
  }
}
container dynamic-filtering-entries {
  description
    "Dynamic filtering entries attributes.";
  leaf control-element {
    type enumeration {
      enum forward {
        description
```

```
                "Forwarded, independently of any dynamic filtering
                information held by the FDB.";
            }
          }
          description
            "Containing a control element for each outbound Port,
            specifying that a frame with a destination MAC address,
            and in the case of VLAN Bridge components, VID that meets
            this specification.";
          reference
            "8.8.3 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
}
grouping bridge-port-statistics-grouping {
  description
    "Grouping of bridge port statistics.";
  reference
    "12.6.1.1.3 of IEEE Std 802.1Q-2022";
  leaf delay-exceeded-discards {
    type yang:counter64;
    description
      "The number of frames discarded by this port due to excessive
      transit delay through the Bridge. It is incremented by both
      transparent and source route Bridges.";
    reference
      "12.6.1.1.3, 8.6.6 of IEEE Std 802.1Q-2022";
  }
  leaf mtu-exceeded-discards {
    type yang:counter64;
    description
      "The number of frames discarded by this port due to an excessive
      size. It is incremented by both transparent and source route
      Bridges.";
    reference
      "Item g) in 12.6.1.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf frame-rx {
    type yang:counter64;
    description
      "The number of frames that have been received by this port from
      its segment. Note that a frame received on the interface
      corresponding to this port is only counted by this object if and
      only if it is for a protocol being processed by the local
      bridging function, including Bridge management frames.";
    reference
      "12.6.1.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf octets-rx {
    type yang:counter64;
    description
      "The total number of octets in all valid frames received
      (including BPDUs, frames addressed to the Bridge as an end
      station, and frames that were submitted to the Forwarding
      Process).";
    reference
      "12.6.1.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf frame-tx {
    type yang:counter64;
    description
      "The number of frames that have been transmitted by this port to
      its segment. Note that a frame transmitted on the interface
      corresponding to this port is only counted by this object if and
      only if it is for a protocol being processed by the local
      bridging function, including Bridge management frames.";
  }
  leaf octets-tx {
    type yang:counter64;
    description
```

```
        "The total number of octets that have been transmitted by this
        port to its segment.";
    }
    leaf discard-inbound {
      type yang:counter64;
      description
        "Count of received valid frames that were discarded (i.e.,
        filtered) by the Forwarding Process.";
      reference
        "12.6.1.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf forward-outbound {
      type yang:counter64;
      description
        "The number of frames forwarded to the associated MAC Entity
        (8.5).";
      reference
        "12.6.1.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf discard-lack-of-buffers {
      type yang:counter64;
      description
        "The count of frames that were to be transmitted through the
        associated Port but were discarded due to lack of buffers.";
      reference
        "12.6.1.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf discard-transit-delay-exceeded {
      type yang:counter64;
      description
        "The number of frames discarded by this port due to excessive
        transit delay through the Bridge. It is incremented by both
        transparent and source route Bridges.";
      reference
        "12.6.1.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf discard-on-error {
      type yang:counter64;
      description
        "The number of frames that were to be forwarded on the
        associated MAC but could not be transmitted (e.g., frame would
        be too large, 6.5.8).";
      reference
        "12.6.1.1.3 of IEEE Std 802.1Q-2022";
    }
  }
}
```

48.6.3 The ieee802-dot1q-tsn-types YANG module

```
module ieee802-dot1q-tsn-types {
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-tsn-types;
  prefix dot1q-tsn-types;
  import ietf-inet-types {
    prefix inet;
  }
  organization
    "Institute of Electrical and Electronics Engineers";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
           IEEE Standards Association
           445 Hoes Lane
           Piscataway
           NJ 08854
           USA

    E-mail: stds-802-1@ieee.org";
  description
    "Common typedefs and groupings for TSN user/network configuration in
    IEEE Std 802.1Q.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-03-08 {
    description
      "Published as part of IEEE Std 802.1Q-2022. Second version";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2018-02-15 {
    description
      "Amendment: Stream Reservation Protocol (SRP) Enhancements and
      Performance Improvements. Initial version";
    reference
      "46.3 of IEEE Std 802.1Qcc-2018";
  }
  typedef stream-id-type {
    type string {
      pattern
        "[0-9a-fA-F]{2}"+
        "(-[0-9a-fA-F]{2}){5}"+
        ":"+
        "[0-9a-fA-F]{2}"+
        "-"+
        "[0-9a-fA-F]{2}";
    }
    description
      "This typedef specifies a Stream ID, a unique identifier of the
      Stream's configuration, used by protocols in the network to
      associate the user's Stream with TSN resources.

      The Stream ID is a string that represents two fields:

      MAC Address:

      A 48-bit IEEE 802 MAC address associated with the Talker sourcing
      the Stream to the bridged network. The entire range of MAC
      addresses are acceptable.

      NOTE 1The MAC address component of the StreamID can, but does not
      necessarily, have the same value as the source_address parameter
      of any frame in the actual data Stream. For example, the Stream ID
      can be assigned by a TSN CUC (see 46.1.3.3 of IEEE Std
```

```
    802.1Q-2022), using a pool of MAC addresses that the TSN CUC
    maintains.

    NOTE 2If the MAC addresses used to construct Stream IDs are not
    unique within the network, duplicate Stream IDs can be generated,
    with unpredictable results.

    Unique ID:

    A 16-bit unique ID that is used to distinguish between multiple
    Streams within the station identified by MAC Address.

    The string specifies eight octets, with each octet represented as
    two hexadecimal characters. The first six octets specify the MAC
    Address, using the canonical format of IEEE Std 802, with a dash
    separating each octet. The last two octets specify the Unique ID,
    with the high-order octet, a dash, and then the low-order octet.
    The MAC Address and Unique ID are separated by colon.

    stream-id-type is intended for use by other modules as the type
    for a key to a list of Stream configurations (using group-talker
    and group-listener) and a list of Stream status (using
    group-status-stream and group-status-talker-listener).";
  reference
    "46.2.3.1 of IEEE Std 802.1Q-2022";
}
grouping group-interface-id {
  description
    "This YANG grouping specifies the identification of a distinct
    point of attachment (interface) in a station (end station or
    Bridge).";
  reference
    "46.2.3.3 of IEEE Std 802.1Q-2022";
  leaf mac-address {
    type string {
      pattern "[0-9a-fA-F]{2}(-[0-9a-fA-F]{2}){5}";
    }
    description
      "mac-address is the unique individual MAC address (IEEE Std 802) of
      the interface in the station (end station or Bridge). This MAC
      address uniquely identifies the station within the local
      network.

      mac-address shall be included in an instance of a container
      using group-interface-id.

      NOTEThis MAC address can be discovered in the physical topology
      using protocols such as IEEE Std 802.1AB (LLDP). LLDP supports
      MAC address as a subtype for the stations Chassis ID and Port
      ID. If the station does not use MAC address for its LLDP IDs,
      remote management can be used to associate this mac-address to
      the values provided in the LLDP IDs.

      The string uses the hexadecimal representation specified in IEEE
      Std 802 (i.e. canonical format).";
  }
  leaf interface-name {
    type string;
    description
      "interface-name is the name of the interface that is assigned
      locally by the station (end station or Bridge).

      interface-name may be included in an instance of a container
      using group-interface-id.

      IEEE Std 802 recommends that each distinct point of attachment
      to an IEEE 802 network have its own EUI MAC address. If the
      identified station follows this IEEE 802 recommendation, the
      mac-address leaf uniquely identifies the interface as well as
      the station, and interface-name is not needed.

      If the mac-address applies to more than one interface (distinct
```

```
      point of attachment) within the station, interface-name provides
      a locally assigned name that can help to identify the interface.

      When YANG is used for management of the station, interface-name
      is the interface name that serves as the key for the stations
      interface list (RFC7223).

      NOTE 1The TSN CNC is typically located in a different physical
      product than the station identified by this group-interface-id.
      Since the interface-name is assigned locally by the identified
      station, it is possible that the stations product will change
      interface-name in a manner that the TSN CNC cannot detect. For
      example, RFC7223 mentions that the YANG interface name can
      change when a physical attachment point is inserted or removed.

      NOTE 2This interface name can be discovered in the physical
      topology using protocols such as IEEE Std 802.1AB (LLDP). LLDP
      supports interface name as a subtype for its Port ID. If the
      station does not use interface name for its LLDP Port ID, remote
      management can be used to associate this interface-name to the
      values provided in the LLDP Port ID.";
  }
}
grouping group-ieee802-mac-addresses {
  description
    "This YANG grouping specifies the pair of IEEE 802 MAC addresses
    for Stream identification.

    The use of these fields for Stream identification corresponds to
    the managed objects for Stream identification in IEEE Std 802.1CB.
    If inconsistency arises between this specification and IEEE Std
    802.1CB, IEEE Std 802.1CB takes precedence.";
  reference
    "46.2.3.4.1 of IEEE Std 802.1Q-2022";
  leaf destination-mac-address {
    type string {
      pattern "[0-9a-fA-F]{2}(-[0-9a-fA-F]{2}){5}";
    }
    description
      "Destination MAC address.

      An address of all 1's specifies that the destination MAC address
      is ignored for purposes of Stream identification.

      The string uses the hexadecimal representation specified in IEEE
      Std 802 (i.e. canonical format).";
  }
  leaf source-mac-address {
    type string {
      pattern "[0-9a-fA-F]{2}(-[0-9a-fA-F]{2}){5}";
    }
    description
      "Source MAC address.

      An address of all 1's specifies that the source MAC address is
      ignored for purposes of Stream identification.

      The string uses the hexadecimal representation specified in IEEE
      Std 802 (i.e. canonical format).";
  }
}
grouping group-ieee802-vlan-tag {
  description
    "This YANG grouping specifies a customer VLAN Tag (C-TAG of clause
       9) for Stream identification.

    The Drop Eligible Indicator (DEI) field is not relevant from the
    perspective of a TSN Talker/Listener.

    The use of these fields for Stream identification corresponds to
    the managed objects for Stream identification in IEEE Std 802.1CB.
    If inconsistency arises between this specification and IEEE Std
```

```
      802.1CB, IEEE Std 802.1CB takes precedence.";
    reference
      "46.2.3.4.2 of IEEE Std 802.1Q-2022";
    leaf priority-code-point {
      type uint8 {
        range "0 .. 7";
      }
      description
        "Priority Code Point (PCP) field.

        The priority-code-point is not used to identify the Stream, but
        it does identify a traffic class (queue) in Bridges.";
    }
    leaf vlan-id {
      type uint16 {
        range "0 .. 4095";
      }
      description
        "VLAN ID (VID) field.

        If only the priority-code-point is known, the vlan-id is
        specified as 0.";
    }
  }
  grouping group-ipv4-tuple {
    description
      "This YANG grouping specifies parameters to identify an IPv4
      (RFC791) Stream.

      The use of these fields for Stream identification corresponds to
      the managed objects for Stream identification in IEEE Std 802.1CB.
      If inconsistency arises between this specification and IEEE Std
      802.1CB, IEEE Std 802.1CB takes precedence.";
    reference
      "46.2.3.4.3 of IEEE Std 802.1Q-2022";
    leaf source-ip-address {
      type inet:ipv4-address;
      description
        "Source IPv4 address.

        An address of all 0's specifies that the IP source address is
        ignored for purposes of Stream identification.";
    }
    leaf destination-ip-address {
      type inet:ipv4-address;
      description
        "Destination IPv4 address.";
    }
    leaf dscp {
      type uint8;
      description
        "Differentiated services code point, DSCP (RFC2474).

        A value of 64 decimal specifies that the DSCP is ignored for
        purposes of Stream identification.";
    }
    leaf protocol {
      type uint16;
      description
        "IPv4 Protocol (e.g. UDP).

        The special value of all 1s (FFFF hex) represents None, meaning
        that protocol, source-port, and destination-port are ignored for
        purposes of Stream identification.

        For any value other than all 1s, the lower octet is used to
        match IPv4 Protocol.";
    }
    leaf source-port {
      type uint16;
      description
        "This matches the source port of the protocol.";
```

```
    }
    leaf destination-port {
      type uint16;
      description
        "This matches the destination port of the protocol.";
    }
  }
  grouping group-ipv6-tuple {
    description
      "This YANG grouping specifies parameters to identify an IPv6
      (RFC8200) Stream.

      The use of these fields for Stream identification corresponds to
      the managed objects for Stream identification in IEEE Std 802.1CB.
      If inconsistency arises between this specification and IEEE Std
      802.1CB, IEEE Std 802.1CB takes precedence.";
    reference
      "46.2.3.4.4 of IEEE Std 802.1Q-2022";
    leaf source-ip-address {
      type inet:ipv6-address;
      description
        "Source IPv6 address.

        An address of all 0's specifies that the IP source address is
        ignored for purposes of Stream identification.";
    }
    leaf destination-ip-address {
      type inet:ipv6-address;
      description
        "Destination IPv6 address.";
    }
    leaf dscp {
      type uint8;
      description
        "Differentiated services code point, DSCP (RFC2474).

        A value of 64 decimal specifies that the DSCP is ignored for
        purposes of Stream identification.";
    }
    leaf protocol {
      type uint16;
      description
        "IPv6 Next Header (e.g. UDP).

        The special value of all 1s (FFFF hex) represents None, meaning
        that protocol, source-port, and destination-port are ignored for
        purposes of Stream identification.

        For any value other than all 1s, the lower octet is used to
        match IPv6 Next Header.";
    }
    leaf source-port {
      type uint16;
      description
        "This matches the source port of the protocol.";
    }
    leaf destination-port {
      type uint16;
      description
        "This matches the destination port of the protocol.";
    }
  }
  grouping group-user-to-network-requirements {
    description
      "This YANG grouping specifies specifies user requirements for the
      Stream, such as latency and redundancy.

      The network (e.g. CNC) will merge all user-to-network-requirements
      for a Stream to ensure that all requirements are met.";
    reference
      "46.2.3.6 of IEEE Std 802.1Q-2022";
    leaf num-seamless-trees {
```

```
    type uint8;
    default "1";
    description
      "num-seamless-trees specifies the number of trees that the
      network will configure to deliver seamless redundancy for the
      Stream.

      The value zero is interpreted as one (i.e. no seamless
      redundancy).

      This requirement is provided from the Talker only. Listeners
      shall set this leaf to one.

      From each Talker to a single Listener, the network configures a
      path that relays Stream data through Bridges. If the Talker has
      more than one Listener, the network configures a tree of
      multiple paths.

      num-seamless-trees specifies the number of maximally disjoint
      trees that the network shall configure from the Talker to all
      Listeners. Each tree is disjoint from other trees, in that the
      network evaluates the physical topology to avoid sharing the
      same Bridge and links in each trees paths. This computation of
      disjoint trees is maximal, in that shared Bridges and links are
      avoided to the maximum extent allowed by the physical topology.
      For example, if a single link exists from a Bridge to a
      Listener, and num-seamless-trees is 3, then all 3 trees will
      share that link to the Listener.

      When num-seamless-trees is greater than one, the transfer of the
      Streams data frames shall use a seamless redundancy standard,
      such as IEEE Std 802.1CB. When a link shared by multiple trees
      diverges to multiple disjoint links, the seamless redundancy
      standard replicates (i.e. forwards a distinct copy of each data
      frame to the disjoint trees). When disjoint trees converge to a
      single link, the seamless redundancy standard eliminates the
      duplicate copies of each data frame. Assuming that other sources
      of frame loss are mitigated (e.g. congestion), failure of a link
      or Bridge in one disjoint tree does not result in frame loss as
      long as at least one remaining disjoint tree is operational.

      If the Talker sets this leaf to one, the network may make use of
      redundancy standards that are not seamless (i.e. failure of link
      results in lost frames), such as MSTP and IS-IS.

      If the Talker sets this leaf to greater than one, and seamless
      redundancy is not possible in the current network (no disjoint
      paths, or no seamless redundancy standard in Bridges),
      group-status-stream.status-info.failure-code is non-zero
      (46.2.4.1 of IEEE Std 802.1Q-2022).

      If group-user-to-network-requirements is not provided by the
      Talker or Listener, the network shall use the default value of
      one for this leaf.";
    reference
      "46.2.3.6.1 of IEEE Std 802.1Q-2022";
  }
  leaf max-latency {
    type uint32;
    default "0";
    description
      "Maximum latency from Talker to Listener(s) for a single frame
      of the Stream.

      max-latency is specified as an integer number of nanoseconds.

      Latency shall use the definition of 3.102, with additional
      context as follows: The Known reference point in the frame is
      the message timestamp point specified in IEEE Std 802.1AS for
      various media (i.e. start of the frame). The first point is in
      the Talker, at the reference plane marking the boundary between
      the network media and PHY (see IEEE Std 802.1AS). The second
```

```
        point is in the Listener, at the reference plane marking the
        boundary between the network media and PHY.

        When this requirement is specified by the Talker, it must be
        satisfied for all Listeners.

        When this requirement is specified by the Listener, it must be
        satisfied for this Listener only.

        If group-user-to-network-requirements is not provided by the
        Talker or Listener, the network shall use the default value of
        zero for this leaf.

        The special value of zero represents usage of the initial value
        of group-status-talker-listener.accumulated-latency as the
        maximum latency requirement. This effectively locks-down the
        initial latency that the network calculates after successful
        configuration of the Stream, such that any subsequent increase
        in latency beyond that value causes the Stream to fail.

        The assumption for when the first point occurs in the Talker
        depends on the presence of the time-aware container in the
        Talkers traffic-specification.

        When time-aware is not present:

        The Talker is assumed to transmit at an arbitrary time (not
        scheduled).

        When time-aware is present:

        The first point is assumed to occur at the start of each
        traffic-specification.interval, as if the Talkers offsets
        (earliest-transmit-offset and latest-transmit-offset) are both
        zero. The Talkers offsets are not typically zero, but use of the
        start of interval for purposes of max-latency allows the
        Listener(s) to schedule their application independently from the
        Talkers offset configuration.

        The Listener determines max-latency based on its scheduling of a
        read function in the application. Nevertheless, the time from
        frame reception (i.e. second point) to execution of the read
        function is in the user scope, and therefore not included in
        max-latency.

        max-latency can be set to a value greater than the Talkers
        interval, in order to specify a longer latency requirement. For
        example, if the Talkers interval is 500 microsec, and
        max-latency is 700 microsec, the Listener receives the frame no
        later than 200 microsec into the interval that follows the
        Talkers interval.";
      reference
        "46.2.3.6.2 of IEEE Std 802.1Q-2022";
    }
  }
  grouping group-interface-capabilities {
    description
      "This YANG grouping specifies the network capabilities of all
      interfaces (Ports) contained in end-station-interfaces.

      The network may provide configuration of these capabilities in
      group-status-talker-listener.interface-configuration.

      NOTEIf an end station contains multiple interfaces with different
      network capabilities, each interface should be specified as a
      distinct Talker or Listener (i.e. one entry in
      end-station-interfaces). Use of multiple entries in
      end-station-interfaces is intended for network capabilities that
      span multiple interfaces (e.g. seamless redundancy).";
    reference
      "46.2.3.7 of IEEE Std 802.1Q-2022";
    leaf vlan-tag-capable {
```

```
    type boolean;
    default "false";
    description
      "When vlan-tag-capable is true, the interface supports the
      ability to tag/untag frames using a Customer VLAN Tag (C-TAG of
      clause 9) provided by the network.

      For a Talker, the networks tag replaces the tag specified by the
      data-frame-specification. If the data-frame-specification is
      untagged (no group-ieee802-vlan-tag), the networks tag is
      inserted in the frame as it passes through the interface.

      For a Listener, the users tag from the data-frame-specification
      replaces the networks tag as the frame passes through the
      interface. If the data-frame-specification is untagged (no
      group-ieee802-vlan-tag), the networks tag is removed from the
      frame as it passes through the interface.

      If the end station supports more than one interface (i.e. more
      than one entry in end-station-interfaces), vlan-tag-capable of
      true means that a distinct VLAN tag can be applied to each
      interface. The list of VLAN tag (one for each interface) can be
      provided by the network in
      interface-configuration.interface-list (ieee802-vlan-tag
      choice).

      When vlan-tag-capable is false, the interface does not support
      the capability to tag/untag frames using a Customer VLAN Tag
      (C-TAG of clause 9) provided by the network.

      If interface-capabilities is not provided by the Talker or
      Listener, the network shall use the default value of false for
      this leaf.";
    reference
      "46.2.3.7.1 of IEEE Std 802.1Q-2022";
  }
  leaf-list cb-stream-iden-type-list {
    type uint32;
    description
      "cb-stream-iden-type-list provides a list of the supported
      Stream Identification types as specified in IEEE Std 802.1CB.

      Each Stream Identification type is provided as a 32-bit unsigned
      integer. The upper three octets contain the OUI/CID, and the
      lowest octet contains the type number.

      NOTEIf the Talker/Listener end system supports IEEE Std 802.1CB,
      Null Stream identification is required, and that Stream
      Identification type is included in this list. If the
      Talker/Listener end system does not support IEEE Std 802.1CB,
      this list is empty.

      If the end station supports more than one interface (i.e. more
      than one interface-id in end-station-interfaces, an empty
      cb-stream-iden-type-list means that the end station is capable
      of transferring the Stream on any one of its interfaces (not
      all). When this is specified, the network shall decide which
      interface is best used for TSN purposes, and communicate that
      decision by returning a single interface in
      interface-configuration.interface-list. The Talker/Listener uses
      this interface alone for the Stream.

      If interface-capabilities is not provided within group-talker or
      group-listener, the network shall use an empty list as the
      default value for this element.";
    reference
      "46.2.3.7.2 of IEEE Std 802.1Q-2022";
  }
  leaf-list cb-sequence-type-list {
    type uint32;
    description
      "cb-sequence-type-list provides a list of the supported Sequence
```

```
      Encode/Decode types as specified in IEEE Std 802.1CB.

      Each sequence type is provided as a 32-bit unsigned integer. The
      upper three octets contain the OUI/CID, and the lowest octet
      contains the type number.

      If interface-capabilities is not provided within group-talker or
      group-listener, the network shall use an empty list as the
      default value for this element.";
    reference
      "46.2.3.7.3 of IEEE Std 802.1Q-2022";
  }
}
grouping group-interface-configuration {
  description
    "This YANG grouping provides configuration of interfaces in the
    Talker/Listener. This configuration assists the network in meeting
    the Streams requirements. The interface-configuration meets the
    capabilities of the interface as provided in
    interface-capabilities.";
  reference
    "46.2.5.3 of IEEE Std 802.1Q-2022";
  list interface-list {
    key "mac-address interface-name";
    description
      "A distinct configuration is provided for each interface in the
      Talker/Listener (even if multiple interfaces use the same
      configuration). Each entry in this interface-list consists of an
      interface identification (group-interface-id), followed by a
      list of configuration values for that interface (config-list).

      If interface-configuration is not provided within
      group-status-talker-listener, the network shall assume zero
      entries as the default (no interface configuration).

      Since the interface-name leaf is optional, empty string can be
      used for its key value.";
    uses group-interface-id;
    list config-list {
      key "index";
      description
        "List of configuration values for the interface.";
      leaf index {
        type uint8;
        description
          "This index is provided in order to provide a unique key per
          list entry. The value of index for each entry shall be
          unique (but not necessarily contiguous).";
      }
      choice config-value {
        description
          "One of the following choices is provided for each
          configuration value. Each container name acts as the case
          name for the choice.";
        container ieee802-mac-addresses {
          description
            "Source and destination MAC addresses that apply to the
            network side of the user/network boundary.

            NOTE 1On the userside, the MAC addresses correspond to the
            ieee802-mac-addresses of data-frame-specification.

            NOTE 2The source MAC address of the network is typically
            the same as the user. The destination MAC address can be
            different. For example, the user can use an individual
            address, but the network can use a group (multicast)
            address.

            This configuration value is not provided unless IEEE Std
            802.1CB is supported, and a value for Active Destination
            MAC and VLAN Stream identification is provided in
            cb-stream-iden-type-list of interface-capabilities.";
```

```
      reference
        "46.2.5.3.1 of IEEE Std 802.1Q-2022";
      uses group-ieee802-mac-addresses;
    }
    container ieee802-vlan-tag {
      description
        "Customer VLAN Tag (C-TAG of clause 9) that applies to the
        network side of the user/network boundary.

        NOTEOn the user side, the VLAN tag corresponds to the
        ieee802-vlan-tag of data-frame-specification (including
        untagged if this field is not provided).

        If the user provides a VLAN ID in the ieee802-vlan-tag of
        data-frame-specification, the Streams data frames are
        assumed to be limited to the active topology for that VLAN
        ID. Therefore, if the network uses a different VLAN ID in
        this config-value, the network shall ensure that the
        replacement VLAN ID is limited to the equivalent active
        topology.

        This configuration value is not provided unless
        vlan-tag-capable of interface-capabilities is true.";
      reference
        "46.2.5.3.2 of IEEE Std 802.1Q-2022";
      uses group-ieee802-vlan-tag;
    }
    container ipv4-tuple {
      description
        "IPv4 identification that applies to the network side of
        the user/network boundary.

        This configuration value is not provided unless IEEE Std
        802.1CB is supported, and a value for IP Stream
        identification is provided in cb-stream-iden-type-list of
        interface-capabilities.";
      reference
        "46.2.5.3.3 of IEEE Std 802.1Q-2022";
      uses group-ipv4-tuple;
    }
    container ipv6-tuple {
      description
        "IPv6 identification that applies to the network side of
        the user/network boundary.

        This configuration value is not provided unless IEEE Std
        802.1CB is supported, and a value for IP Stream
        identification is provided in cb-stream-iden-type-list of
        interface-capabilities.";
      reference
        "46.2.5.3.4 of IEEE Std 802.1Q-2022";
      uses group-ipv6-tuple;
    }
    leaf time-aware-offset {
      type uint32;
      description
        "If the time-aware container is present in the
        traffic-specification of the Talker, this config-value
        shall be provided by the network to the Talker.

        If the time-aware container is not present in the
        traffic-specification of the Talker, this config-value
        shall not be provided by the network.

        This config-value shall not be provided to Listeners, as
        it is not applicable.

        time-aware-offset specifies the offset that the Talker
        shall use for transmit. The network returns a value
        between earliest-transmit-offset and
        latest-transmit-offset of the Talkers
        traffic-specification. The value is expressed as
```

```
            nanoseconds after the start of the Talkers interval.";
          reference
            "46.2.5.3.5 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
}
grouping group-talker {
  description
    "This YANG grouping specifies: - Talkers behavior for Stream
    (how/when transmitted) - Talkers requirements from the network -
    TSN capabilities of the Talkers interface(s)

    In the fully centralized model of TSN configuration, this grouping
    originates from the CUC, and is delivered to the CNC.";
  reference
    "46.2.3 of IEEE Std 802.1Q-2022";
  container stream-rank {
    description
      "Rank of this Stream's configuration relative to other Streams
      in the network. This rank is used to determine success/failure
      of Stream resource configuration, and it is unrelated to the
      Streams data.";
    reference
      "46.2.3.2 of IEEE Std 802.1Q-2022";
    leaf rank {
      type uint8;
      description
        "The Rank is used by the network to decide which Streams can
        and cannot exist when TSN resources reach their limit. If a
        Bridges Port becomes oversubscribed (e.g. network
        reconfiguration, IEEE 802.11 bandwidth reduction), the Rank is
        used to help determine which Streams can be dropped (i.e.
        removed from Bridge configuration).

        The only valid values for Rank shall be zero and one. The
        configuration of a Stream with Rank zero is more important
        than the configuration of a Stream with Rank one. The Rank
        value of zero is intended for emergency traffic, and the Rank
        value of one is intended for non-emergency traffic.

        NOTEIt is expected that higher layer applications and
        protocols can use the Rank to indicate the relative importance
        of Streams based on user preferences. Those user preferences
        are expressed by means beyond the scope of this standard. When
        multiple applications exist in a network (e.g. audio/video
        along with industrial control), it can be challenging for the
        varied applications and vendors to agree on multiple Rank
        values. To mitigate such challenges, this Rank uses a simple
        concept of emergency (zero) and non-emergency (one) that can
        be applied over all applications. For example, in a network
        that carries audio Streams for fire safety announcements, all
        applications are likely to agree that those Streams use Rank
        of zero.";
      reference
        "46.2.3.2.1 of IEEE Std 802.1Q-2022";
    }
  }
  list end-station-interfaces {
    key "mac-address interface-name";
    min-elements 1;
    description
      "List of identifiers, one for each physical interface (distinct
      point of attachment) in the end station acting as a Talker.

      Although many end stations contain a single interface, this list
      allows for multiple interfaces. Some TSN features allow a single
      Stream to span multiple interfaces (e.g. seamless redundancy).

      Each entry of end-station-interfaces is used by the CNC to
      locate the Talker in the topology.
```

```
    Since the interface-name leaf is optional, empty string can be
    used for its key value.";
  reference
    "46.2.3.3 of IEEE Std 802.1Q-2022";
  uses group-interface-id;
}
list data-frame-specification {
  key "index";
  min-elements 1;
  description
    "data-frame-specification specifies the frame that carries the
    Talkers Stream data. The network uses the specification to
    identify this Streams frames as TSN, in order to apply the
    required TSN configuration.

    The specification is based on the users knowledge of the frame,
    without any network specifics. In other words, this specifies
    the frame that the Talker would use in the absence of TSN.

    The specification is provided as a list of fields that the user
    knows. The list is ordered from start of frame to end of header.
    For example, if the Talker uses a VLAN-tagged Ethernet frame
    (not IP), the list consists of ieee802-mac-addresses followed by
    ieee802-vlan-tag. For example, if the Talker uses a UDP/IPv4
    packet without knowledge of the Ethernet header, the list
    consists of ipv4-tuple.

    This list is optional, and its absence indicates that Stream
    transformation is performed in the Talker and Listeners of this
    Stream (46.2.2 of IEEE Std 802.1Q-2022).";
  reference
    "46.2.3.4 of IEEE Std 802.1Q-2022";
  leaf index {
    type uint8;
    description
      "This index is provided in order to provide a unique key per
      list entry. The value of index for each entry shall be unique
      (but not necessarily contiguous).";
  }
  choice field {
    description
      "One of the following choices is provided for each field that
      the user knows. Each container name acts as the case name for
      the choice.";
    container ieee802-mac-addresses {
      description
        "IEEE 802 MAC addresses.";
      uses group-ieee802-mac-addresses;
    }
    container ieee802-vlan-tag {
      description
        "IEEE 802.1 CTAG";
      uses group-ieee802-vlan-tag;
    }
    container ipv4-tuple {
      description
        "IPv4 packet identification";
      uses group-ipv4-tuple;
    }
    container ipv6-tuple {
      description
        "IPv6 packet identification";
      uses group-ipv6-tuple;
    }
  }
}
container traffic-specification {
  description
    "This traffic-specification specifies how the Talker transmits
    frames for the Stream. This is effectively the Talkers promise
    to the network. The network uses this traffic spec to allocate
```

```
    resources and adjust queue parameters in Bridges.";
  reference
    "46.2.3.5 of IEEE Std 802.1Q-2022";
  container interval {
    description
      "This interval specifies the period of time in which the
      traffic specification cannot be exceeded. The traffic
      specification is specified by max-frames-per-interval and
      max-frame-size.

      The interval is a rational number of seconds, defined by an
      integer numerator and an integer denominator.

      If the time-aware container is not present, the interval
      specifies a sliding window of time. The Talkers transmission
      is not synchronized to a time on the network, and therefore
      the traffic specification cannot be exceeded during any
      interval in time.

      If the time-aware container is present, the interval specifies
      a window of time that is aligned with the time epoch that is
      synchronized on the network. For example, if IEEE Std
      802.1AS-2011 is used with the PTP timescale, the first
      interval begins at 1 January 00:00:00 TAI. If CurrentTime
      represents the current time, then the start of the next
      interval (StartOfNextInterval) is: StartOfNextInterval = N *
      interval where N is the smallest integer for which the
      relation StartOfNextInterval >= CurrentTime would be TRUE.";
    reference
      "46.2.3.5.1 of IEEE Std 802.1Q-2022";
    leaf numerator {
      type uint32;
      description
        "intervals numerator.";
    }
    leaf denominator {
      type uint32;
      description
        "intervals denominator.";
    }
  }
  leaf max-frames-per-interval {
    type uint16;
    description
      "max-frames-per-interval specifies the maximum number of
      frames that the Talker can transmit in one interval.";
    reference
      "46.2.3.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf max-frame-size {
    type uint16;
    description
      "max-frame-size specifies maximum frame size that the Talker
      will transmit, excluding any overhead for media-specific
      framing (e.g., preamble, IEEE 802.3 header, Priority/VID tag,
      CRC, interframe gap). As the Talker or Bridge determines the
      amount of bandwidth to reserve on the egress Port (interface),
      it will calculate the media-specific framing overhead on that
      Port and add it to the number specified in the max-frame-size
      leaf.";
    reference
      "46.2.3.5.3 of IEEE Std 802.1Q-2022";
  }
  leaf transmission-selection {
    type uint8;
    description
      "transmission-selection specifies the algorithm that the
      Talker uses to transmit this Streams traffic class. This
      algorithm is often referred to as the shaper for the traffic
      class.

      The value for this leaf uses Table 8-5 (Transmission selection
```

```
      algorithm identifiers) of 8.6.8 of IEEE Std 802.1Q-2022. If no
      algorithm is known, the value zero (strict priority) can be
      used.

      The Talkers shaping and scheduling of the Stream is considered
      to be on the user side of the user/network boundary, and this
      leaf specifies the Talkers behavior to the network.";
    reference
      "46.2.3.5.4 of IEEE Std 802.1Q-2022";
  }
  container time-aware {
    presence
      "Specifies that the Talkers traffic is synchronized to"+
      "a known time on the network (e.g. using IEEE Std 802.1AS)";
    description
      "The time-aware container provides leafs to specify the
      Talkers time-aware transmit to the network.

      The Talker and Listeners of a Stream are assumed to coordinate
      using user (application) mechanisms, such that each Listener
      is aware that its Talker transmits in a time-aware manner.

      If max-frames-per-interval is greater than one, the Talker
      shall transmit multiple frames as a burst within the interval,
      with the minimum inter-frame gap allowed by the media.

      NOTE: Although scheduled traffic (8.6.8.4 of IEEE Std
      802.1Q-2022) specifies a valid implementation of a time-aware
      Talker, the time-aware container is intended to support
      alternate implementations of scheduling.";
    reference
      "46.2.3.5 of IEEE Std 802.1Q-2022";
    leaf earliest-transmit-offset {
      type uint32;
      description
        "earliest-transmit-offset specifies the earliest offset
        within each interval at which the Talker is capable of
        starting transmit of its frames. As part of
        group-status-talker-listener.interface-configuration, the
        network will return a specific time-aware-offset to the
        Talker (within the earliest/latest range), which the Talker
        uses to schedule its transmit.

        earliest-transmit-offset is specified as an integer number
        of nanoseconds.

        The Talkers transmit offsets include
        earliest-transmit-offset, latest-transmit-offset, and the
        time-aware-offset returned to the Talker. Each of the
        Talkers offsets is specified at the point when the message
        timestamp point of the first frame of the Stream passes the
        reference plane marking the boundary between the network
        media and PHY. The message timestamp point is specified by
        IEEE Std 802.1AS for various media.";
      reference
        "46.2.3.5.5 of IEEE Std 802.1Q-2022";
    }
    leaf latest-transmit-offset {
      type uint32;
      description
        "latest-transmit-offset specifies the latest offset within
        the interval at which the Talker is capable of starting
        transmit ofits frames. As part of
        group-status-talker-listener.interface-configuration, the
        network will return a specific time-aware-offset to the
        Talker within the earliest/latest range), which the Talker
        uses to schedule its transmit.

        latest-transmit-offset is specified as an integer number of
        nanoseconds.";
      reference
        "46.2.3.5.6 of IEEE Std 802.1Q-2022";
```

```
      }
      leaf jitter {
        type uint32;
        description
          "The jitter leaf specifies the maximum difference in time
          between the Talkers transmit offsets, and the ideal
          synchronized network time (e.g. IEEE 802.1AS time). Jitter
          is specified as an unsigned integer number of nanoseconds.

          The maximum difference means sooner or later than the ideal
          (e.g. transmit +/- 500 nanoseconds relative to IEEE 802.1AS
          time results in jitter of 500).

          The ideal synchronized network time refers to time at the
          source (e.g. IEEE 802.1AS grandmaster). The jitter does not
          include inaccuracies as time is propagated from the time
          source to the Talker, because those inaccuracies are assumed
          to be known by the network, and time synchronization is a
          network technology. The jitter leaf is intended to specify
          inaccuracies in the Talkers implementation. For example, if
          the Talkers IEEE 802.1AS time is +/- 812 nanoseconds
          relative to the grandmaster, and the Talker schedules using
          a 100 microsecond timer tick driven by IEEE 802.1AS time,
          Jitter is 50000 (not 50812).

          The Talkers transmit offsets include
          earliest-transmit-offset, latest-transmit-offset, and the
          time-aware-offset returned to the Talker in
          group-status-talker-listener.interface-configuration.";
        reference
          "46.2.3.5.7 of IEEE Std 802.1Q-2022";
      }
    }
  }
  container user-to-network-requirements {
    description
      "user-to-network-requirements specifies user requirements for
      the Stream, such as latency and redundancy. The network (CNC)
      will merge all user-to-network-requirements for a Stream to
      ensure that all requirements are met.";
    reference
      "46.2.3.6 of IEEE Std 802.1Q-2022";
    uses group-user-to-network-requirements;
  }
  container interface-capabilities {
    description
      "interface-capabilities specifies the network capabilities of
      all interfaces (Ports) contained in end-station-interfaces.

      The network may provide configuration of these capabilities in
      group-status-talker-listener.interface-configuration.

      NOTEIf an end station contains multiple interfaces with
      different network capabilities, each interface should be
      specified as a distinct Talker or Listener (i.e. one entry in
      end-station-interfaces). Use of multiple entries in
      end-station-interfaces is intended for network capabilities that
      span multiple interfaces (e.g. seamless redundancy).";
    reference
      "46.2.3.7 of IEEE Std 802.1Q-2022";
    uses group-interface-capabilities;
  }
}
grouping group-listener {
  description
    "This YANG grouping specifies: - Listeners requirements from the
    network - TSN capabilities of the Listeners interface(s)

    In the fully centralized model of TSN configuration, this grouping
    originates from the CUC, and is delivered to the CNC.";
  reference
    "46.2.4 of IEEE Std 802.1Q-2022";
```

```
    list end-station-interfaces {
      key "mac-address interface-name";
      min-elements 1;
      description
        "List of identifiers, one for each physical interface (distinct
        point of attachment) in the end station acting as a Listener.

        Although many end stations contain a single interface, this list
        allows for multiple interfaces. Some TSN features allow a single
        Stream to span multiple interfaces (e.g. seamless redundancy).

        Each entry of end-station-interfaces is used by the CNC to
        locate the Listener in the topology.

        Since the interface-name leaf is optional, empty string can be
        used for its key value.";
      reference
        "46.2.3.3 of IEEE Std 802.1Q-2022";
      uses group-interface-id;
    }
    container user-to-network-requirements {
      description
        "user-to-network-requirements specifies user requirements for
        the Stream, such as latency and redundancy. The network (CNC)
        will merge all user-to-network-requirements for a Stream to
        ensure that all requirements are met.";
      reference
        "46.2.3.6 of IEEE Std 802.1Q-2022";
      uses group-user-to-network-requirements;
    }
    container interface-capabilities {
      description
        "interface-capabilities specifies the network capabilities of
        all interfaces (Ports) contained in end-station-interfaces.

        The network may provide configuration of these capabilities in
        group-status-talker-listener.interface-configuration.

        NOTEIf an end station contains multiple interfaces with
        different network capabilities, each interface should be
        specified as a distinct Talker or Listener (i.e. one entry in
        end-station-interfaces). Use of multiple entries in
        end-station-interfaces is intended for network capabilities that
        span multiple interfaces (e.g. seamless redundancy).";
      reference
        "46.2.3.7 of IEEE Std 802.1Q-2022";
      uses group-interface-capabilities;
    }
  }
  grouping group-status-stream {
    description
      "This YANG grouping provides the status of a Streams configuration
      from the network to each user. The status in this grouping applies
      to the entire Stream (Talker and all Listeners).

      In the fully centralized model of TSN configuration, this grouping
      originates from the CNC, and is delivered to the CUC.

      The group-status-stream and group-status-talker-listener groupings
      are intended to be used by other modules within a list of status
      (state) for each Stream, with each list entry using: - leaf of
      type stream-id-type, used as key to the list - container using
      group-status-stream - container for Talker, using
      group-status-talker-listener - list for Listeners, using
      group-status-talker-listener";
    reference
      "46.2.5 of IEEE Std 802.1Q-2022";
    container status-info {
      description
        "status-info provides information regarding the status of a
        Streams configuration in the network.";
      reference
```

```
      "46.2.5.1 of IEEE Std 802.1Q-2022";
    leaf talker-status {
      type enumeration {
        enum none {
          value 0;
          description
            "No Talker detected.";
        }
        enum ready {
          value 1;
          description
            "Talker ready (configured).";
        }
        enum failed {
          value 2;
          description
            "Talker failed.";
        }
      }
      description
        "This is an enumeration for the status of the Streams Talker.";
      reference
        "46.2.5.1.1 of IEEE Std 802.1Q-2022";
    }
    leaf listener-status {
      type enumeration {
        enum none {
          value 0;
          description
            "No Listener detected.";
        }
        enum ready {
          value 1;
          description
            "All Listeners ready (configured).";
        }
        enum partial-failed {
          value 2;
          description
            "One or more Listeners ready, and one or more Listeners
            failed. If Talker is ready, Stream can be used.";
        }
        enum failed {
          value 3;
          description
            "All Listeners failed";
        }
      }
      description
        "This is an enumeration for the status of the Streams
        Listener(s).";
      reference
        "46.2.5.1.2 of IEEE Std 802.1Q-2022";
    }
    leaf failure-code {
      type uint8;
      description
        "If the Stream encounters a failure (talker-status is failed,
        or listener-status is failed, or listener-status is
        partial-failed), failure-code provides a non-zero code that
        specifies the problem. Table 46-15 of IEEE Std 802.1Q-2022
        describes each code.)";
      reference
        "46.2.5.1.3 of IEEE Std 802.1Q-2022";
    }
  }
  list failed-interfaces {
    key "mac-address interface-name";
    description
      "When a failure occurs in network configuration (i.e. non-zero
      failure-code in status-info), failed-interfaces provides a list
      of one or more physical interfaces (distinct points of
```

```
        attachement) in the failed end station or Bridge. Each
        identifier is sufficient to locate the interface in the physical
        topology.

        The failed-interfaces list is optional.

        Since the interface-name leaf is optional, empty string can be
        used for its key value.";
      reference
        "46.2.5.4 of IEEE Std 802.1Q-2022";
      uses group-interface-id;
    }
  }
  grouping group-status-talker-listener {
    description
      "This YANG grouping provides the status for a specific Talker or
      Listener.

      In the fully centralized model of TSN configuration, this grouping
      originates from the CNC, and is delivered to the CUC.";
    reference
      "46.2.5 of IEEE Std 802.1Q-2022";
    leaf accumulated-latency {
      type uint32;
      description
        "accumulated-latency provides the worst-case maximum latency
        that a single frame of the Stream can encounter along its
        current path(s).

        When provided to a Listener, accumulated-latency is the
        worst-case maximum latency for that Listener only.

        When provided to a Talker, accumulated-latency is the worst-case
        maximum latency for all Listeners (worst path).

        accumulated-latency is specified as an integer number of
        nanoseconds.

        accumulated-latency uses the same definition for latency as
        user-to-network-requirements.max-latency.

        For successful status-info, the network returns a value less
        than or equal to user-to-network-requirements.max-latency.

        If the time-aware container is present in the
        traffic-specification of the Talker, the value is expressed as
        nanoseconds after the start of the Talkers
        traffic-specification.interval.

        If the time-aware container is not present in the
        traffic-specification of the Talker, the value is expressed as
        nanoseconds after the Talkers transmit of any frame in the
        Stream, at any arbitrary time.

        If user-to-network-requirements.num-seamless-trees is one,
        accumulated-latency shall provide the worst-case maximum latency
        for the current path from Talker to each Listener. If the path
        is changed (e.g. by a spanning tree protocol),
        accumulated-latency changes accordingly.

        If user-to-network-requirements.num-seamless-trees is greater
        than one, accumulated-latency shall provide the worst-case
        maximum latency for all paths configured from the Talker to each
        Listener.";
      reference
        "46.2.5.2 of IEEE Std 802.1Q-2022";
    }
    container interface-configuration {
      description
        "interface-configuration provides configuration of interfaces in
        the Talker/Listener. This configuration assists the network in
        meeting the Streams requirements. The interface-configuration
```

```
        meets the capabilities of the interface as provided in
        interface-capabilities.";
      reference
        "46.2.5.3 of IEEE Std 802.1Q-2022";
      uses group-interface-configuration;
    }
  }
}
```

48.6.4 The ieee802-dot1q-bridge YANG module

```
module ieee802-dot1q-bridge {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-bridge;
  prefix dot1q;
  import ieee802-types {
    prefix ieee;
  }
  import ietf-yang-types {
    prefix yang;
  }
  import ietf-interfaces {
    prefix if;
  }
  import iana-if-type {
    prefix ianaif;
  }
  import ieee802-dot1q-types {
    prefix dot1qtypes;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This YANG module describes the bridge configuration model for the
    following IEEE 802.1Q Bridges:
       1) Two Port MAC Relays
       2) Customer VLAN Bridges
       3) Provider Bridges.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-11-06 {
    description
      "Published as part of IEEE Std 802.1Qcr-2020. Third version.";
    reference
      "IEEE Std 802.1Qcr-2020, Bridges and Bridged Networks -
      Asynchronous Traffic Shaping.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Second version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  revision 2018-03-07 {
    description
      "Published as part of IEEE Std 802.1Q-2018. Initial version.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
```

```
}
feature ingress-filtering {
  description
    "Each Port may support an Enable Ingress Filtering parameter. A
    frame received on a Port that is not in the member set (8.8.10)
    associated with the frames VID shall be discarded if this
    parameter is set. The default value for this parameter is reset,
    i.e., Disable Ingress Filtering, for all Ports. Any Port that
    supports setting this parameter shall also support resetting it.
    The parameter may be configured by the management operations
    defined in Clause 12.";
  reference
    "8.6.2 of IEEE Std 802.1Q-2022";
}
feature extended-filtering-services {
  description
    "Extended Filtering Services support the filtering behavior
    required for regions of a network in which potential recipients of
    multicast frames exist, and where both the potential recipients of
    frames and the Bridges are able to support dynamic configuration
    of filtering information for group MAC addresses. In order to
    integrate this extended filtering behavior with the needs of
    regions of the network that support only Basic Filtering Services,
    Bridges that support Extended Filtering Services can be statically
    and dynamically configured to modify their filtering behavior on a
    per-group MAC address basis, and also on the basis of the overall
    filtering service provided by each outbound Port with regard to
    multicast frames. The latter capability permits configuration of
    the Ports default forwarding or filtering behavior with regard to
    group MAC addresses for which no specific static or dynamic
    filtering information has been configured.";
  reference
    "8.8.4, Clause 10 of IEEE Std 802.1Q-2022";
}
feature port-and-protocol-based-vlan {
  description
    "A VLAN-aware bridge component implementation in conformance to
    the provisions of this standard for Port-and-Protocol-based VLAN
    classification (5.4.1) shall 1) Support one or more of the
    following Protocol Classifications and Protocol Template formats:
    Ethernet, RFC_1042, SNAP_8021H, SNAP_Other, or LLC_Other (6.12);
    and may 2) Support configuration of the contents of the Protocol
    Group Database.";
  reference
    "5.4.1.2 of IEEE Std 802.1Q-2022";
}
feature flow-filtering {
  description
    "Flow filtering support enables Bridges to distinguish frames
    belonging to different client flows and to use this information in
    the forwarding process. Information related to client flows may be
    used at the boundary of an SPT Domain to generate a flow hash
    value. The flow hash, carried in an F-TAG, serves to distinguish
    frames belonging to different flows and can be used in the
    forwarding process to distribute frames over equal cost paths.
    This provides for finer granularity load spreading while
    maintaining frame order for each client flow.";
  reference
    "44.2 of IEEE Std 802.1Q-2022";
}
feature simple-bridge-port {
  description
    "A simple bridge port allows underlying (MAC) layers to share the
    same Interface as the Bridge Port.";
}
feature flexible-bridge-port {
  description
    "A flexible bridge port supports an Interface that is a Bridge
    Port to be a separate Interface from the underlying (MAC) layer.";
}
identity type-of-bridge {
  description
```

```
    "Represents the configured Bridge type.";
}
identity customer-vlan-bridge {
  base type-of-bridge;
  description
    "Base identity for a Customer VLAN Bridge.";
}
identity provider-bridge {
  base type-of-bridge;
  description
    "Base identity for a Provider Bridge (PB).";
}
identity provider-edge-bridge {
  base type-of-bridge;
  description
    "Base identity for a Provider Edge Bridge (PEB).";
}
identity two-port-mac-relay-bridge {
  base type-of-bridge;
  description
    "Base identity for a Two Port MAC Relay (TPMR).";
}
identity type-of-component {
  description
    "Represents the type of Component.";
}
identity c-vlan-component {
  base type-of-component;
  description
    "Base identity for a C-VLAN component.";
}
identity s-vlan-component {
  base type-of-component;
  description
    "Base identity for a S-VLAN component.";
}
identity d-bridge-component {
  base type-of-component;
  description
    "Base identity for a VLAN unaware component.";
}
identity edge-relay-component {
  base type-of-component;
  description
    "Base identity for an EVB station ER component.";
}
identity type-of-port {
  description
    "Represents the type of Bridge port.";
}
identity c-vlan-bridge-port {
  base type-of-port;
  description
    "Indicates the port can be a C-TAG aware port of an enterprise
    VLAN aware Bridge.";
}
identity provider-network-port {
  base type-of-port;
  description
    "Indicates the port can be an S-TAG aware port of a Provider
    Bridge or Backbone Edge Bridge used for connections within a PBN
    (Provider Bridged Network) or PBBN (Provider Backbone Bridged
    Network).";
}
identity customer-network-port {
  base type-of-port;
  description
    "Indicates the port can be an S-TAG aware port of a Provider
    Bridge or Backbone Edge Bridge used for connections to the
    exterior of a PBN (Provider Bridged Network) or PBBN (Provider
    Backbone Bridged Network).";
}
```

```
identity customer-edge-port {
  base type-of-port;
  description
    "Indicates the port can be a C-TAG aware port of a Provider Bridge
    used for connections to the exterior of a PBN (Provider Bridged
    Network) or PBBN (Provider Backbone Bridged Network).";
}
identity d-bridge-port {
  base type-of-port;
  description
    "Indicates the port can be a VLAN-unaware member of an 802.1Q
    Bridge.";
}
identity remote-customer-access-port {
  base type-of-port;
  description
    "Indicates the port can be an S-TAG aware port of a Provider
    Bridge capable of providing Remote Customer Service Interfaces.";
}
identity bridge-interface {
  description
    "Generic interface property that represents any interface that can
    be associated with an IEEE 802.1Q compliant Bridge component. Any
    new Interface types would derive from this identity to
    automatically pick up Bridge related configuration or operational
    data.";
}
container bridges {
  description
    "Contains the Bridge(s) configuration information.";
  list bridge {
    key "name";
    unique "address";
    description
      "Provides configuration data in support of the Bridge
      Configuration resources. There is a single bridge data node per
      Bridge.";
    leaf name {
      type dot1qtypes:name-type;
      description
        "A text string associated with the Bridge, of locally
        determined significance.";
      reference
        "12.4 of IEEE Std 802.1Q-2022";
    }
    leaf address {
      type ieee:mac-address;
      mandatory true;
      description
        "The MAC address for the Bridge from which the Bridge
        Identifiers used by the STP, RSTP, and MSTP are derived.";
      reference
        "12.4 of IEEE Std 802.1Q-2022";
    }
    leaf bridge-type {
      type identityref {
        base type-of-bridge;
      }
      mandatory true;
      description
        "The type of Bridge.";
    }
    leaf ports {
      type uint16 {
        range "1..4095";
      }
      config false;
      description
        "The number of Bridge Ports (MAC Entities)";
      reference
        "12.4 of IEEE Std 802.1Q-2022";
    }
```

```
leaf up-time {
  type yang:zero-based-counter32;
  units "seconds";
  config false;
  description
    "The count in seconds of the time elapsed since the Bridge was
    last reset or initialized.";
  reference
    "12.4 of IEEE Std 802.1Q-2022";
}
leaf components {
  type uint32;
  config false;
  description
    "The number of components associated with the Bridge.";
}
list component {
  key "name";
  description
    "The set of components associated with a given Bridge. For
    example, - A TPMR is associated with a single VLAN unaware
    component. - A Customer VLAN Bridge is associated with a
    single VLAN aware component. - A Provider Bridge is associated
    with a single S-VLAN component and zero or more C-VLAN
    components.";
  reference
    "Item 1)a in 12.4.1.5 of IEEE Std 802.1Q-2022";
  leaf name {
    type string;
    description
      "The name of the Component.";
  }
  leaf id {
    type uint32;
    description
      "Unique identifier for a particular Bridge component within
      the system.";
    reference
      "Item l) in 12.3 of IEEE Std 802.1Q-2022";
  }
  leaf type {
    type identityref {
      base type-of-component;
    }
    mandatory true;
    description
      "The type of component used to classify a particular Bridge
      component within a Bridge system comprising multiple
      components.";
    reference
      "Item m) in 12.3 of IEEE Std 802.1Q-2022";
  }
  leaf address {
    type ieee:mac-address;
    description
      "Unique EUI-48 Universally Administered MAC address assigned
      to a Bridge component.";
    reference
      "13.24, 8.13.8 of IEEE Std 802.1Q-2022";
  }
  leaf traffic-class-enabled {
    type boolean;
    default "true";
    description
      "Indication of Traffic Classes enablement associated with
      the Bridge Component. A value of True indicates that Traffic
      Classes are enabled on this Bridge Component. A value of
      False indicates that the Bridge Component operates with a
      single priority level for all traffic.";
    reference
      "12.4.1.5.1 of IEEE Std 802.1Q-2022";
  }
```

```
leaf ports {
  type uint16 {
    range "1..4095";
  }
  config false;
  description
    "The number of Bridge Ports associated with the Bridge
    Component.";
  reference
    "Item c) in 12.4.1.1.3 of IEEE Std 802.1Q-2022";
}
leaf-list bridge-port {
  type if:interface-ref;
  config false;
  description
    "List of bridge-port references.";
}
container capabilities {
  config false;
  description
    "Array of Boolean values of the feature capabilities
    associated with a given Bridge Component.";
  reference
    "Item b) in 12.10.1.1.3, 12.4.1.5.2 of IEEE Std 802.1Q-2022";
  leaf extended-filtering {
    type boolean;
    default "false";
    description
      "Can perform filtering on individual multicast addresses
      controlled by MMRP.";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf traffic-classes {
    type boolean;
    default "false";
    description
      "Can map priority to multiple traffic classes.";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf static-entry-individual-port {
    type boolean;
    default "false";
    description
      "Static entries per port.";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf ivl-capable {
    type boolean;
    default "true";
    description
      "Independent VLAN Learning (IVL).";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf svl-capable {
    type boolean;
    default "false";
    description
      "Shared VLAN Learning (SVL).";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
  }
  leaf hybrid-capable {
    type boolean;
    default "false";
    description
      "Both IVL and SVL simultaneously.";
    reference
      "12.4.1.5.2 of IEEE Std 802.1Q-2022";
```

```
    }
    leaf configurable-pvid-tagging {
      type boolean;
      default "false";
      description
        "Whether the implementation supports the ability to
        override the default PVID setting and its egress status
        (VLAN-tagged or Untagged) on each port.";
      reference
        "12.4.1.5.2 of IEEE Std 802.1Q-2022";
    }
    leaf local-vlan-capable {
      type boolean;
      default "false";
      description
        "Can support multiple local Bridges, outside the scope of
        802.1Q defined VLANs.";
      reference
        "12.4.1.5.2 of IEEE Std 802.1Q-2022";
    }
  }
  container filtering-database {
    when
      "not(derived-from-or-self(../../bridge-type, "+
      "'two-port-mac-relay-bridge'))" {
      description
        "Applies to non TPMRs.";
    }
    description
      "Contains filtering information used by the Forwarding
      Process in deciding through which Ports of the Bridge frames
      should be forwarded.";
    reference
      "12.7 of IEEE Std 802.1Q-2022";
    leaf aging-time {
      type uint32 {
        range "10..10000000";
      }
      units "seconds";
      default "300";
      description
        "The timeout period in seconds for aging out
        dynamically-learned forwarding information.";
      reference
        "12.7, 8.8.3 of IEEE Std 802.1Q-2022";
    }
    leaf size {
      type yang:gauge32;
      config false;
      description
        "The maximum number of entries that can be held in the
        FDB.";
      reference
        "12.7 of IEEE Std 802.1Q-2022";
    }
    leaf static-entries {
      type yang:gauge32;
      config false;
      description
        "The number of Static Filtering entries currently in the
        FDB.";
      reference
        "12.7, 8.8.1 of IEEE Std 802.1Q-2022";
    }
    leaf dynamic-entries {
      type yang:gauge32;
      config false;
      description
        "The number of Dynamic Filtering entries currently in the
        FDB.";
      reference
        "12.7, 8.8.3 of IEEE Std 802.1Q-2022";
```

```
}
leaf static-vlan-registration-entries {
  type yang:gauge32;
  config false;
  description
    "The number of Static VLAN Registration entries currently
    in the FDB.";
  reference
    "12.7, 8.8.2 of IEEE Std 802.1Q-2022";
}
leaf dynamic-vlan-registration-entries {
  type yang:gauge32;
  config false;
  description
    "The number of Dynamic VLAN Registration entries currently
    in the FDB.";
  reference
    "12.7, 8.8.5 of IEEE Std 802.1Q-2022";
}
leaf mac-address-registration-entries {
  if-feature "extended-filtering-services";
  type yang:gauge32;
  config false;
  description
    "The number of MAC Address Registration entries currently
    in the FDB.";
  reference
    "12.7, 8.8.4 of IEEE Std 802.1Q-2022";
}
list filtering-entry {
  key "database-id vids address";
  description
    "Information for the entries associated with the Permanent
    Database.";
  leaf database-id {
    type uint32;
    description
      "The identity of this Filtering Database.";
    reference
      "12.7.7 of IEEE Std 802.1Q-2022";
  }
  leaf address {
    type ieee:mac-address;
    description
      "A MAC address (unicast, multicast, broadcast) for which
      the device has forwarding and/or filtering information.";
    reference
      "12.7.7 of IEEE Std 802.1Q-2022";
  }
  leaf vids {
    type dot1qtypes:vid-range-type;
    description
      "The set of VLAN identifiers to which this entry
      applies.";
    reference
      "12.7.7 of IEEE Std 802.1Q-2022";
  }
  leaf entry-type {
    type enumeration {
      enum static {
        description
          "Static entry type";
      }
      enum dynamic {
        description
          "Dynamic/learnt entry type";
      }
    }
    description
      "The type of filtering entry. Whether static or dynamic.
      Static entries can be created, deleted, and retrieved.
      However, dynamic entries can only be deleted or
```

```
        retrieved by the management entity. Consequently, a
        Bridge is not required to accept a command that can
        alter the dynamic entries except delete a dynamic entry.";
      reference
        "12.7.7 of IEEE Std 802.1Q-2022";
    }
    uses dot1qtypes:port-map-grouping;
    leaf status {
      type enumeration {
        enum other {
          description
            "None of the following. This may include the case
            where some other object is being used to determine
            if and how frames addressed to the value of the
            corresponding instance of 'address' are being
            forwarded.";
        }
        enum invalid {
          description
            "This entry is no longer valid (e.g., it was learned
            but has since aged out), but has not yet been
            flushed from the table.";
        }
        enum learned {
          description
            "The value of the corresponding instance of the port
            node was learned and is being used.";
        }
        enum self {
          description
            "The value of the corresponding instance of the
            address node representing one of the devices
            address.";
        }
        enum mgmt {
          description
            "The value of the corresponding instance of address
            node that is also the value of an existing instance.";
        }
      }
      config false;
      description
        "The status of this entry.";
    }
  }
  list vlan-registration-entry {
    key "database-id vids";
    description
      "The VLAN Registration Entries models the operations that
      can be performed on a single VLAN Registration Entry in
      the FDB. The set of VLAN Registration Entries within the
      FDB changes under management control and also as a result
      of MVRP exchanges";
    reference
      "12.7.5 of IEEE Std 802.1Q-2022";
    leaf database-id {
      type uint32;
      description
        "The identity of this Filtering Database.";
      reference
        "12.7.7 of IEEE Std 802.1Q-2022";
    }
    leaf vids {
      type dot1qtypes:vid-range-type;
      description
        "The set of VLAN identifiers to which this entry
        applies.";
      reference
        "12.7.7 of IEEE Std 802.1Q-2022";
    }
    leaf entry-type {
      type enumeration {
```

```
        enum static {
          description
            "Static entry type";
        }
        enum dynamic {
          description
            "Dynamic/learnt entry type";
        }
      }
      description
        "The type of filtering entry. Whether static or dynamic.
        Static entries can be created, deleted, and retrieved.
        However, dynamic entries can only be deleted or
        retrieved by the management entity. Consequently, a
        Bridge is not required to accept a command that can
        alter the dynamic entries except delete a dynamic entry.";
      reference
        "12.7.7 of IEEE Std 802.1Q-2022";
    }
    uses dot1qtypes:port-map-grouping;
  }
}
container permanent-database {
  description
    "The Permanent Database container models the operations that
    can be performed on, or affect, the Permanent Database.
    There is a single Permanent Database per FDB.";
  leaf size {
    type yang:gauge32;
    config false;
    description
      "The maximum number of entries that can be held in the
      FDB.";
    reference
      "12.7.6 of IEEE Std 802.1Q-2022";
  }
  leaf static-entries {
    type yang:gauge32;
    config false;
    description
      "The number of Static Filtering entries currently in the
      FDB.";
    reference
      "12.7.6 of IEEE Std 802.1Q-2022";
  }
  leaf static-vlan-registration-entries {
    type yang:gauge32;
    config false;
    description
      "The number of Static VLAN Registration entries currently
      in the FDB.";
    reference
      "12.7.6 of IEEE Std 802.1Q-2022";
  }
  list filtering-entry {
    key "database-id vids address";
    description
      "Information for the entries associated with the Permanent
      Database.";
    leaf database-id {
      type uint32;
      description
        "The identity of this Filtering Database.";
      reference
        "12.7.7 of IEEE Std 802.1Q-2022";
    }
    leaf address {
      type ieee:mac-address;
      description
        "A MAC address (unicast, multicast, broadcast) for which
        the device has forwarding and/or filtering information.";
      reference
```

```
        "12.7.7 of IEEE Std 802.1Q-2022";
      }
      leaf vids {
        type dot1qtypes:vid-range-type;
        description
          "The set of VLAN identifiers to which this entry
          applies.";
        reference
          "12.7.7 of IEEE Std 802.1Q-2022";
      }
      leaf status {
        type enumeration {
          enum other {
            description
              "None of the following. This may include the case
              where some other object is being used to determine
              if and how frames addressed to the value of the
              corresponding instance of 'address' are being
              forwarded.";
          }
          enum invalid {
            description
              "This entry is no longer valid (e.g., it was learned
              but has since aged out), but has not yet been
              flushed from the table.";
          }
          enum learned {
            description
              "The value of the corresponding instance of the port
              node was learned and is being used.";
          }
          enum self {
            description
              "The value of the corresponding instance of the
              address node representing one of the devices
              address.";
          }
          enum mgmt {
            description
              "The value of the corresponding instance of address
              node that is also the value of an existing instance.";
          }
        }
        config false;
        description
          "The status of this entry.";
      }
      uses dot1qtypes:port-map-grouping;
    }
  }
  container bridge-vlan {
    when
      "not(derived-from-or-self(../../bridge-type, "+
      "'two-port-mac-relay-bridge'))" {
      description
        "Applies to non TPMRs.";
    }
    description
      "The Bridge VLAN container models configuration information
      that modify, or inquire about, the overall configuration of
      the Bridges VLAN resources. There is a single Bridge VLAN
      Configuration managed object per Bridge.";
    reference
      "12.10 of IEEE Std 802.1Q-2022";
    leaf version {
      type uint16;
      config false;
      description
        "The version number supported.";
      reference
        "12.10.1.3 of IEEE Std 802.1Q-2022";
    }
```

```
leaf max-vids {
  type uint16;
  config false;
  description
    "The maximum number of VIDs supported.";
  reference
    "12.10.1.3 of IEEE Std 802.1Q-2022";
}
leaf override-default-pvid {
  type boolean;
  default "false";
  config false;
  description
    "Indicates if the default PVID can be overridden, and its
    egress status (VLAN-tagged or untagged) on each port.";
  reference
    "12.10.1.3 of IEEE Std 802.1Q-2022";
}
leaf protocol-template {
  if-feature "port-and-protocol-based-vlan";
  type dot1qtypes:protocol-frame-format-type;
  config false;
  description
    "The data-link encapsulation format or the
    detagged_frame_type in a Protocol Template";
  reference
    "12.10.1.7 of IEEE Std 802.1Q-2022";
}
leaf max-msti {
  type uint16;
  config false;
  description
    "The maximum number of MSTIs supported within an MST
    region (i.e., the number of spanning tree instances that
    can be supported in addition to the CIST), for MST
    Bridges. For SST Bridges, this parameter may be either
    omitted or reported as 0.";
  reference
    "12.10.1.7 of IEEE Std 802.1Q-2022";
}
list vlan {
  key "vid";
  description
    "List of VLAN related configuration nodes associated with
    the Bridge.";
  reference
    "12.10.2 of IEEE Std 802.1Q-2022";
  leaf vid {
    type dot1qtypes:vlan-index-type;
    description
      "The VLAN identifier to which this entry applies.";
    reference
      "12.10.2 of IEEE Std 802.1Q-2022";
  }
  leaf name {
    type dot1qtypes:name-type;
    description
      "A text string of up to 32 characters of locally
      determined significance.";
    reference
      "12.10.2 of IEEE Std 802.1Q-2022";
  }
  leaf-list untagged-ports {
    type if:interface-ref;
    config false;
    description
      "The set of ports in the untagged set for this VID.";
    reference
      "12.10.2.1.3, 8.8.2 of IEEE Std 802.1Q-2022";
  }
  leaf-list egress-ports {
    type if:interface-ref;
```

```
      config false;
      description
        "The set of egress ports in the member set for this VID.";
      reference
        "12.10.2.1.3, 8.8.10 of IEEE Std 802.1Q-2022";
    }
  }
  list protocol-group-database {
    if-feature "port-and-protocol-based-vlan";
    key "db-index";
    description
      "List of the protocol group database entries.";
    reference
      "12.10.1.7, 6.12.3 of IEEE Std 802.1Q-2022";
    leaf db-index {
      type uint16;
      description
        "The protocol group database index.";
    }
    leaf frame-format-type {
      type dot1qtypes:protocol-frame-format-type;
      description
        "The data-link encapsulation format or the
        detagged_frame_type in a Protocol Template";
      reference
        "12.10.1.7 of IEEE Std 802.1Q-2022";
    }
    choice frame-format {
      description
        "The identification of the protocol above the data-link
        layer in a Protocol Template. Depending on the frame
        type, the octet string will have one of the following
        values: - For ethernet, rfc1042 and snap8021H, this is
        the 16-bit (2-octet) IEEE 802 Clause 9.3 EtherType
        field. - For snapOther, this is the 40-bit (5-octet)
        PID. - For llcOther, this is the 2-octet IEEE 802.2 Link
        Service Access Point (LSAP) pair: first octet for
        Destination Service Access Point (DSAP) and second octet
        for Source Service Access Point (SSAP).";
      reference
        "12.10.1.7 of IEEE Std 802.1Q-2022";
      case ethernet-rfc1042-snap8021H {
        when
          "frame-format-type = 'Ethernet' or "+
          "frame-format-type = 'rfc1042' or frame-format-type "+
          "= 'snap8021H'" {
          description
            "Applies to Ethernet, RFC 1042, SNAP 8021H frame
            formats.";
        }
        description
          "Identifier used if Ethenet, RFC1042, or SNAP 8021H.";
        leaf ethertype {
          type dot1qtypes:ethertype-type;
          description
            "Format containing the 16-bit IEEE 802 EtherType
            field.";
          reference
            "9.3 of IEEE Std 802-2014";
        }
      }
      case snap-other {
        when
          "frame-format-type = 'snapOther'" {
          description
            "Applies to Snap Other frame formats.";
        }
        description
          "Identifier used if SNAP other.";
        leaf protocol-id {
          type string {
            pattern "[0-9a-fA-F]{2}(-[0-9a-fA-F]{2}){4}";
```

```
        }
        description
          "Format containing the 40-bit protocol identifier
          (PID). The canonical representation uses uppercase
          characters.";
        reference
          "12.10.1.7.1 of IEEE Std 802.1Q-2022";
      }
    }
    case llc-other {
      when
        "frame-format-type = 'llcOther'" {
        description
          "Applies to LLC Other frame formats";
      }
      description
        "Identifier used if LLC other.";
      container dsap-ssap-pairs {
        description
          "A pair of ISO/IEC 8802-2 DSAP and SSAP address
          field values, for matching frame formats of
          LLC_Other.";
        leaf llc-address {
          type string {
            pattern "[0-9a-fA-F]{2}-[0-9a-fA-F]{2}";
          }
          description
            "A pair of ISO/IEC 8802-2 DSAP and SSAP address
            field values, for matching frame formats of
            LLC_Other. The canonical representation uses
            uppercase characters.";
          reference
            "12.10.1.7.1 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
  leaf group-id {
    type uint32;
    description
      "Designates a group of protocols in the Protocol Group
      Database.";
    reference
      "6.12.2 of IEEE Std 802.1Q-2022";
  }
}
list vid-to-fid-allocation {
  key "vids";
  description
    "This list allows inquiries about VID to FID allocations.";
  leaf vids {
    type dot1qtypes:vid-range-type;
    description
      "Range of VLAN identifiers.";
    reference
      "12.10.3 of IEEE Std 802.1Q-2022";
  }
  leaf fid {
    type uint32;
    config false;
    description
      "The Filtering Database used by a set of VIDs.";
    reference
      "12.10.3 of IEEE Std 802.1Q-2022";
  }
  leaf allocation-type {
    type enumeration {
      enum undefined {
        description
          "No allocation defined.";
      }
      enum fixed {
```

```
        description
          "A fixed allocation to FID is defined.";
      }
      enum dynamic {
        description
          "A dynamic allocation to FID is defined.";
      }
    }
    config false;
    description
      "The type of allocation used";
    reference
      "12.10.3 of IEEE Std 802.1Q-2022";
  }
}
list fid-to-vid-allocation {
  key "fid";
  description
    "The FID to VID allocations managed object models
    operations that inquire about FID to VID allocations.";
  leaf fid {
    type uint32;
    description
      "The Filtering Database used by a set of VIDs.";
    reference
      "12.10.3 of IEEE Std 802.1Q-2022";
  }
  leaf allocation-type {
    type enumeration {
      enum undefined {
        description
          "No allocation defined.";
      }
      enum fixed {
        description
          "A fixed allocation to FID is defined.";
      }
      enum dynamic {
        description
          "A dynamic allocation to FID is defined.";
      }
    }
    config false;
    description
      "The type of allocation used";
    reference
      "12.10.3 of IEEE Std 802.1Q-2022";
  }
  leaf-list vid {
    type dot1qtypes:vlan-index-type;
    config false;
    description
      "The VLAN identifier to which this entry applies.";
    reference
      "12.7.7 of IEEE Std 802.1Q-2022";
  }
}
list vid-to-fid {
  key "vid";
  description
    "Fixed allocation of a VID to an FID. The underlying
    system will ensure that subsequent commands that make
    changes to the VID to FID mapping can override previous
    associations.";
  reference
    "12.10.3.4, 12.10.3.5 of IEEE Std 802.1Q-2022";
  leaf vid {
    type dot1qtypes:vlan-index-type;
    description
      "A list of VLAN identifier associated with a given
      database identifier (i.e., FID).";
    reference
```

```
            "12.7.7 of IEEE Std 802.1Q-2022";
        }
        leaf fid {
          type uint32;
          description
            "The Filtering Database used by this VLAN";
          reference
            "12.10.3 of IEEE Std 802.1Q-2022";
        }
      }
    }
    container bridge-mst {
      when
        "not(derived-from-or-self(../../bridge-type, "+
        "'two-port-mac-relay-bridge'))" {
        description
          "Applies to non TPMRs.";
      }
      description
        "The Bridge MST container models configuration information
        that modify, or inquire about, the overall configuration of
        the Bridges MST resources.";
      reference
        "12.12 of IEEE Std 802.1Q-2022";
      leaf-list mstid {
        type dot1qtypes:mstid-type;
        description
          "The list of MSTID values that are currently supported by
          the Bridge";
      }
      list fid-to-mstid {
        key "fid";
        description
          "The FID to MSTID allocation table.";
        reference
          "12.12.2 of IEEE Std 802.1Q-2022";
        leaf fid {
          type uint32;
          description
            "The Filtering Database identifier.";
          reference
            "12.12.2 of IEEE Std 802.1Q-2022";
        }
        leaf mstid {
          type dot1qtypes:mstid-type;
          description
            "The MSTID to which the FID is to be allocated.";
          reference
            "12.12.2 of IEEE Std 802.1Q-2022";
        }
      }
      list fid-to-mstid-allocation {
        key "fids";
        description
          "The FID to MSTID allocation table";
        leaf fids {
          type dot1qtypes:vid-range-type;
          description
            "Range of FIDs.";
          reference
            "12.12.2 of IEEE Std 802.1Q-2022";
        }
        leaf mstid {
          type dot1qtypes:mstid-type;
          description
            "The MSTID to which the FID is allocated.";
          reference
            "12.12.2 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
```

```
  }
}
augment "/if:interfaces/if:interface" {
  when
    "derived-from-or-self(if:type,'ianaif:bridge') or "+
    "derived-from-or-self(if:type,'ianaif:ethernetCsmacd') or "+
    "derived-from-or-self(if:type,'ianaif:ieee8023adLag') or "+
    "derived-from-or-self(if:type,'ianaif:ilan')" {
    description
      "Applies when a Bridge interface.";
  }
  description
    "Augment the interface model with the Bridge Port";
  container bridge-port {
    description
      "Bridge Port is an extension of the IETF Interfaces model
      (RFC7223).";
    leaf component-name {
      type string;
      description
        "Used to reference configured Component node.";
    }
    leaf port-type {
      type identityref {
        base type-of-port;
      }
      description
        "The port type. Indicates the capabilities of this port.";
      reference
        "12.4.2.1 of IEEE Std 802.1Q-2022";
    }
    leaf pvid {
      when
        "../component-name != 'd-bridge-component'" {
        description
          "Applies to non TPMRs";
      }
      type dot1qtypes:vlan-index-type;
      default "1";
      description
        "The primary (default) VID assigned to a specific Bridge Port.";
      reference
        "12.10.1, 5.4, item m) of IEEE Std 802.1Q-2022";
    }
    leaf default-priority {
      type dot1qtypes:priority-type;
      default "0";
      description
        "The default priority assigned to a specific Bridge Port.";
      reference
        "12.6.2 of IEEE Std 802.1Q-2022";
    }
    container priority-regeneration {
      description
        "The Priority Regeneration Table parameters associated with a
        specific Bridge Port. A list of Regenerated User Priorities
        for each received priority on each port of a Bridge. The
        regenerated priority value may be used to index the Traffic
        Class Table for each input port. This only has effect on media
        that support native priority. The default values for
        Regenerated User Priorities are the same as the User
        Priorities";
      reference
        "12.6.2, 6.9.4 of IEEE Std 802.1Q-2022";
      uses dot1qtypes:priority-regeneration-table-grouping;
    }
    leaf pcp-selection {
      type dot1qtypes:pcp-selection-type;
      default "8P0D";
      description
        "The Priority Code Point selection assigned to a specific
        Bridge Port. This object identifies the rows in the PCP
```

```
    encoding and decoding tables that are used to remark frames on
    this port if this remarking is enabled";
  reference
    "12.6.2, 6.9.3 of IEEE Std 802.1Q-2022";
}
container pcp-decoding-table {
  description
    "The Priority Code Point Decoding Table parameters associated
    with a specific Bridge Port.";
  uses dot1qtypes:pcp-decoding-table-grouping;
}
container pcp-encoding-table {
  description
    "The Priority Code Point Encoding Table parameters associated
    with a specific Bridge Port.";
  uses dot1qtypes:pcp-encoding-table-grouping;
}
leaf use-dei {
  type boolean;
  default "false";
  description
    "The Drop Eligible Indicator. If it is set to True, then the
    drop_eligible parameter is encoded in the DEI of transmitted
    frames, and the drop_eligible parameter shall be true(1) for a
    received frame if the DEI is set in the VLAN tag or the
    Priority Code Point Decoding Table indicates drop_eligible
    True for the received PCP value. If this parameter is False,
    the DEI shall be transmitted as zero and ignored on receipt.";
  reference
    "12.6.2, 6.9.3 of IEEE Std 802.1Q-2022";
}
leaf drop-encoding {
  type boolean;
  default "false";
  description
    "The Drop Encoding parameter. If a Bridge supports encoding or
    decoding of drop_eligible from the PCP field of a VLAN tag
    (6.7.3) on any of its Ports, then it shall implement a Boolean
    parameter Require Drop Encoding on each of its Ports with
    default value False. If Require Drop Encoding is True and the
    Bridge Port cannot encode particular priorities with
    drop_eligible, then frames queued with those priorities and
    drop_eligible True shall be discarded and not transmitted.";
  reference
    "12.6.2, 6.9.3 of IEEE Std 802.1Q-2022";
}
leaf service-access-priority-selection {
  type boolean;
  default "false";
  description
    "The Service Access Priority selection. Indication of whether
    the Service Access Priority Selection function is supported on
    the Customer Bridge Port to request priority handling of the
    frame from a Port-based service interface.";
  reference
    "12.6.2, 6.13 of IEEE Std 802.1Q-2022";
}
container service-access-priority {
  description
    "The Service Access Priority table parameters. A table that
    contains information about the Service Access Priority
    Selection function for a Provider Bridge. The use of this
    table enables a mechanism for a Customer Bridge attached to a
    Provider Bridged Network to request priority handling of
    frames.";
  reference
    "12.6.2, 6.13.1 of IEEE Std 802.1Q-2022";
  uses dot1qtypes:service-access-priority-table-grouping;
}
container traffic-class {
  description
    "The Traffic Class table parameters. A table mapping evaluated
```

```
      priority to Traffic Class, for forwarding by the Bridge";
    reference
      "12.6.3, 8.6.6 of IEEE Std 802.1Q-2022";
    uses dot1qtypes:traffic-class-table-grouping;
  }
  container transmission-selection-algorithm-table {
    description
      "The Transmission Selection Algorithm Table for a given Port
      assigns, for each traffic class that the Port supports, the
      transmission selection algorithm that is to be used to select
      frames for transmission from the corresponding queue.
      Transmission Selection Algorithm Tables may be managed, and
      allow the identification of vendor-specific transmission
      selection algorithms. The transmission selection algorithms
      are identified in the Transmission Selection Algorithm Table
      by means of integer identifiers.";
    reference
      "12.20.2, 8.6.8 of IEEE Std 802.1Q-2022";
    uses dot1qtypes:transmission-selection-table-grouping;
  }
  leaf acceptable-frame {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    type enumeration {
      enum admit-only-VLAN-tagged-frames {
        description
          "Admit only VLAN-tagged frames.";
      }
      enum admit-only-untagged-and-priority-tagged {
        description
          "Admit only untagged and priority-tagged frames.";
      }
      enum admit-all-frames {
        description
          "Admit all frames.";
      }
    }
    default "admit-all-frames";
    description
      "To configure the Acceptable Frame Types parameter associated
      with one or more Ports";
    reference
      "12.10.1.3, 6.9 of IEEE Std 802.1Q-2022";
  }
  leaf enable-ingress-filtering {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    type boolean;
    default "false";
    description
      "To enable the Ingress Filtering feature associated with one
      or more Ports.";
    reference
      "12.10.1.4, 8.6.2 of IEEE Std 802.1Q-2022";
  }
  leaf enable-restricted-vlan-registration {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    type boolean;
    default "false";
    description
      "To enable the Restricted VLAN Registration associated with
      one or more Ports.";
```

```
    reference
      "11.2.3.2.3, 12.10.1.6 of IEEE Std 802.1Q-2022";
  }
  leaf enable-vid-translation-table {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    type boolean;
    default "false";
    description
      "To enable VID Translation table associated with a Bridge
      Port. This is not applicable to Bridge Ports that do no
      support a VID Translation Table.";
    reference
      "12.10.1.8, 6.9 of IEEE Std 802.1Q-2022";
  }
  leaf enable-egress-vid-translation-table {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    type boolean;
    default "false";
    description
      "To enable Egress VID Translation table associated with a
      Bridge Port. This is not applicable to Ports that do not
      support an Egress VID Translation table.";
    reference
      "12.10.1.8, 6.9 of IEEE Std 802.1Q-2022";
  }
  list protocol-group-vid-set {
    when
      "../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    if-feature "port-and-protocol-based-vlan";
    key "group-id";
    description
      "The list of VID values associated with the Protocol Group
      Identifier for this port.";
    reference
      "12.10.1.1.3 of IEEE Std 802.1Q-2022";
    leaf group-id {
      type uint32;
      description
        "The protocol group identifier";
      reference
        "12.10.1.7 of IEEE Std 802.1Q-2022";
    }
    leaf-list vid {
      type dot1qtypes:vlanid;
      description
        "The VLAN identifier to which this entry applies.";
      reference
        "12.10.2 of IEEE Std 802.1Q-2022";
    }
  }
  leaf admin-point-to-point {
    type enumeration {
      enum force-true {
        value 1;
        description
          "Indicates that this port should always be treated as if
          it is connected to a point-to-point link.";
      }
      enum force-false {
        value 2;
        description
```

```
        "Indicates that this port should be treated as having a
        shared media connection.";
    }
    enum auto {
      value 3;
      description
        "Indicates that this port is considered to have a
        point-to-point link if it is an Aggregator and all of its
        members are aggregatable, or if the MAC entity is
        configured for full duplex operation, either through
        auto-negotiation or by management means.";
    }
  }
  description
    "For a port running spanning tree, this object represents the
    administrative point-to-point status of the LAN segment
    attached to this port, using the enumeration values of IEEE
    Std 802.1AC. A value of forceTrue(1) indicates that this port
    should always be treated as if it is connected to a
    point-to-point link. A value of forceFalse(2) indicates that
    this port should be treated as having a shared media
    connection. A value of auto(3) indicates that this port is
    considered to have a point-to-point link if it is an
    Aggregator and all of its members are aggregatable, or if the
    MAC entity is configured for full duplex operation, either
    through auto-negotiation or by management means. Manipulating
    this object changes the underlying adminPointToPointMAC.";
  reference
    "12.4.2, 6.8.2 of IEEE Std 802.1Q-2022";
}
leaf protocol-based-vlan-classification {
  when
    "../component-name != 'd-bridge-component'" {
    description
      "Applies to non TPMRs";
  }
  if-feature "port-and-protocol-based-vlan";
  type boolean;
  config false;
  description
    "A boolean indication indicating if Port-and-Protocol-based
    VLAN classification is supported on a given Port.";
  reference
    "5.4.1.2 of IEEE Std 802.1Q-2022";
}
leaf max-vid-set-entries {
  when
    "../component-name != 'd-bridge-component'" {
    description
      "Applies to non TPMRs";
  }
  if-feature "port-and-protocol-based-vlan";
  type uint16;
  config false;
  description
    "The maximum number of entries supported in the VID set on a
    given Port.";
  reference
    "12.10.1.1.3 of IEEE Std 802.1Q-2022";
}
leaf port-number {
  type dot1qtypes:port-number-type;
  config false;
  description
    "An integer that uniquely identifies a Bridge Port.";
  reference
    "Item i) in 12.3, 17.3.2.2 of IEEE Std 802.1Q-2022";
}
leaf address {
  type ieee:mac-address;
  config false;
  description
```

```
    "The specific MAC address of the individual MAC Entity
    associated with the Port.";
  reference
    "12.4.2, Item a) in 12.4.2.1.1.3 of IEEE Std 802.1Q-2022";
}
leaf capabilities {
  type bits {
    bit tagging {
      position 0;
      description
        "Supports 802.1Q VLAN tagging of frames and MVRP.";
    }
    bit configurable-acceptable-frame-type {
      position 1;
      description
        "Allows modified values of acceptable frame types";
    }
    bit ingress-filtering {
      position 2;
      description
        "Supports the discarding of any frame received on a Port
        whose VLAN classification does not include that Port in
        its member set.";
    }
  }
  config false;
  description
    "The feature capabilities associated with port. Indicates the
    parts of IEEE 802.1Q that are optional on a per-port basis,
    that are implemented by this device, and that are manageable.";
  reference
    "Item c) in 12.10.1.1.3, 12.4.2 of IEEE Std 802.1Q-2022";
}
leaf type-capabilties {
  type bits {
    bit customer-vlan-port {
      position 0;
      description
        "Indicates the port can be a C-TAG aware port of an
        enterprise VLAN aware Bridge";
    }
    bit provider-network-port {
      position 1;
      description
        "Indicates the port can be an S-TAG aware port of a
        Provider Bridge or Backbone Edge Bridge used for
        connections within a PBN or PBBN.";
    }
    bit customer-network-port {
      position 2;
      description
        "Indicates the port can be an S-TAG aware port of a
        Provider Bridge or Backbone Edge Bridge used for
        connections to the exterior of a PBN or PBBN.";
    }
    bit customer-edge-port {
      position 3;
      description
        "Indicates the port can be a C-TAG aware port of a
        Provider Bridge used for connections to the exterior of a
        PBN or PBBN.";
    }
    bit customer-backbone-port {
      position 4;
      description
        "Indicates the port can be a I-TAG aware port of a
        Backbone Edge Bridge's B-component.";
    }
    bit virtual-instance-port {
      position 5;
      description
        "Indicates the port can be a virtual S-TAG aware port
```

```
          within a Backbone Edge Bridge's I-component which is
          responsible for handling S-tagged traffic for a specific
          backbone service instance.";
      }
      bit d-bridge-port {
        position 6;
        description
          "Indicates the port can be a VLAN-unaware member of an
          802.1Q Bridge.";
      }
      bit remote-customer-access-port {
        position 7;
        description
          "Indicates the port can be an S-TAG aware port of a
          Provider Bridge capable of providing Remote Customer
          Service Interfaces.";
      }
      bit station-facing-bridge-port {
        position 8;
        description
          "Indicates the station-facing Bridge Port in a EVB Bridge.";
      }
      bit uplink-access-port {
        position 9;
        description
          "Indicates the uplink access port in an EVB Bridge or EVB
          station.";
      }
      bit uplink-relay-port {
        position 10;
        description
          "Indicates the uplink relay port in an EVB station.";
      }
    }
    config false;
    description
      "The type of feature capabilities supported with port.
      Indicates the capabilities of this port.";
    reference
      "12.4.2 of IEEE Std 802.1Q-2022";
  }
  leaf external {
    type boolean;
    config false;
    description
      "A boolean indicating whether the port is external. A value of
      True means the port is external. A value of False means the
      port is internal.";
    reference
      "12.4.2 of IEEE Std 802.1Q-2022";
  }
  leaf oper-point-to-point {
    type boolean;
    config false;
    description
      "For a port running spanning tree, this object represents the
      operational point-to-point status of the LAN segment attached
      to this port. It indicates whether a port is considered to
      have a point-to-point connection.

      If admin-point-to-point is set to auto(2), then the value of
      oper-point-to-point is determined in accordance with the
      specific procedures defined for the MAC entity concerned, as
      defined in IEEE Std 802.1AC.

      The value is determined dynamically; that is, it is
      re-evaluated whenever the value of admin-point-to-point
      changes, and whenever the specific procedures defined for the
      MAC entity evaluate a change in its point-to-point status.";
    reference
      "IEEE Std 802.1AC;" +
      "12.4.2 of IEEE Std 802.1Q-2022";
```

```
}
leaf media-dependent-overhead {
  type uint8;
  units "octets";
  config false;
  description
    "The portMediaDependentOverhead parameter provides the number
    of additional octets for media-dependent framing. The overhead
    includes all octets prior the first octet of the Destination
    Address field and all octets after the last octet of the frame
    check sequence.";
  reference
    "12.4.2 of IEEE Std 802.1Q-2022";
}
container statistics {
  config false;
  description
    "Container of operational state node information associated
    with the bridge port.";
  uses dot1qtypes:bridge-port-statistics-grouping;
  leaf discard-on-ingress-filtering {
    when
      "../../component-name != 'd-bridge-component'" {
      description
        "Applies to non TPMRs";
    }
    if-feature "ingress-filtering";
    type yang:counter64;
    description
      "The number of frames that were discarded as a result of
      Ingress Filtering being enabled.

      Discontinuities in the value of this counter can occur at
      re-initialization of the management system, and at other
      times as indicated by the value of 'discontinuity-time'.";
    reference
      "12.6.1.1.3 of IEEE Std 802.1Q-2022";
  }
}
list vid-translations {
  when
    "../component-name != 'd-bridge-component'" {
    description
      "Applies to non TPMRs";
  }
  key "local-vid";
  description
    "To configure the VID Translation Table (6.9) associated with
    a Port. This object is not applicable to Ports that do not
    support a VID Translation Table. The default configuration of
    the table has the value of the Relay VID equal to the value of
    the Local VID. If no local VID is configured, then it is
    assumed that the relay VID is the same value as the local VID.

    If the port supports an Egress VID translation table, the VID
    Translation Configuration object configures the Local VID to
    Relay VID mapping on ingress only. If an Egress VID
    translation is not supported, the VID Translation
    Configuration object defines a single bidirectional mapping.
    In this case, the Bridge should not allow multiple keys
    ('local-vid') mapped to the same 'relay-vid' value.";
  leaf local-vid {
    type dot1qtypes:vlanid;
    description
      "The Local VID after translation received at the ISS or
      EISS.";
    reference
      "12.10.1.8, 6.9 of IEEE Std 802.1Q-2022";
  }
  leaf relay-vid {
    type dot1qtypes:vlanid;
    description
```

```
            "The Relay VID received before translation received at ISS
            or EISS.";
          reference
            "12.10.1.8, 6.9 of IEEE Std 802.1Q-2022";
        }
      }
      list egress-vid-translations {
        when
          "../component-name != 'd-bridge-component'" {
          description
            "Applies to non TPMRs";
        }
        key "relay-vid";
        description
          "To configure the Egress VID Translation Table (6.9)
          associated with a Port. This object is not applicable to Ports
          that do not support an Egress VID Translation Table. The
          default configuration of the table has the value of the Local
          VID equal to the value of the Relay VID. If no Relay VID is
          configured, then it is assumed that the local VID is the same
          value as the relay VID.";
        leaf relay-vid {
          type dot1qtypes:vlanid;
          description
            "The Relay VID received before translation received at ISS
            or EISS.";
          reference
            "12.10.1.9, 6.9 of IEEE Std 802.1Q-2022";
        }
        leaf local-vid {
          type dot1qtypes:vlanid;
          description
            "The Local VID after translation received at the ISS or
            EISS.";
          reference
            "12.10.1.9, 6.9 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }
}
```

48.6.5 The ieee802-dot1q-tpmr YANG module

```
module ieee802-dot1q-tpmr {
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-tpmr;
  prefix dot1q-tpmr;
  import ieee802-dot1q-bridge {
    prefix dot1q;
  }
  import ietf-yang-types {
    prefix yang;
  }
  import ietf-interfaces {
    prefix if;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
           IEEE Standards Association
           445 Hoes Lane
           Piscataway, NJ 08854
           USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This YANG module describes the bridge configuration model for the
    Two Port MAC Relays.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022. Third version.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Second version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  revision 2018-09-30 {
    description
      "Creation for Working Group review.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
  }
  revision 2018-03-07 {
    description
      "Published as part of IEEE Std 802.1Q-2018. Initial version.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
  }
  augment "/if:interfaces/if:interface/dot1q:bridge-port" {
    when
      "dot1q:port-type = 'dot1q:d-bridge-port'" {
      description
        "Applies to TPMRs ports";
    }
    description
      "Augment Interface model with TPMR port configuration specific
      nodes.";
    leaf managed-address {
```

```
    type boolean;
    default "true";
    description
      "A Boolean value, which is TRUE if the MAC address is the
      management address for the TPMR, and is otherwise FALSE.

      The TPMR management entity may make use of one or both Ports of
      a TPMR to transmit and receive management frames. However, the
      MAC address used by the TPMR management entity as the source MAC
      address in transmitted management frames (the management MAC
      address) is the individual MAC address associated with one of
      the Ports of the TPMR";
    reference
      "12.19.1.1.1.3 of IEEE Std 802.1Q-2022";
  }
  container mac-status-propagation {
    description
      "MAC status propagation configuration node parameters.";
    leaf link-notify {
      type boolean;
      default "true";
      description
        "The current value (Boolean) of LinkNotify (23.5.1) being used
        by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf link-notify-wait {
      type yang:timeticks {
        range "20..100";
      }
      default "40";
      description
        "The current value, in centiseconds, of LinkNotifyWait
        (23.5.2) being used by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf link-notify-retry {
      type yang:timeticks {
        range "10..100";
      }
      default "100";
      description
        "The current value, in centiseconds, of LinkNotifyRetry
        (23.5.3) being used by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf mac-notify {
      type boolean;
      default "true";
      description
        "The current value (Boolean) of MACNotify (23.5.4) being used
        by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf mac-notify-time {
      type yang:timeticks {
        range "1..50";
      }
      default "20";
      description
        "The current value, in centiseconds, of MACNotifyTime (23.5.5)
        being used by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf mac-recover-time {
      type yang:timeticks {
        range "2..50";
```

```
      }
      default "10";
      description
        "The current value, in centiseconds, of MACRecoverTime
        (23.5.6) being used by the MSP state machines.";
      reference
        "12.19.4.1.1.3, 12.19.4.1.2.2 of IEEE Std 802.1Q-2022";
    }
  }
}
augment
  "/if:interfaces/if:interface/dot1q:bridge-port/dot1q:statistics" {
  when
    "../dot1q:port-type = 'dot1q:d-bridge-port'" {
    description
      "Applies to TPMRs ports";
  }
  description
    "Augment Interface model with TPMR port operational state specific
    nodes.";
  leaf acks-tx {
    type yang:counter64;
    config false;
    description
      "The number of acks transmitted (23.6.15) by the Ports Transmit
      Process as a consequence of txAck being set.

      Discontinuities in the value of this counter can occur at
      re-initialization of the management system, and at other times
      as indicated by the value of 'discontinuity-time'.";
    reference
      "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
  }
  leaf add-notificatons-tx {
    type yang:counter64;
    config false;
    description
      "The number of adds transmitted (23.6.16) by the Ports Transmit
      Process as a consequence of txAdd being set.

      Discontinuities in the value of this counter can occur at
      re-initialization of the management system, and at other times
      as indicated by the value of 'discontinuity-time'.";
    reference
      "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
  }
  leaf add-confirmations-tx {
    type yang:counter64;
    config false;
    description
      "The number of add confirms transmitted (23.6.17) by the Ports
      Transmit Process as a consequence of txAddConfirm being set.

      Discontinuities in the value of this counter can occur at
      re-initialization of the management system, and at other times
      as indicated by the value of 'discontinuity-time'.";
    reference
      "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
  }
  leaf loss-notification-tx {
    type yang:counter64;
    config false;
    description
      "The number of losses transmitted (23.6.18) by the Ports
      Transmit Process as a consequence of txLoss being set.

      Discontinuities in the value of this counter can occur at
      re-initialization of the management system, and at other times
      as indicated by the value of 'discontinuity-time'.";
    reference
      "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
  }
```

```
leaf loss-confirmation-tx {
  type yang:counter64;
  config false;
  description
    "The number of loss confirms transmitted (23.6.19) by the Ports
    Transmit Process as a consequence of txLossConfirm being set.

    Discontinuities in the value of this counter can occur at
    re-initialization of the management system, and at other times
    as indicated by the value of 'discontinuity-time'.";
  reference
    "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
}
leaf acks-rx {
  type yang:counter64;
  config false;
  description
    "The number of acks received (23.6.10) by the Ports Transmit
    Process.

    Discontinuities in the value of this counter can occur at
    re-initialization of the management system, and at other times
    as indicated by the value of 'discontinuity-time'.";
  reference
    "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
}
leaf add-notificatons-rx {
  type yang:counter64;
  config false;
  description
    "The number of adds received (23.6.11) by the Ports Receive
    Process.

    Discontinuities in the value of this counter can occur at
    re-initialization of the management system, and at other times
    as indicated by the value of 'discontinuity-time'.";
  reference
    "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
}
leaf add-confirmations-rx {
  type yang:counter64;
  config false;
  description
    "The number of add confirms received (23.6.12) by the Ports
    Receive Process.

    Discontinuities in the value of this counter can occur at
    re-initialization of the management system, and at other times
    as indicated by the value of 'discontinuity-time'.";
  reference
    "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
}
leaf loss-notification-rx {
  type yang:counter64;
  config false;
  description
    "The number of losses received (23.6.13) by the Ports Receive
    Process.

    Discontinuities in the value of this counter can occur at
    re-initialization of the management system, and at other times
    as indicated by the value of 'discontinuity-time'.";
  reference
    "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
}
leaf loss-confirmation-rx {
  type yang:counter64;
  config false;
  description
    "The number of loss confirms received (23.6.14) by the Ports
    Receive Process.
```

```
        Discontinuities in the value of this counter can occur at
        re-initialization of the management system, and at other times
        as indicated by the value of 'discontinuity-time'.";
      reference
        "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
    }
    leaf add-events {
      type yang:counter64;
      config false;
      description
        "The number of transitions to STM:ADD directly from STM:DOWN or
        STM:LOSS (23.8).

        Discontinuities in the value of this counter can occur at
        re-initialization of the management system, and at other times
        as indicated by the value of 'discontinuity-time'.";
      reference
        "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
    }
    leaf loss-events {
      type yang:counter64;
      config false;
      description
        "The number of transitions to STM:LOSS directly from STM:UP or
        STM:ADD (23.8).

        Discontinuities in the value of this counter can occur at
        re-initialization of the management system, and at other times
        as indicated by the value of 'discontinuity-time'.";
      reference
        "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
    }
    leaf mac-status-notifications {
      type yang:counter64;
      config false;
      description
        "The number of transitions to SNM:MAC_NOTIFICATION (23.9).

        Discontinuities in the value of this counter can occur at
        re-initialization of the management system, and at other times
        as indicated by the value of 'discontinuity-time'.";
      reference
        "12.19.4.1.3.3 of IEEE Std 802.1Q-2022";
    }
  }
}
```

48.6.6 The ieee802-dot1q-pb YANG module

```
module ieee802-dot1q-pb {
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-pb;
  prefix dot1q-pb;
  import ieee802-dot1q-bridge {
    prefix dot1q;
  }
  import ieee802-dot1q-types {
    prefix dot1qtypes;
  }
  import ietf-interfaces {
    prefix if;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
           IEEE Standards Association
           445 Hoes Lane
           Piscataway, NJ 08854
           USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This YANG module describes the bridge configuration model for
    Provider Bridges.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Second version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  revision 2018-03-07 {
    description
      "Published as part of IEEE Std 802.1Q-2018. Initial version.";
    reference
      "IEEE Std 802.1Q-2018, Bridges and Bridged Networks.";
  }
  augment "/if:interfaces/if:interface/dot1q:bridge-port" {
    description
      "Augment the interface model with 802.1Q Bridge Port configuration
      specific nodes.";
    leaf svid {
      type dot1qtypes:vlanid;
      description
        "Service VLAN identifier.";
      reference
        "12.13.2.1 of IEEE Std 802.1Q-2022";
    }
    list cvid-registration {
      when
        "../dot1q:component-name = 'dot1q:c-vlan-component' and "+
        "../dot1q:port-type = 'dot1q:customer-edge-port'" {
        description
```

```
        "Applies when the component associated with this interface is
        a C-VLAN component and the port-type is a customer edge port.";
    }
    key "cvid";
    description
      "The C-VID Registration Table, provides a mapping between a
      C-VID and the service instance represented by an S-VID selected
      for that C-VLAN. This table provides the equivalent
      functionality of
         1) Configuring the PVID of the internal CNP on the S-VLAN
            component
         2) Adding the corresponding PEP on the C-VLAN component to
            the member set of the C-VLAN
         3) Adding the PEP and/or CEP to the untagged set of the
            C-VLAN (if it is desired that frames forwarded to that
            port are transmitted untagged for this C-VLAN).";
    leaf cvid {
      type dot1qtypes:vlanid;
      description
        "Customer VLAN identifiers associated with this bridge port.";
      reference
        "12.13.2.1 of IEEE Std 802.1Q-2022";
    }
    leaf svid {
      type dot1qtypes:vlanid;
      description
        "Service VLAN identifier.";
      reference
        "12.13.2.1 of IEEE Std 802.1Q-2022";
    }
    leaf untagged-pep {
      type boolean;
      default "true";
      description
        "A boolean indicating frames for this C-VLAN should be
        forwarded untagged through the Provider Edge Port.";
      reference
        "12.13.2.1 of IEEE Std 802.1Q-2022";
    }
    leaf untagged-cep {
      type boolean;
      default "true";
      description
        "A boolean indicating frames for this C-VLAN should be
        forwarded untagged through the Customer Edge Port.";
      reference
        "12.13.2.1 of IEEE Std 802.1Q-2022";
    }
  }
  list service-priority-regeneration {
    when
      "../dot1q:component-name = 'dot1q:c-vlan-component' and "+
      "../dot1q:port-type = 'dot1q:customer-edge-port'" {
      description
        "Applies when the component associated with this interface is
        a C-VLAN component and the port-type is a customer edge port.";
    }
    key "svid";
    description
      "The Service Priority Regeneration Table, which provides the
      Priority Regeneration Table (12.6.2) for each internal CNP
      connected to the C-VLAN component associated with the CEP.";
    leaf svid {
      type dot1qtypes:vlanid;
      description
        "Service VLAN identifier.";
      reference
        "12.13.2.6 of IEEE Std 802.1Q-2022";
    }
    container priority-regeneration {
      description
        "Contains Service Priority Regeneration table nodal
```

```
          information.";
        reference
          "12.13.2.6 of IEEE Std 802.1Q-2022";
        uses dot1qtypes:priority-regeneration-table-grouping;
      }
    }
    list rcap-internal-interface {
      when
        "../dot1q:component-name = 'dot1q:s-vlan-component' and "+
        "../dot1q:port-type = 'dot1q:remote-customer-access-port'" {
        description
          "Applies when the component associated with this interface is
          a C-VLAN component and the port-type is a customer edge port.";
      }
      key "external-svid";
      description
        "Designating an external port as an RCAP automatically creates a
        Port-mapping S-VLAN component associated with that port. This
        Port-mapping S-VLAN component includes one internal PNP.";
      leaf external-svid {
        type dot1qtypes:vlanid;
        description
          "External Service VLAN identifier.";
        reference
          "12.13.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf internal-port-number {
        type dot1qtypes:port-number-type;
        description
          "The number of the RCAP.";
        reference
          "12.13.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf internal-svid {
        type dot1qtypes:vlanid;
        description
          "Internal Service VLAN Identifier (not applicable for a
          C-tagged RCSI).";
        reference
          "12.13.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf internal-interface-type {
        type enumeration {
          enum port-based-rcsi {
            description
              "Port-based RCSI";
          }
          enum c-tagged-rcsi {
            description
              "C-tagged RCSI";
          }
          enum pnp {
            description
              "Provider Network Port";
          }
          enum discard {
            description
              "Discard (external S-VID is not associated with an
              internal port).";
          }
        }
        description
          "A value indicating the type of internal interface associated
          with the external S-VID.";
        reference
          "12.13.3.2 of IEEE Std 802.1Q-2022";
      }
    }
  }
}
```

48.6.7 The ieee802-dot1q-cfm-types YANG module

```
module ieee802-dot1q-cfm-types {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-cfm-types;
  prefix cfm-types;
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
           IEEE Standards Association
           445 Hoes Lane
           Piscataway, NJ 08854
           USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "Common types used within ieee802-dot1q-cfm modules.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Revision of IEEE Standard for Local and
      metropolitan area networks— Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Initial version.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }

  /* ---------------------------------------------------
   * Type definitions used by 802.1Qcx YANG module.
   * ---------------------------------------------------
   */
  typedef unicast-mac-address-type {
    type string {
      pattern "[0-9a-fA-F][02468aAcCeE](-[0-9a-fA-F]{2}){5}";
    }
    description
      "A unicast destination MAC address. The I/G address bit is used to
      identify the destination MAC address as an individual MAC address
      or a group MAC address. If the I/G address bit is 0, it indicates
      that the MAC address field is an individual MAC address. If this
      bit is 1, the MAC address is a group MAC address that identifies
      one or more (or all) stations connected to the IEEE 802 network";
  }
  typedef multicast-class1-mac-address-type {
    type string {
      pattern "(01-80-C2-00-00-3)[0-7]";
    }
    description
      "The multicast class 1 MAC address must take the form of
      01-80-C2-00-00-3x, where x represents the MEG level, with x being
      a value in the range of 0..7.";
  }
  typedef mp-type {
    type enumeration {
      enum mhf {
        value 1;
        description
```

```
        "Indicates a MHF.";
    }
    enum mep {
      value 2;
      description
        "Indicates a MEP.";
    }
  }
  description
    "Indicates the type of Maintenance Point.";
}
typedef mhf-creation-type {
  type enumeration {
    enum mhf-none {
      value 1;
      description
        "No MHFs can be created for designated VID(s) or ISID.";
    }
    enum mhf-default {
      value 2;
      description
        "MHFs can be created for designated VID(s) or ISID on any
        Bridge Port through which the VID(s) or ISID can pass, where:
         i) There are no lower active MD levels; or
        ii) There is a MEP at the next lower active MD level on the
            port.";
    }
    enum mhf-explicit {
      value 3;
      description
        "MHFs can be created for designated VID(s) or ISID only on
        Bridge Ports through which the VID(s) or ISID can pass, and
        only if there is a MEP at the next lower active MD level on
        the port.";
    }
    enum mhf-defer {
      value 4;
      description
        "In the Maintenance Association only, the control of MHF
        creation is deferred to the corresponding variable in the
        enclosing Maintenance Domain.";
    }
  }
  description
    "Indicates if the Management Entity can create MHFs.";
}
typedef mp-direction-type {
  type enumeration {
    enum down {
      value 1;
      description
        "Down maintenance point, where CFM protocol messages are
        dispatched away from the MAC Relay entity.";
    }
    enum up {
      value 2;
      description
        "Up maintenance point, where CFM protocol messages are
        dispatched towards the MAC Relay entity.";
    }
  }
  description
    "Indicates the direction in which the Maintenance Point (MEP or
    MIP) faces on the Bridge Port.";
}
typedef mep-id-type {
  type uint16 {
    range "1..8191";
  }
  description
    "Maintenance association End Point Identifier, which is unique
    over a given Maintenance Association.";
```

```
}
typedef md-level-type {
  type uint8 {
    range "0..7";
  }
  description
    "Integer identifying the Maintenance Domain Level (MD Level).
    Higher numbers correspond to higher Maintenance Domains, those
    with the greatest physical reach, with the highest values for
    customers' CFM PDUs. Lower numbers correspond to lower Maintenance
    Domains, those with more limited physical reach, with the lowest
    values for CFM PDUs protecting single bridges or physical links.";
}
typedef port-status-tlv-value-type {
  type enumeration {
    enum no-port-state-tlv {
      value 0;
      description
        "Indicates either that no CCM has been received or that no
        port status TLV was present in the last CCM received.";
    }
    enum blocked {
      value 1;
      description
        "Ordinary data cannot pass freely through the port on which
        the remote MEP resides.";
    }
    enum up {
      value 2;
      description
        "Ordinary data can pass freely through the port on which the
        remote MEP resides.";
    }
  }
  description
    "An enumerated value from the Port Status TLV from the last CCM
    received from the last MEP. It indicates the ability of the Bridge
    Port on which the transmitting MEP resides to pass ordinary data,
    regardless of the status of the MAC.";
}
typedef interface-status-tlv-value-type {
  type enumeration {
    enum no-interface-status-tlv {
      value 0;
      description
        "Indicates either that no CCM has been received or that no
        interface status TLV was present in the last CCM received.";
    }
    enum up {
      value 1;
      description
        "The interface is ready to pass frames.";
    }
    enum down {
      value 2;
      description
        "The interface can not pass frames.";
    }
    enum testing {
      value 3;
      description
        "The interface is in some test mode.";
    }
    enum unknown {
      value 4;
      description
        "The interface status cannot be determined for some reason.";
    }
    enum dormant {
      value 5;
      description
        "The interface is not in a state to pass frames but is in a
```

```
          pending state, waiting for some external event.";
      }
      enum not-present {
        value 6;
        description
          "Some component of the interface is missing.";
      }
      enum lower-layer-down {
        value 7;
        description
          "The interface is down due to state of the lower layer
          interface.";
      }
    }
    description
      "An enumerated value from the Interface Status TLV from the last
      CCM received from the last MEP. It indicates the status of the
      Interface within which the MEP transmitting the CCM is configured,
      or the next lower Interface in the Interface Stack, if the MEP is
      not configured within an Interface.";
  }
  typedef highest-defect-priority-type {
    type enumeration {
      enum none {
        value 0;
        description
          "No defects since Fault Notification Generator state machine
          reset.";
      }
      enum def-rdi-ccm {
        value 1;
        description
          "The last CCM received by this MEP from some remote MEP
          contained the RDI bit set.";
      }
      enum def-mac-status {
        value 2;
        description
          "The last CCM received by this MEP from some remote MEP
          indicating that the transmitting MEP's associated MAC is
          reporting its status via the Port Status TLV or Interface
          Status TLV.";
      }
      enum def-remote-ccm {
        value 3;
        description
          "This MEP is not receiving CCMs from some other MEP in its
          configured list.";
      }
      enum def-error-ccm {
        value 4;
        description
          "This MEP is receiving invalid CCMs.";
      }
      enum def-xcon-ccm {
        value 5;
        description
          "This MEP is receiving CCMs that could be from some other MA.";
      }
    }
    description
      "An enumerated value, equal to the contents of the variable
      highestDefect (20.35.9 and Table 20-1), indicating the
      highest-priority defect that has been present since the MEP Fault
      Notification Generator State Machine was last in the FNG_RESET
      state. The integer value assigned to the enum value determines the
      priority. The higher value corresponds to the higher priority.";
  }
  typedef lowest-alarm-priority-type {
    type enumeration {
      enum all-def {
        value 1;
```

```
      description
        "Includes def-rdi-ccm, def-mac-status, def-remote-ccm,
        def-error-ccm, and def-xcon-ccm.";
    }
    enum mac-remote-error-xcon {
      value 2;
      description
        "Only includes def-mac-status, def-remote-ccm, def-error-ccm,
        and def-xcon-ccm.";
    }
    enum remote-error-xcon {
      value 3;
      description
        "Includes def-remote-ccm, def-error-ccm, and def-xcon-ccm.";
    }
    enum error-xcon {
      value 4;
      description
        "Includes def-error-ccm and def-xcon-ccm.";
    }
    enum xcon {
      value 5;
      description
        "Only def-xcon-ccm";
    }
    enum no-xcon {
      value 6;
      description
        "No defects def-xcon or lower are to be reported.";
    }
  }
  description
    "Specifies the lowest priority defect that is allowed to generate
    a Fault Alarm (20.9.5). The to be reported defects are identified
    per enum value.";
}
typedef sender-id-permission-type {
  type enumeration {
    enum send-id-none {
      value 1;
      description
        "The Sender ID TLV is not to be sent.";
    }
    enum send-id-chassis {
      value 2;
      description
        "The Chassis ID Length, Chassis ID Subtype, and Chassis ID
        fields of the Sender ID TLV are to be sent.";
    }
    enum send-id-manage {
      value 3;
      description
        "The Management Address Length and Management Address of the
        Sender ID TLV are to be sent.";
    }
    enum send-id-chassis-manage {
      value 4;
      description
        "The Chassis ID Length, Chassis ID Subtype, Chassis ID,
        Management Address Length and Management Address fields are
        all to be sent.";
    }
    enum send-id-defer {
      value 5;
      description
        "The content of the Sender ID TLV are determined by the
        corresponding Maintenance Domain variable.";
    }
  }
  description
    "Indicates what, if anything, is to be included in the Sender ID
    TLV transmitted in CCMs, LBMs, LTMs, and LTRs.";
```

```
}
typedef ccm-interval-type {
  type enumeration {
    enum 300hz {
      value 1;
      description
        "CCM PDUs are sent every 3 1/3 milliseconds (300Hz).";
    }
    enum 10ms {
      value 2;
      description
        "CCM PDUs are sent every 10 milliseconds.";
    }
    enum 100ms {
      value 3;
      description
        "CCM PDUs are sent every 100 milliseconds.";
    }
    enum 1sec {
      value 4;
      description
        "CCM PDUs are sent every second.";
    }
    enum 10sec {
      value 5;
      description
        "CCM PDUs are sent every 10 seconds.";
    }
    enum 1min {
      value 6;
      description
        "CCM PDUs are sent every minute.";
    }
    enum 10min {
      value 7;
      description
        "CCM PDUs are sent every 10 minutes.";
    }
  }
  description
    "Indicates the interval at which CCM PDUs are sent by a MEP.";
}
typedef fng-state-type {
  type enumeration {
    enum fng-reset {
      value 1;
      description
        "No defect has been present since the MEP's fng-reset-time
        timer expired, or since the state machine was last reset.";
    }
    enum fng-defect {
      value 2;
      description
        "A defect is present, but not for a long enough time to be
        reported.";
    }
    enum fng-report-defect {
      value 3;
      description
        "A momentary state during which the defect is reported by
        sending a fault-alarm notification, if that action is enabled.";
    }
    enum fng-defect-reported {
      value 4;
      description
        "A defect is present, and some defect has been reported.";
    }
    enum fng-defect-clearing {
      value 5;
      description
        "No defect is present, but the MEP's fng-reset-time timer has
        not yet expired.";
```

```
    }
  }
  description
    "Indicates the different states of the MEP Fault Notification
    Generator State Machine.";
}
typedef relay-action-field-value-type {
  type enumeration {
    enum relay-hit {
      value 1;
      description
        "The LTM reached a Maintenance Point whose MAC address matches
        the target address.";
    }
    enum relay-fdb {
      value 2;
      description
        "The Egress Port was determined by consulting the Filtering
        Database.";
    }
    enum relay-mpdb {
      value 3;
      description
        "The Egress Port was determined by consulting the MIP CCM
        Database.";
    }
  }
  description
    "Possible values the Relay action field can take.";
}
typedef ingress-action-field-value-type {
  type enumeration {
    enum ingress-ok {
      value 1;
      description
        "The target data frame would be passed through to the MAC
        Relay Entity.";
    }
    enum ingress-down {
      value 2;
      description
        "The Bridge Ports MAC_Operational parameter is false.";
    }
    enum ingress-blocked {
      value 3;
      description
        "The target data frame would not be forwarded if received on
        this Port due to active topology enforcement.";
    }
    enum ingress-vid {
      value 4;
      description
        "The ingress port is not in the member set of the LTMs VID,
        and ingress filtering is enabled, so the target data frame
        would be filtered by ingress filtering.";
    }
  }
  description
    "Possible values returned in the ingress action field.";
}
typedef egress-action-field-value-type {
  type enumeration {
    enum egress-okay {
      value 1;
      description
        "The targeted data frame would be forwarded.";
    }
    enum egress-down {
      value 2;
      description
        "The Egress Port can be identified, but that Bridge Port
        MAC_Operational parameter is false.";
```

```
    }
    enum egress-blocked {
      value 3;
      description
        "The Egress Port can be identified, but the data frame would
        not pass through the Egress Port due to active topology
        management (i.e., the Bridge Port is not in the Forwarding
        state.";
    }
    enum egress-vid {
      value 4;
      description
        "The Egress Port can be identified, but the Bridge Port is not
        in the LTMs VIDs member set, so would be filtered by egress
        filtering.";
    }
  }
  description
    "Possible values returned in the egress action field.";
}
typedef remote-mep-state-type {
  type enumeration {
    enum rmep-idle {
      value 1;
      description
        "Momentary state during reset.";
    }
    enum rmep-start {
      value 2;
      description
        "The timer has not expired since the state machine was reset,
        and no valid CCM has yet been received.";
    }
    enum rmep-failed {
      value 3;
      description
        "The timer has expired, both since the state machine was
        reset, and since a valid CCM was received.";
    }
    enum rmep-ok {
      value 4;
      description
        "The timer has not expired since a valid CCM was received.";
    }
  }
  description
    "Operational state of the remote MEP state machine. This state
    machine monitors the reception of valid CCMs from a remote MEP
    with a specific MEPID. It uses a timer that expires in 3.5 times
    the length of time indicated by the MA's ccm-interval object.";
}
typedef mep-defects-type {
  type bits {
    bit def-rdi-ccm {
      position 0;
      description
        "A remote MEP reported that RDI bit in its last CCM.";
    }
    bit def-mac-status {
      position 1;
      description
        "Either some remote MEP is reporting its Interface Status TLV
        as not isUp, or all remote MEPs are reporting a Port Status
        TLV that contains some value other than psUp.";
    }
    bit def-remote-ccm {
      position 2;
      description
        "The MEP is not receiving valid CCMs from at least one of the
        remote MEPs.";
    }
    bit def-error-ccm {
```

```
      position 3;
      description
        "The MEP has received at least one invalid CCM whose CCM
        Interval has not yet timed out.";
    }
    bit def-xcon-ccm {
      position 4;
      description
        "The MEP has received at last one CCM from either another MAID
        or a lower MD level whose CCM Interval has not yet timed out.";
    }
  }
  description
    "A MEP can detect and report a number of defects, and multiple
    defects can be present at the same time.";
}
typedef config-error-type {
  type bits {
    bit cfm-leak {
      position 0;
      description
        "MA x is associated with a specific VID list, one or more of
        the VIDs in MA x can pass through the Bridge Port, no Down MEP
        is configured on any Bridge Port for MA x, and some other MA
        y, at a higher MD Level than MA x, and associated with at
        least one of the VID(s) also in MA x, does have a MEP
        configured on the Bridge Port.";
    }
    bit conflicting-vids {
      position 1;
      description
        "MA x is associated with a specific VID list, an Up MEP is
        configured on MA x on the Bridge Port, and some other MA y,
        associated with at least one of the VID(s) also in MA x, also
        has an Up MEP configured on some Bridge Port.";
    }
    bit excessive-levels {
      position 2;
      description
        "The number of different MD Levels at which MIPs are to be
        created on this port exceeds the Bridge's capabilities.";
    }
    bit overlapped-levels {
      position 3;
      description
        "A MEP is created for one VID at one MD Level, but a MEP is
        configured on another VID at that MD Level or higher,
        exceeding the Bridge's capabilities.";
    }
  }
  description
    "While making the MIP creation evaluation described in 22.2.3, the
    management entity can encounter errors in the configuration.";
}
typedef mep-tx-ltm-flags-type {
  type bits {
    bit use-fdb-only {
      position 1;
      description
        "Use FDB only";
    }
  }
  description
    "The flags field for LTMs transmitted by the MEP.";
}
typedef fault-alarm-type {
  type enumeration {
    enum address {
      value 1;
      description
        "Indicates that a Network address to which Fault Alarms are to
        be transmitted should be used.";
```

```
    }
    enum not-transmitted {
      value 2;
      description
        "Indicates that Fault alarms are not to be transmitted.";
    }
  }
  description
    "The Fault Alarm indicators.";
}
typedef lbm-data-tlv-type {
  type binary {
    length "1..1480";
  }
  description
    "The loopback message Data TLV type.";
}
typedef name-key-type {
  type string {
    length "1..255";
    pattern '[0-9a-zA-Z\-_.]*';
  }
  description
    "String type with at least 1 and up to 255 of the specified
    characters.";
}
typedef seq-number-type {
  type uint32 {
    range "0..4294967295";
  }
  description
    "The transaction identifier or sequence number of the CFM PDU.";
}
typedef service-selector-type {
  type enumeration {
    enum ieee-reserved-0 {
      value 0;
      description
        "Reserved for definition by IEEE 802.1.";
    }
    enum vlan-id {
      value 1;
      description
        "12-bit identifier found in a VLAN tag.";
    }
    enum isid {
      value 2;
      description
        "24-bit identifier found in an I-TAG.";
    }
    enum tesid {
      value 3;
      description
        "32-bit identifier";
    }
    enum segid {
      value 4;
      description
        "32-bit identifier";
    }
    enum path-tesid {
      value 5;
      description
        "32-bit identifier";
    }
    enum group-isid {
      value 6;
      description
        "24 bit identifier";
    }
    enum ieee-reserved {
      value 7;
```

```
        description
          "Reserved for definition by IEEE 802.1";
      }
    }
    default "vlan-id";
    description
      "A value that represents a type (and thereby the format) of a
      service-selector-value.";
  }
  typedef service-selector-value-type {
    type uint32 {
      range "1..4294967295";
    }
    description
      "An integer that uniquely identifies a generic MAC Service, or
      none. Examples of service selectors are a VLAN-ID and an I-SID. A
      service-selector-value value is always interpreted within the
      context of a service-selector-type value. Every usage of the
      service-selector-value textual convention is required to specify
      the service-selector-type object that provides the context. The
      value of a service-selector-value object must always be consistent
      with the value of the associated service-selector-type object.
      Attempts to set a service-selector-value object to a value
      inconsistent with the associated service-selector-type must fail
      with an inconsistent-value error.";
  }
}
```

48.6.8 The ieee802-dot1q-cfm YANG module

```
module ieee802-dot1q-cfm {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-cfm;
  prefix dot1q-cfm;
  import ieee802-dot1q-cfm-types {
    prefix cfm-types;
  }
  import ieee802-dot1q-types {
    prefix dot1q-types;
  }
  import ieee802-types {
    prefix ieee;
  }
  import ietf-yang-types {
    prefix yang;
  }
  import ietf-inet-types {
    prefix inet;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
           IEEE Standards Association
           445 Hoes Lane
           Piscataway, NJ 08854
           USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "Connectivity Fault Management (CFM) comprises capabilities for
    detecting, verifying, and isolating connectivity failures in Virtual
    Bridged Local Area Networks. These capabilities can be used in
    networks operated by multiple independent organizations, each with
    restricted management access to each other's equipment.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Initial version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }

  /* ------------------------------------------------
   * Grouping definitions used by 802.1Qcx YANG module
   * ------------------------------------------------
   */
  grouping mac-address-and-uint-type-grouping {
    description
      "The MAC address and uint type grouping.";
    container mac-address-and-uint-type {
      description
        "The MAC address and uint type definition.";
      leaf address {
```

```
      type ieee:mac-address;
      mandatory true;
      description
        "The MAC address.";
    }
    leaf int {
      type uint16;
      mandatory true;
      description
        "The additional 2-octet (unsigned) integer.";
    }
  }
}
grouping md-name-choice-grouping {
  description
    "The Maintenance Domain name and name format choice.";
  choice md-name {
    default "char-string";
    description
      "The Maintenance Domain name type.";
    case none {
      leaf none {
        type empty;
        description
          "No format specified, usually because there is not a
          Maintenance Domain Name. The Maintenance Domain name
          inserted in CFM protocol messages will be a zero length
          OCTET string.";
      }
    }
    case dns-like-name {
      leaf dns-like-name {
        type string {
          length "1..43";
        }
        description
          "Domain name like string, globally unique text string
          derived from a DNS name.";
      }
    }
    case mac-address-and-uint {
      description
        "MAC address plus 2-octet (unsigned) integer.";
      uses mac-address-and-uint-type-grouping;
    }
    case char-string {
      leaf char-string {
        type string {
          length "1..43";
          pattern "[ -~]*";
        }
        default "DEFAULT";
        description
          "RFC2579 DisplayString, except that the character codes 0-31
          (decimal) are not used.";
      }
    }
  }
}
grouping ma-name-choice-grouping {
  description
    "The Maintenance Association name and name format choice.";
  choice ma-name {
    mandatory true;
    description
      "The Maintenance Association name type.";
    case primary-vid {
      leaf primary-vid {
        type dot1q-types:vlanid;
        description
          "Primary VLAN ID. 12 bits represented in a 2-octet integer.";
      }
```

```
      }
      case char-string {
        leaf char-string {
          type string {
            length "1..45";
            pattern "[ -~]*";
          }
          description
            "RFC2579 DisplayString, except that the character codes 0-31
            (decimal) are not used.";
        }
      }
      case unsigned-int16 {
        leaf unsigned-int16 {
          type uint16;
          description
            "2-octet integer.";
        }
      }
      case rfc2865-vpn-id {
        container vpn-id {
          description
            "RFC2685 VPN ID. 3 octet VPN authority Organizationally
            Unique Identifier followed by 4 octet VPN index identifying
            VPN according to the OUI.";
          leaf vpn-oui {
            type uint32 {
              range "0..16777215";
            }
            mandatory true;
            description
              "3 octet VPN authority Organizationally Unique Identifier.";
          }
          leaf vpn-index {
            type uint32;
            mandatory true;
            description
              "4 octet VPN index identifying VPN according to OUI.";
          }
        }
      }
    }
  }
  grouping management-address-grouping {
    description
      "Defines the Management Address.";
    reference
      "21.5.3.5 of IEEE Std 802.1Q-2022";
    leaf domain {
      type yang:object-identifier-128;
      description
        "The domain type.";
    }
    choice management-address {
      when
        "./domain";
      mandatory true;
      description
        "Selects the management address";
      case ip {
        description
          "Represents an IP TCP, UDP, or SCTP transport address
          consisting of an IPv4/v6 address, and a port number,
          associated with the domain type defined by the domain leaf
          node.";
        leaf ip-address {
          type inet:ip-address;
          mandatory true;
          description
            "IPv4 or IPv6 address.";
        }
        leaf ip-port {
```

```
        type inet:port-number;
        mandatory true;
        description
          "IP port.";
      }
    }
    case local {
      leaf local-address {
        type string {
          length "1..255";
        }
        mandatory true;
        description
          "Represents a POSIX Local IPC transport address, associated
          with the domain type defined by the domain leaf node.";
      }
    }
    case dns {
      leaf dns-address {
        type string {
          length "1..255";
        }
        mandatory true;
        description
          "The transport domain using fully qualified domain names,
          associated with the domain type defined by the domain leaf
          node. Represents a DNS domain name followed by a colon ':'
          (ASCII character 0x3A) and a port number in ASCII. The name
          SHOULD be fully qualified whenever possible.";
      }
    }
    case other {
      leaf unknown-address {
        type binary {
          length "1..255";
        }
        description
          "This represents an undefined address, for the case when the
          domain type provided is an unrecognizable value.";
      }
    }
  }
}
grouping loopback-input-grouping {
  description
    "Defines the group of loopback input parameters.";
  choice lbm-destination {
    mandatory true;
    description
      "Selects the destination type (which is either MEP identifier or
      MAC address) used for the Loopback transmissions.";
    case dest-ucast-mac-address {
      description
        "The target unicast MAC Address field to be transmitted. A
        unicast destination MAC address.";
      leaf lbm-dest-ucast-mac-address {
        type cfm-types:unicast-mac-address-type;
        description
          "The target MAC Address field to be transmitted. A unicast
          destination MAC address.";
        reference
          "Item b) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
      }
    }
    case dest-mcast-class1-mac-address {
      description
        "The target multicast Class 1 MAC address field to be
        transmitted.";
      leaf lbm-dest-mcast-class1-mac-address {
        type cfm-types:multicast-class1-mac-address-type;
        description
          "The target multicast Class 1 MAC address field to be
```

```
            transmitted";
          }
        }
        case dest-mep-id {
          description
            "The identifier of a remote MEP in the same MA to which the
            LBM is to be sent.";
          leaf lbm-dest-mep-id {
            type cfm-types:mep-id-type;
            description
              "The identifier of a remote MEP in the same MA to which the
              LBM is to be sent.";
            reference
              "Item b) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
          }
        }
      }
      leaf lbm-messages {
        type uint16 {
          range "1..1024";
        }
        default "1";
        description
          "The number of Loopback messages to be transmitted.";
        reference
          "Item c) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf lbm-priority {
        type dot1q-types:priority-type;
        default "7";
        description
          "Priority. 3 bit value to be used in the VLAN tag, if present in
          the transmitted frame. The default value should be priority 7,
          which is the default CCM priority (ccm-ltm-priority).";
        reference
          "Item e) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf lbm-drop-eligible {
        type boolean;
        default "false";
        description
          "Drop eligible bit value to be used in the VLAN tag, if present
          in the transmitted frame. A value 'true' means inserting value
          '1' in the DEI field, while a value 'false' means inserting
          value '0' in the DEI field.";
        reference
          "Item e) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
      }
      leaf lbm-data-tlv {
        type cfm-types:lbm-data-tlv-type;
        description
          "An arbitrary amount of data to be included in the Data TLV, if
          the Data TLV is selected to be sent.";
        reference
          "Item d) in 12.14.7.3.2 of IEEE Std 802.1Q-2022";
      }
    }
    grouping linktrace-input-grouping {
      description
        "Defines the group of linktrace input parameters. By default, the
        priority used is that of the CCMs (ccm-ltm-priority) and the drop
        eligibility is false.";
      choice ltr-target {
        mandatory true;
        description
          "Selects the target address type (which is either MEP identifier
          or MAC address) used for the Linktrace transmissions.";
        case target-ucast-mac-address {
          description
            "The target MAC address field to be transmitted. A unicast MAC
            address.";
          leaf ltm-target-mac-address {
```

```
        type cfm-types:unicast-mac-address-type;
        description
          "The target MAC address field to be transmitted. A unicast
          MAC address.";
        reference
          "Item c) in 12.14.7.4.2 of IEEE Std 802.1Q-2022";
      }
    }
    case target-mep-id {
      description
        "The MEP identifier of another MEP in the same MA.";
      leaf ltm-target-mep-id {
        type cfm-types:mep-id-type;
        description
          "The MEP identifier of another MEP in the same MA.";
        reference
          "Item c) in 12.14.7.4.2 of IEEE Std 802.1Q-2022";
      }
    }
  }
  leaf ltm-ttl {
    type uint8 {
      range "0..255";
    }
    default "64";
    description
      "The LTM TTL field. Indicates the number of hops remaining to
      the LTM. Decremented by 1 by each Linktrace Responder that
      handles the LTM. The value returned in the LTR is one less than
      that received in the LTM. If the LTM TTL is 0 or 1, the LTM is
      not forwarded to the next hop, and if 0, no LTR is generated.";
    reference
      "Item d) in 12.14.7.4.2, 21.8.4 of IEEE Std 802.1Q-2022";
  }
  leaf ltm-flags {
    type cfm-types:mep-tx-ltm-flags-type;
    default "";
    description
      "The flags field for the LTMs transmitted by the MEP.";
    reference
      "Item b) in 12.14.7.4.2, 20.42.1 of IEEE Std 802.1Q-2022";
  }
}
grouping ltm-egress-identifier-grouping {
  description
    "The grouping used to identify the MEP Linktrace initiator that is
    originating the LTM. It defines the MAC address and uint type
    definition.";
  leaf int {
    type uint16;
    mandatory true;
    description
      "A value used to uniquely identify the MEP Linktrace Initiator
      or Linktrace Responder within that system.";
  }
  leaf address {
    type ieee:mac-address;
    mandatory true;
    description
      "A 48-bit IEEE MAC address unique to the system in which the MEP
      Linktrace Initiator or Linktrace Responder resides.";
  }
}

/* ---------------------------------------------------
 * Configuration objects used by 802.1Qcx YANG module
 * ---------------------------------------------------
 */
container cfm {
  description
    "Connectivity Fault Management configuration and operational
    information.";
```

```
list maintenance-domain {
  key "md-id";
  description
    "Contains the Maintenance Domain configuration and operational
    data. A Maintenance Domain is the network or the part of the
    network for which faults in connectivity can be managed. The
    boundary of a Maintenance Domain is defined by a set of Domain
    Service Access Points (DoSAPs), each of which can become a point
    of connectivity to a service instance.";
  leaf md-id {
    type cfm-types:name-key-type;
    description
      "The index to the Maintenance Domain list.";
  }
  uses md-name-choice-grouping;
  leaf md-level {
    type cfm-types:md-level-type;
    default "0";
    description
      "The Maintenance Domain level.";
    reference
      "3.123, Item b) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf mhf-creation {
    type cfm-types:mhf-creation-type;
    must
      ". != 'mhf-defer'" {
      description
        "The value mhf-defer is not allowed";
    }
    default "mhf-none";
    description
      "Value indicating whether the management entity can create
      MHFs (MIP Half Function) for this Maintenance Domain. Since
      there is no encompassing Maintenance Domain, the value
      mhf-defer is not allowed.";
    reference
      "3.123, Item c) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf id-permission {
    type cfm-types:sender-id-permission-type;
    must
      ". != 'send-id-defer'" {
      description
        "The value send-id-defer is not allowed";
    }
    default "send-id-none";
    description
      "Value indicating what, if anything, is to be included in the
      Sender ID TLV transmitted by Maintenance Points configured in
      this Maintenance Domain. Since there is no encompassing
      Maintenance Domain, the value send-id-defer is not allowed.";
    reference
      "3.123, item d) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf fault-alarm-transmission {
    type cfm-types:fault-alarm-type;
    default "not-transmitted";
    description
      "A value indicating whether Fault Alarms are to be transmitted
      or not. The default is not transmit.";
    reference
      "3.123, item e) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
  }
  list maintenance-association {
    key "ma-id";
    description
      "Provides configuration and operational data for the
      Maintenance Associations. A Maintenance Association is a set
      of MEPs, each configured with the same MAID and MD level,
      established to verify the integrity of a single service
      instance. A Maintenance Association can be thought of as a
```

```
        full mesh of Maintenance Entities among a set of MEPs so
        configured.";
      leaf ma-id {
        type cfm-types:name-key-type;
        description
          "Key of the Maintenance Association list of entries.";
      }
      uses ma-name-choice-grouping;
      leaf ccm-interval {
        type cfm-types:ccm-interval-type;
        default "1sec";
        description
          "The interval between CCM transmissions to be used by all
          MEPs in the Maintenance Association.";
        reference
          "Item e) in 12.14.6.1.3 of IEEE Std 802.1Q-2022";
      }
      leaf fault-alarm-transmission {
        type cfm-types:fault-alarm-type;
        description
          "A value indicating whether Fault Alarms are to be
          transmitted or not. If this leaf node is not present then
          the disposition of the fault-alarm used by the MD should be
          used.";
        reference
          "3.123, Item e) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
      }
      leaf mhf-creation {
        type cfm-types:mhf-creation-type;
        default "mhf-defer";
        description
          "Value indicating whether the management entity can create
          MHFs (MIP Half Function) for this Maintenance Association.";
        reference
          "3.123, Item c) in 12.14.5.1.3 of IEEE Std 802.1Q-2022";
      }
      leaf id-permission {
        type cfm-types:sender-id-permission-type;
        default "send-id-defer";
        description
          "Enumerated value indicating what, if anything, is to be
          included in the Sender ID TLV (21.5.3) transmitted by MPs
          configured in this MA.";
        reference
          "Item d) in 12.14.3.1.3 of IEEE Std 802.1Q-2022";
      }
      list maintenance-association-mep {
        key "mep-id";
        description
          "The list of all MEPs that belong to this Maintenance
          Association.";
        leaf mep-id {
          type cfm-types:mep-id-type;
          description
            "Integer that is unique among all the MEPs in the same
            Maintenance Association.";
          reference
            "Item g) in 12.14.6.1.3 of IEEE Std 802.1Q-2022";
        }
      }
    }
  }

  // maintenance-domain
  list maintenance-group {
    key "maintenance-group-id";
    description
      "The list of maintenance association groups, which are uniquely
      associated with a maintenance domain, maintenance association,
      for which the MEPs belong.";
    leaf maintenance-group-id {
      type cfm-types:name-key-type;
```

```
    description
      "The maintenance group provides a handle for the MD and MA
      combination.";
  }
  leaf md-id {
    type leafref {
      path '/cfm/maintenance-domain/md-id';
    }
    mandatory true;
    description
      "A reference to the maintenance domain that this maintenance
      group is associated with.";
  }
  leaf ma-id {
    type leafref {
      path
        '/cfm'+
        '/maintenance-domain[md-id = current()'+
        '/..'+
        '/md-id]'+
        '/maintenance-association'+
        '/ma-id';
    }
    mandatory true;
    description
      "A reference to the maintenance association in the specified
      maintenance domain, that this maintenance group is associated
      with.";
  }
  list mep {
    key "mep-id";
    description
      "A list of local Maintenance association End Points (MEPs). A
      MEP is an actively managed CFM entity, associated with a
      specific DoSAP of a service instance, which can generate and
      receive CFM PDUs and track any responses. It is an end point
      of a single Maintenance Association (MA) and is an end point
      of a separate Maintenance Entity for each of the other MEPs in
      the same MA.";
    leaf mep-id {
      type leafref {
        path
          '/cfm'+
          '/maintenance-domain[md-id = current()'+
          '/..'+
          '/..'+
          '/md-id]'+
          '/maintenance-association[ma-id = current()'+
          '/..'+
          '/..'+
          '/ma-id]'+
          '/maintenance-association-mep'+
          '/mep-id';
      }
      description
        "Integer that is unique among all the MEPs in the same
        Maintenance Association.";
      reference
        "12.14.7, 19.2 of IEEE Std 802.1Q-2022";
    }
    leaf direction {
      type cfm-types:mp-direction-type;
      mandatory true;
      description
        "The direction in which the MEP faces on the Bridge Port.
        Example, up or down.";
      reference
        "Item c) in 12.14.7.1.3, 19.2 of IEEE Std 802.1Q-2022";
    }
    leaf enabled {
      type boolean;
      default "false";
```

```
    description
      "The administrative state of the MEP. TRUE indicates that
      the MEP is to functional normally, and FALSE indicates that
      it is to cease functioning.";
    reference
      "Item e) in 12.14.7.1.3, 20.9.1 of IEEE Std 802.1Q-2022";
  }
  leaf ccm-ltm-priority {
    type dot1q-types:priority-type;
    default "7";
    description
      "The priority value for CCMs and LTMs transmitted by the
      MEP. The default value is the highest priority allowed to
      pass through the Bridge Port for any of the MEPs VID(s).";
    reference
      "Item h) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf mac-address {
    type ieee:mac-address;
    config false;
    mandatory true;
    description
      "The MAC address of the MEP.";
    reference
      "Item i) in 12.14.7.1.3, 19.4 of IEEE Std 802.1Q-2022";
  }
  list inactive-remote-mep {
    key "inactive-rmep-id";
    description
      "A list indicating which of the remote MEPs in the same MA
      are inactive. The Remote MEP state machines (20.20) are
      instantiated only for the remote MEPs which are present in
      the maintenance-association-mep-list, but not in this list.
      By default, all configured remote MEPs in the same MA are
      active";
    leaf inactive-rmep-id {
      type leafref {
        path
          '/cfm'+
          '/maintenance-domain[md-id = current()'+
          '/..'+
          '/..'+
          '/..'+
          '/md-id]'+
          '/maintenance-association[ma-id = current()'+
          '/..'+
          '/..'+
          '/..'+
          '/ma-id]'+
          '/maintenance-association-mep'+
          '/mep-id';
      }
      description
        "Maintenance association Endpoint Identifier of a remote
        MEP for which the Remote MEP state machine should not be
        instantiated.";
      reference
        "Item ae) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
    }
  }

  //inactive-remote-mep
  list mep-db {
    key "rmep-id";
    config false;
    description
      "The MEP CCM Database. A database, maintained by every MEP,
      that maintains received information about other MEPs in the
      Maintenance Association.";
    leaf rmep-id {
      type cfm-types:mep-id-type;
      description
```

```
    "Maintenance association Endpoint Identifier of a remote
    MEP whose information from the MEP Database is to be
    returned.";
  reference
    "Item b) in 12.14.7.6.2 of IEEE Std 802.1Q-2022";
}
leaf rmep-state {
  type cfm-types:remote-mep-state-type;
  mandatory true;
  description
    "The operational state of the remote MEP state machine";
  reference
    "Item b) in 12.14.7.6.3, 20.20 of IEEE Std 802.1Q-2022";
}
leaf rmep-failed-ok-time {
  type yang:timeticks;
  mandatory true;
  description
    "The time (SysUpTime) at which the Remote MEP state
    machine last entered either the RMEP_FAILED or RMEP_OK
    state";
  reference
    "Item c) in 12.14.7.6.3 of IEEE Std 802.1Q-2022";
}
leaf mac-address {
  type ieee:mac-address;
  mandatory true;
  description
    "The MAC address of the remote MEP.";
  reference
    "Item d) in 12.14.7.6.3, 20.19.7 of IEEE Std 802.1Q-2022";
}
leaf rdi {
  type boolean;
  mandatory true;
  description
    "State of the RDI bit in the last received CCM (true for
    RDI=1), or false if none has been received.";
  reference
    "Item e) in 12.14.7.6.3, 20.19.2 of IEEE Std 802.1Q-2022";
}
leaf port-status-tlv {
  type cfm-types:port-status-tlv-value-type;
  description
    "An enumerated value of the Port status TLV received in
    the last CCM from the remote MEP or the default value
    no-port-state-tlv indicating either no CCM has been
    received, or that no port status TLV was received in the
    last CCM.";
  reference
    "Item f) in 12.14.7.6.3, 20.19.3 of IEEE Std 802.1Q-2022";
}
leaf interface-status-tlv {
  type cfm-types:interface-status-tlv-value-type;
  description
    "An enumerated value of the Interface status TLV received
    in the last CCM from the remote MEP or the default value
    is-no-interface-status-tlv indicating either no CCM has
    been received, or that no interface status TLV was
    received in the last CCM.";
  reference
    "Item g) in 12.14.7.6.3, 20.19.4 of IEEE Std 802.1Q-2022";
}
leaf chassis-id-subtype {
  type ieee:chassis-id-subtype-type;
  description
    "This object specifies the format of the Chassis ID
    received in the last CCM.";
  reference
    "Item h) in 12.14.7.6.3, 21.5.3.2 of IEEE Std 802.1Q-2022";
}
leaf chassis-id {
```

```
    type ieee:chassis-id-type;
    description
      "The Chassis ID. The format of this object is determined
      by the value of the ltr-chassis-id-subtype object.";
    reference
      "Item h) in 12.14.7.6.3, 21.5.3.3 of IEEE Std 802.1Q-2022";
  }
  container transport-service-domain {
    description
      "The transport management domain and address.";
    reference
      "Item h) in 12.14.7.6.3 of IEEE Std 802.1Q-2022";
    uses management-address-grouping;
  }
  leaf rmep-is-active {
    type boolean;
    default "true";
    description
      "A Boolean value stating if the remote MEP is active.";
    reference
      "Item ae) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
  }
}

// mep-db
container continuity-check {
  description
    "Continuity check protocol";
  leaf ccm-enabled {
    type boolean;
    default "false";
    description
      "Indicates whether the MEP can generate CCMs. If TRUE, the
      MEP will generate CCM PDUs.";
    reference
      "Item g) in 12.14.7.1.3, 20.10.1 of IEEE Std 802.1Q-2022";
  }
  leaf fng-state {
    type cfm-types:fng-state-type;
    default "fng-reset";
    config false;
    description
      "The current state of the MEP Fault Notification Generator
      state machine.";
    reference
      "Item f) in 12.14.7.1.3, 20.35 of IEEE Std 802.1Q-2022";
  }
  leaf fault-alarm-transmission {
    type cfm-types:fault-alarm-type;
    description
      "A value indicating whether Fault Alarms are to be
      transmitted or not. If this leaf is not specified, the
      disposition of the fault-alarm used by the MD should be
      used.";
    reference
      "3.124, Item j) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf lowest-priority-defect {
    type cfm-types:lowest-alarm-priority-type;
    default "mac-remote-error-xcon";
    description
      "The lowest priority defect that is allowed to generate
      fault alarms.";
    reference
      "Item k) in 12.14.7.1.3, 20.9.5 of IEEE Std 802.1Q-2022";
  }
  leaf fng-alarm-time {
    type uint16 {
      range "2500..10000";
    }
    units "milliseconds";
    default "2500";
```

```
      description
        "The time that defect must be present before a Fault Alarm
        is issued.";
      reference
        "Item l) in 12.14.7.1.3, 20.35.3 of IEEE Std 802.1Q-2022";
    }
    leaf fng-reset-time {
      type uint16 {
        range "2500..10000";
      }
      units "milliseconds";
      default "10000";
      description
        "The time that defects must be absent before resetting a
        Fault Alarm.";
      reference
        "Item m) in 12.14.7.1.3, 20.35.4 of IEEE Std 802.1Q-2022";
    }
    leaf highest-priority-defect {
      type cfm-types:highest-defect-priority-type;
      config false;
      mandatory true;
      description
        "The highest priority defect that has been present since
        the MEPs Fault Notification Generator state machine was
        last in the FNG_RESET state.";
      reference
        "Item n) in 12.14.7.1.3, 20.35.9 of IEEE Std 802.1Q-2022";
    }
    leaf defects {
      type cfm-types:mep-defects-type;
      config false;
      mandatory true;
      description
        "Vector of boolean error conditions";
      reference
        "12.14.7.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf error-ccm-last-failure {
      type binary {
        length "1..128";
      }
      config false;
      description
        "The last received CCM that triggered a def-error-ccm
        fault.";
      reference
        "Item t) in 12.14.7.1.3, 20.21.2 of IEEE Std 802.1Q-2022";
    }
    leaf xcon-ccm-last-failure {
      type binary {
        length "1..128";
      }
      config false;
      description
        "The last received CCM that triggered a def-xcon-ccm
        fault.";
      reference
        "Item u) in 12.14.7.1.3, 20.23.2 of IEEE Std 802.1Q-2022";
    }
  }

  // continuity-check
  container stats {
    config false;
    description
      "Contains the counters associated with the MEP.";
    leaf mep-ccm-sequence-errors {
      type yang:counter64;
      mandatory true;
      description
        "The total number of out-of-sequence CCMs received from
```

```
        all remote MEPs.";
      reference
        "Item v) in 12.14.7.1.3, 20.16.12 of IEEE Std 802.1Q-2022";
    }
    leaf mep-ccms-sent {
      type yang:counter64;
      mandatory true;
      description
        "Total number of CCMs transmitted";
      reference
        "Item w) in 12.14.7.1.3, 20.10.2 of IEEE Std 802.1Q-2022";
    }
    leaf mep-lbr-in {
      type yang:counter64;
      mandatory true;
      description
        "Total number of valid, in-order Loopback Replies
        received.";
      reference
        "Item y) in 12.14.7.1.3, 20.31.1 of IEEE Std 802.1Q-2022";
    }
    leaf mep-lbr-in-out-of-order {
      type yang:counter64;
      mandatory true;
      description
        "The total number of valid, out-of-order Loopback Replies
        received";
      reference
        "Item z) in 12.14.7.1.3, 20.31.1 of IEEE Std 802.1Q-2022";
    }
    leaf mep-lbr-bad-msdu {
      type yang:counter64;
      mandatory true;
      description
        "The total number of LBRs received whose
        mac_service_data_unit did not match (except for the
        OpCode) that of the corresponding LBM.";
      reference
        "Item aa) in 12.14.7.1.3, 20.2.3 of IEEE Std 802.1Q-2022";
    }
    leaf mep-unexpected-ltr-in {
      type yang:counter64;
      mandatory true;
      description
        "The total number of unexpected LTRs received.";
      reference
        "Item ac) in 12.14.7.1.3, 20.44.1 of IEEE Std 802.1Q-2022";
    }
    leaf mep-lbr-out {
      type yang:counter64;
      mandatory true;
      description
        "Total number of Loopback Replies transmitted.";
      reference
        "Item ad) in 12.14.7.1.3, 20.28.2 of IEEE Std 802.1Q-2022";
    }
  }

  // transmit-linktrace
  list linktrace-reply {
    key "ltr-transaction-id";
    config false;
    description
      "This list extends the MEP table and reports on accepted
      transmit-linktrace actions. In case linktrace replies are
      received it also reports with data from the received
      Linktrace reply messages.";
    leaf ltr-transaction-id {
      type cfm-types:seq-number-type;
      description
        "Transaction identifier returned by a previous transmit
        linktrace message command, indicating which LTMs response
```

```
      is going to be returned.";
    reference
      "Item b) in 12.14.7.5.2 of IEEE Std 802.1Q-2022";
  }
  container linktrace-input {
    description
      "The linktrace parameter input. By default, the priority
      used is that of the CCMs (ccm-ltm-priority) and the drop
      elibility is false.";
    uses linktrace-input-grouping;
  }
  list responses {
    key "ltr-receive-order";
    description
      "The responses associated with the request.";
    leaf ltr-receive-order {
      type uint32 {
        range "1..4294967295";
      }
      description
        "An index to distinguish among multiple LTRs with the
        same LTR Transaction Identifier field value. Assigned
        sequentially from 1, in the order that the Linktrace
        Initiator received the LTRs.";
    }
    leaf ltr-ttl {
      type uint8 {
        range "0..255";
      }
      mandatory true;
      description
        "TTL field value for a returned LTR.";
      reference
        "12.14.7.5, 20.41.2.2 of IEEE Std 802.1Q-2022";
    }
    leaf ltr-forwarded {
      type boolean;
      mandatory true;
      description
        "Indicates if an LTM was forwarded by the responding MP,
        as returned in the FwdYes flag of the flags field.";
      reference
        "Item c) in 12.14.7.5.3, 20.41.2.1 of IEEE Std 802.1Q-2022";
    }
    leaf ltr-terminal-mep {
      type boolean;
      mandatory true;
      description
        "A Boolean value stating whether the forwarded LTM
        reached a MEP enclosing its MA, as returned in the
        Terminal MEP flag of the Flags field";
      reference
        "Item d) in 12.14.7.5.3, 20.41.2.1 of IEEE Std 802.1Q-2022";
    }
    container ltr-last-egress-identifier {
      description
        "An octet field holding the Last Egress Identifier
        returned in the LTR Egress Identifier TLV of the LTR.
        The Last Egress Identifier identifies the MEP Linktrace
        Initiator that originated, or the Linktrace Responder
        that forwarded, the LTM to which this LTR is the
        response. This is the same value as the Egress
        Identifier TLV of that LTM.";
      reference
        "Item e) in 12.14.7.5.3, 20.41.2.3 of IEEE Std 802.1Q-2022";
      uses ltm-egress-identifier-grouping;
    }
    container ltr-next-egress-identifier {
      description
        "An octet field holding the Next Egress Identifier
        returned in the LTR Egress Identifier TLV of the LTR.
        The Next Egress Identifier Identifies the Linktrace
```

```
    Responder that transmitted this LTR, and can forward the
    LTM to the next hop. This is the same value as the
    Egress Identifier TLV of the forwarded LTM, if any. If
    the FwdYes bit of the Flags field is false, the contents
    of this field are undefined, i.e., any value can be
    transmitted, and the field is ignored by the receiver.";
  reference
    "Item f) in 12.14.7.5.3, 20.41.2.4 of IEEE Std 802.1Q-2022";
  uses ltm-egress-identifier-grouping;
}
leaf ltr-relay {
  type cfm-types:relay-action-field-value-type;
  mandatory true;
  description
    "Value returned in the Relay Action field.";
  reference
    "Item g) in 12.14.7.5.3, 20.41.2.5 of IEEE Std 802.1Q-2022";
}
leaf ltr-chassis-id-subtype {
  type ieee:chassis-id-subtype-type;
  description
    "Specifies the format of the Chassis ID returned in the
    Sender ID TLV of the LTR, if any. This leaf is not
    present if the LTR did not contain a Sender ID TLV or if
    the Sender ID TLV did not contain a Chassis ID.";
  reference
    "Item h) in 12.14.7.5.3, 21.5.3.2 of IEEE Std 802.1Q-2022";
}
leaf ltr-chassis-id {
  when
    "../ltr-chassis-id-subtype";
  type ieee:chassis-id-type;
  mandatory true;
  description
    "The Chassis ID returned in the Sender ID TLV of the
    LTR, if any. The format of this object is determined by
    the value of the ltr-chassis-id-subtype object. This
    leaf is not present if the LTR did not contain a Sender
    ID TLV or if the Sender ID TLV did not contain a Chassis
    ID.";
  reference
    "Item i) in 12.14.7.5.3, 21.5.3.2 of IEEE Std 802.1Q-2022";
}
container ltr-transport-service-domain {
  description
    "The transport management domain and address. This
    container is empty if the LTR did not contain a Sender
    ID TLV or if the Sender ID TLV did not contain a
    Management Address.";
  reference
    "Item j) in 12.14.7.5.3 of IEEE Std 802.1Q-2022";
  uses management-address-grouping;
}
leaf ltr-ingress {
  type cfm-types:ingress-action-field-value-type;
  description
    "The value returned in the Ingress Action Field of the
    LTM. This leaf is not present if no Reply Ingress TLV
    was returned in the LTM.";
  reference
    "Item k) in 12.14.7.5.3, 20.41.2.6 of IEEE Std 802.1Q-2022";
}
leaf ltr-ingress-mac {
  when
    "../ltr-ingress";
  type ieee:mac-address;
  mandatory true;
  description
    "MAC address returned in the ingress MAC address field.
    This leaf is not present if the ltr-ingress leaf is not
    present.";
  reference
```

```
    "Item l) in 12.14.7.5.3, 20.41.2.7 of IEEE Std 802.1Q-2022";
}
leaf ltr-ingress-port-id-subtype {
  when
    "../ltr-ingress";
  type ieee:port-id-subtype-type;
  description
    "Format of the ingress Port ID. This leaf is not present
    if the ltr-ingress leaf is not present, or if the Reply
    Ingress TLV did not contain a Port ID.";
  reference
    "Item m) in 12.14.7.5.3, 20.41.2.8 of IEEE Std 802.1Q-2022";
}
leaf ltr-ingress-port-id {
  when
    "../ltr-ingress and ../ltr-ingress-port-id-subtype";
  type ieee:port-id-type;
  mandatory true;
  description
    "Ingress Port ID. The format of this object is
    determined by the value of the
    ltr-ingress-port-id-subtype object. This leaf is not
    present if the ltr-ingress leaf or the
    ltr-ingress-port-id-subtype leaf are not present.";
  reference
    "Item n) in 12.14.7.5.3, 20.41.2.9 of IEEE Std 802.1Q-2022";
}
leaf ltr-egress {
  type cfm-types:egress-action-field-value-type;
  description
    "The value returned in the Egress Action Field of the
    LTM. The node is not present if no Reply Egress TLV was
    returned in the LTM.";
  reference
    "Item o) in 12.14.7.5.3, 20.41.2.10 of IEEE Std 802.1Q-2022";
}
leaf ltr-egress-mac {
  when
    "../ltr-egress";
  type ieee:mac-address;
  mandatory true;
  description
    "MAC address returned in the egress MAC address field.
    This leaf is not present if the ltr-egress leaf is not
    present.";
  reference
    "Item p) in 12.14.7.5.3, 20.41.2.11 of IEEE Std 802.1Q-2022";
}
leaf ltr-egress-port-id-subtype {
  when
    "../ltr-egress";
  type ieee:port-id-subtype-type;
  description
    "Format of the egress Port ID. This leaf is not present
    if the ltr-egress leaf is not present, or if the Reply
    Egress TLV did not contain a Port ID.";
  reference
    "Item q) in 12.14.7.5.3, 20.41.2.12 of IEEE Std 802.1Q-2022";
}
leaf ltr-egress-port-id {
  when
    "../ltr-egress and ../ltr-egress-port-id-subtype";
  type ieee:port-id-type;
  mandatory true;
  description
    "Egress Port ID. The format of this object is determined
    by the value of the ltr-egress-port-id-subtype object.
    This leaf is not present if the ltr-egress leaf or the
    ltr-egress-port-id-subtype leaf are not present.";
  reference
    "Item r) in 12.14.7.5.3, 20.41.2.13 of IEEE Std 802.1Q-2022";
}
```

```
    leaf ltr-organization-specific-tlv {
      type binary {
        length "0 | 4..1500";
      }
      description
        "All Organization specific TLVs returned in the LTR, if
        any. Includes all octets including and following the TLV
        Length field of each TLV, concatenated together.";
      reference
        "Item s) in 12.14.7.5.3, 21.5.2 of IEEE Std 802.1Q-2022";
    }
  }
}

// stats
action transmit-loopback {
  description
    "To signal to the MEP to transmit some number of LBMs.
    Accepting the action means the device will transmit LBM
    messages according the input leaf nodes.";
  input {
    uses loopback-input-grouping;
  }

  // input
  output {
    leaf lbm-request-id {
      type cfm-types:seq-number-type;
      mandatory true;
      description
        "The Loopback transaction identifier of the first LBM
        (to
        be) sent.";
      reference
        "Item b) in 12.14.7.3.3 of IEEE Std 802.1Q-2022";
    }
  }
}

// transmit-loopback
action transmit-linktrace {
  description
    "To signal to the MEP to transmit an LTM and to create an
    LTM entry in the MEPs Linktrace Database. Accepting the
    action means the device will transmit LTM messages according
    to the input leafs. The outcome of sending these LTM
    messages will be reported through the list
    'linktrace-reply'.";
  input {
    uses linktrace-input-grouping;
  }

  // input
  output {
    leaf ltm-transaction-id {
      type cfm-types:seq-number-type;
      mandatory true;
      description
        "The LTM transaction identifier of the LTM sent. The
        value returned is undefined if and RPC error is
        returned.";
      reference
        "Item b) in 12.14.7.4.3 of IEEE Std 802.1Q-2022";
    }
    container ltm-egress-identifier {
      description
        "Identifies the MEP Linktrace Initiator that is
        originating this LTM.

        The low-order six octets contain a 48-bit IEEE MAC
        address unique to the system in which the MEP Linktrace
        Initiator or Linktrace Responder resides. The high-order
```

```
                two octets contain a value sufficient to uniquely
                identify the MEP Linktrace Initiator or Linktrace
                Responder within that system.

                For most Bridges, the address of any MAC attached to the
                Bridge will suffice for the low-order six octets, and 0
                for the high-order octets. In some situations, e.g., if
                multiple virtual Bridges utilizing emulated LANs are
                implemented in a single physical system, the high-order
                two octets can be used to differentiate among the
                transmitting entities.

                The value returned is undefined if the
                transmit-linktrace input action was not accepted.";
              reference
                "Item c) in 12.14.7.4.3 of IEEE Std 802.1Q-2022";
              uses ltm-egress-identifier-grouping;
            }
          }
        }
      }
    }
  }
}
```

48.6.9 The ieee802-dot1q-cfm-bridge YANG module

```
module ieee802-dot1q-cfm-bridge {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-cfm-bridge;
  prefix cfm-bridge;
  import ieee802-dot1q-bridge {
    prefix dot1q;
  }
  import ieee802-dot1q-cfm {
    prefix dot1q-cfm;
  }
  import ietf-interfaces {
    prefix if;
  }
  import ieee802-types {
    prefix ieee;
  }
  import ieee802-dot1q-cfm-types {
    prefix cfm-types;
  }
  import ieee802-dot1q-types {
    prefix dot1q-types;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "Connectivity Fault Management (CFM) comprises capabilities for
    detecting, verifying, and isolating connectivity failures in Virtual
    Bridged Local Area Networks. This module binds the CFM modules to an
    IEEE 802.1Q Bridge.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Initial version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }
  typedef bridge-ref {
    type leafref {
      path '/dot1q:bridges/dot1q:bridge/dot1q:name';
    }
    description
      "This type is used by data models that need to reference a
      configured Bridge.";
  }
  typedef port-ref {
    type if:interface-ref;
```

```
  description
    "This type is used to represent interfaces that can be used by a
    Bridge device.";
}

/* ------------------------------------------------
 * Grouping definitions used by 802.1Qcx YANG module
 * ------------------------------------------------
 */
grouping service-id-grouping {
  description
    "The list of VIDs, the I-SID, the TE-SID, or the SEG-ID monitored
    by this MA, if present. In the case that a list of VIDs is
    specified, the first VID in the list is the MA's Primary VID
    (default none). The specification of I-SID is allowed only in the
    case of I- or B-components. The TE-SID is allowed only in the case
    that PBB-TE or SPBM is supported. The SEG-ID is allowed only in
    the case that IPS is supported.";
  choice service-id {
    description
      "The type of service identifier.";
    case vids {
      list vid {
        key "vlan-id";
        description
          "A list of VIDs associated with any MHF on the VID, always
          including that VID. The first VID is the MA's primary VID.
          List is empty if no primary VID specified";
        leaf vlan-id {
          type dot1q-types:vlanid;
          description
            "The 12-bit VLAN identifier.";
        }
      }
    }
    case isid {
      leaf isid {
        type uint32 {
          range "1..16777215";
        }
        description
          "24-bit I-SID identifier.";
      }
    }
    case tesid {
      leaf tesid {
        type uint32 {
          range "1..4294967295";
        }
        description
          "The tesid is used as a service selector for MAs that are
          present in Bridges that implement PBB-TE functionality.";
      }
    }
    case segid {
      leaf segid {
        type uint32 {
          range "1..4294967295";
        }
        description
          "The segid is used as a service selector for MAs that are
          present in Bridges that implement IPS functionality.";
      }
    }
    case path-tesid {
      leaf path-tesid {
        type uint32 {
          range "1..4294967295";
        }
        description
          "The path-tesid is used as a service selector for SPBM path
          MAs.";
```

```
      }
    }
    case group-isid {
      leaf group-isid {
        type uint32 {
          range "1..4294967295";
        }
        description
          "The group-isid is used as a service selector for SPBM group
          MAs.";
      }
    }
  }
}

/* ---------------------------------------------------------------
 *  Augmentations of objects defined in generic CFM YANG module
 *  (ieee802-dot1q-cfm) and generic MEP YANG module
 *  (ieee802-dot1q-cfm-mep).
 * ---------------------------------------------------------------
 */
augment "/dot1q-cfm:cfm" {
  description
    "Augment the base/common CFM model with CFM Bridge specific
    attributes.";
  list cfm-stack {
    key "port service-selector service-id md-level direction";
    config false;
    description
      "The CFM Stack contains information about the Maintenance Points
      configured on a particular Bridge Port (or Aggregation Port). It
      contains all CFM Stack specific related configuration and
      operational data.

      Upon a restart of the system, the system SHALL, if necessary,
      change the value of this variable, and rearrange the cfm-stack,
      so that it indexes the entry in the interface table with the
      same value of interface-ref that it indexed before the system
      restart. If no such entry exists, then the system SHALL delete
      all entries in the cfm-stack with the interface index.";
    leaf port {
      type port-ref;
      description
        "An interface on which maintenance points might be configured.
        This object represents the Bridge Port or Aggregation Port on
        which MEPs or MHFs might be configured.";
      reference
        "Item a) in 12.14.2.1.2 of IEEE Std 802.1Q-2022";
    }
    leaf md-level {
      type cfm-types:md-level-type;
      description
        "The MD level of the maintenance point";
      reference
        "Item b) in 12.14.2.1.2  of IEEE Std 802.1Q-2022";
    }
    leaf direction {
      type cfm-types:mp-direction-type;
      description
        "The direction in which the maintenance point faces on the
        Bridge Port.";
      reference
        "Item c) in 12.14.2.1.2 of IEEE Std 802.1Q-2022";
    }
    leaf service-selector {
      type cfm-types:service-selector-type;
      description
        "The type of the service selector";
    }
    leaf service-id {
      type cfm-types:service-selector-value-type;
      description
```

```
    "A VID, I-SID, Traffic Engineering service instance Identifier
    (TE-SID), or Segment Identifier (SEG-ID) associated with an
    MP, or 0, in the case that the MP is associated with no VID,
    I-SID, TE-SID, or SEG-ID.";
  reference
    "Item d) in 12.14.2.1.2 of IEEE Std 802.1Q-2022";
}
leaf maintenance-group-id {
  when
    "../maintenance-point = \"mep\"" {
    description
      "This should only exist if the configured maintenance point
      is a MEP (and not a MHF).";
  }
  type leafref {
    path
      '/dot1q-cfm:cfm'+
      '/dot1q-cfm:maintenance-group'+
      '/dot1q-cfm:maintenance-group-id';
  }
  mandatory true;
  description
    "The maintenance group that the MEP is associated with. If the
    Maintenance Point is a MHF created due to an entry in the
    default-md-levels list, it has no associated maintenance
    group, and therefore this leaf is not present.";
}
leaf mep-id {
  when
    "../maintenance-point = \"mep\"" {
    description
      "This should only exist if the configured maintenance-point
      is a MEP.";
  }
  type leafref {
    path
      "/dot1q-cfm:cfm/dot1q-cfm:maintenance-group[dot1q-cfm:main"+
      "tenance-group-id = current()/../maintenance-group-id]/dot"+
      "1q-cfm:mep/dot1q-cfm:mep-id";
  }
  mandatory true;
  description
    "The MEP identifier if a MEP is configured. Does not exist if
    the maintenance point is a MHF.";
  reference
    "Item d) in 12.14.2.1.3 of IEEE Std 802.1Q-2022";
}
leaf md-id {
  when
    "../maintenance-point != \"mep\"" {
    description
      "This should only exist if the configured maintenance point
      is a MHF (and not a MEP).";
  }
  type leafref {
    path
      '/dot1q-cfm:cfm'+
      '/dot1q-cfm:maintenance-domain'+
      '/dot1q-cfm:md-id';
  }
  description
    "The maintenance domain that the MHF is associated with. If
    the MHF is created due to an entry in the default-md-levels
    list, it has no associated maintenance domain, and therefore
    this leaf is not present.";
}
leaf ma-id {
  when
    "../maintenance-point != \"mep\"" {
    description
      "This should only exist if the configured maintenance point
      is a MHF (and not a MEP), and it has a Maintenance Domain.";
```

```
    }
    type leafref {
      path
        '/dot1q-cfm:cfm'+
        '/dot1q-cfm:maintenance-domain[dot1q-cfm:md-id = current()'+
        '/..'+
        '/md-id]'+
        '/dot1q-cfm:maintenance-association'+
        '/dot1q-cfm:ma-id';
    }
    description
      "The maintenance association that the MHF is associated with.
      If the MHF is created due to an entry in the default-md-levels
      list, it has no associated maintenance association, and
      therefore this leaf is not present.";
  }
  leaf mac-address {
    type ieee:mac-address;
    mandatory true;
    description
      "The MAC address of the maintenance point.";
    reference
      "Item e) in 12.14.2.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf maintenance-point {
    type cfm-types:mp-type;
    mandatory true;
    description
      "Indicates the type of maintenance point. That is whether a
      MEP or MHF.";
    reference
      "Item a) in 12.14.2.1.3 of IEEE Std 802.1Q-2022";
  }
}

// cfm-stack
list default-md-level {
  key "bridge-id component-id service-selector primary-service-id";
  description
    "For each bridge component, the Default MD Level Managed Object
    controls MHF creation for VIDs that are not attached to a
    specific Maintenance Association Managed Object, and Sender ID
    TLV transmission by those MHFs.

    For each Bridge Port, and for each VLAN ID whose data can pass
    through that Bridge Port, an entry in this table is used by the
    algorithm in subclause 22.2.3 only if there is no entry in the
    Maintenance Association table defining an MA for the same VLAN
    ID and MD Level as this table's entry, and on which MA an Up MEP
    is defined. If there exists such an MA, that MA's objects are
    used by the algorithm in subclause 22.2.3 in place of this table
    entry objects.

    The agent maintains the value of md-status to indicate whether
    this entry is overridden by an MA. When first initialized, the
    agent creates this table automatically with entries for all VLAN
    IDs, with the default values specified for each object. After
    this initialization, the writable objects in this table need to
    be persistent upon reboot or restart of a device.";
  leaf bridge-id {
    type bridge-ref;
    description
      "The reference to the IEEE 802.1Q Bridge associated with the
      CFM objects.";
  }
  leaf component-id {
    type leafref {
      path
        '/dot1q:bridges'+
        '/dot1q:bridge[dot1q:name = current()'+
        '/..'+
        '/bridge-id]'+
```

```
        '/dot1q:component'+
        '/dot1q:name';
    }
    description
      "The Bridge component within the system to which the
      information in this entry applies. If the system is not a
      Bridge, or if only one component is present in the Bridge,
      then this variable (index) MUST be equal to 1.";
    reference
      "12.3l of IEEE Std 802.1Q-2022";
  }
  leaf service-selector {
    type cfm-types:service-selector-type;
    description
      "The type of the service selector";
  }
  leaf primary-service-id {
    type cfm-types:service-selector-value-type;
    description
      "A vid or isid in an I or B component.";
    reference
      "Item a) in 12.14.3.1.2 of IEEE Std 802.1Q-2022";
  }
  container associated-service-ids {
    description
      "A list of VIDs associated with any MHF on the VID, always
      including that VID, or the Backbone-SID of the B-component or
      VIP-SID of the I-component associated with any MHF on the
      I-SID. The first VID is the MAs Primary VID.

      List is empty if no primary VID specified.";
    reference
      "Item a) in 12.14.3.1.3 of IEEE Std 802.1Q-2022";
    uses service-id-grouping;
  }
  leaf md-status {
    type boolean;
    config false;
    mandatory true;
    description
      "A Boolean value indicating whether this entry is in effect or
      has been overridden by the existence of a Maintenance
      Association managed object associated with the same VID or
      I-SID of I- or B-components and MD Level, and on which is
      configured an Up MEP. True if this Maintenance Domain managed
      object is in effect.";
    reference
      "Item b) in 12.14.3.1.3 of IEEE Std 802.1Q-2022";
  }
  leaf md-level {
    type cfm-types:md-level-type;
    mandatory true;
    description
      "A value indicating the MD Level at which MHFs are to be
      created, and Sender ID TLV transmission by those MHFs is to be
      controlled, for the VLAN to which this entry's objects apply.";
    reference
      "Item c) in 12.14.3.1.3, Item b) in 12.14.3.2.2 of IEEE Std
      802.1Q-2022";
  }
  leaf mhf-creation {
    type cfm-types:mhf-creation-type;
    must
      ". != \"mhf-defer\"" {
      description
        "The value can not be mhf-defer. Must be one of mhf-none,
        mhf-default, or mfh-explicit.";
    }
    default "mhf-none";
    description
      "An enumerated value indicating whether the management entity
      can create MHFs for this VID(s) or I-SID(s) of I- or
```

```
          B-components.";
        reference
          "Item d) in 12.14.3.1.3 of IEEE Std 802.1Q-2022";
      }
      leaf id-permission {
        type cfm-types:sender-id-permission-type;
        must
          ". != \"send-id-defer\"" {
          description
            "The value can not be send-id-defer. Must be one of
            send-id-none, send-id-chassis, send-id-manage,
            send-id-chassis-manage.";
        }
        default "send-id-none";
        description
          "An enumerated value indicating what, if anything, is to be
          included in the Sender ID TLV transmitted by MPs configured in
          the Default Maintenance Domain.";
        reference
          "Item e) in 12.14.3.1.3, Item a) in 12.14.3.2.2 of IEEE Std
          802.1Q-2022";
      }
    }

    // default-md-level
    list config-error {
      key "port service-selector service-id";
      config false;
      description
        "The CFM Configuration Error List table provides a list of
        Interfaces and VIDs that are incorrectly configured.";
      leaf port {
        type port-ref;
        description
          "The interface index of the interface (i.e., Bridge Port).

          Upon a restart of the system, the system SHALL, if necessary,
          change the value of this variable so that it indexes the entry
          in the interface table with the same value of the index that
          it indexed before the system restart. If no such entry exists,
          then the system SHALL delete any entries in config-error-list
          indexed by that interface-ref.";
        reference
          "Item b) in 12.14.4.1.2 of IEEE Std 802.1Q-2022";
      }
      leaf service-selector {
        type cfm-types:service-selector-type;
        description
          "The type of the service selector";
      }
      leaf service-id {
        type cfm-types:service-selector-value-type;
        description
          "A vid or isid in an I or B component.";
        reference
          "Item a) in 12.14.4.1.2 of IEEE Std 802.1Q-2022";
      }
      leaf error-type {
        type cfm-types:config-error-type;
        mandatory true;
        description
          "vector of Boolean error conditions from 22.2.4.";
        reference
          "Item b) in 12.14.4.1.3 of IEEE Std 802.1Q-2022";
      }
    }
  }
  augment "/dot1q-cfm:cfm/dot1q-cfm:maintenance-group" {
    when
      "dot1q-cfm:maintenance-group-id";
    description
      "Augment the maintenance group list object with the maintenance
```

```
      association component identifier, since the maintenance
      association component is an Bridge specific attributes.";
    leaf bridge-id {
      type bridge-ref;
      description
        "The reference to the IEEE 802.1Q Bridge associated with the CFM
        objects.";
    }
    leaf component-name {
      when
        "../bridge-id";
      type leafref {
        path
          '/dot1q:bridges'+
          '/dot1q:bridge[dot1q:name = current()'+
          '/..'+
          '/cfm-bridge:bridge-id]'+
          '/dot1q:component'+
          '/dot1q:name';
      }
      mandatory true;
      description
        "A reference to the maintenance association component within the
        provided maintenance domain and maintenance association values.";
    }
    container service-id {
      description
        "The service identifier grouping.";
      uses service-id-grouping;
    }
  }
  augment "/dot1q-cfm:cfm/dot1q-cfm:maintenance-group/dot1q-cfm:mep" {
    when
      "dot1q-cfm:mep-id";
    description
      "Augment the MEP object defined in the ieee802-dot1q-cfm (CFM MEP)
      YANG module with Bridge specific attributes.";
    leaf port {
      type port-ref;
      must
        "not(/dot1q-cfm:cfm/dot1q-cfm:maintenance-group/cfm-bridge:com"+
        "ponent-name) or /dot1q-cfm:cfm/dot1q-cfm:maintenance-group/cf"+
        "m-bridge:component-name = /if:interfaces/if:interface[current"+
        "() = ./if:name]/dot1q:bridge-port/dot1q:component-name" {
        description
          "If there is a Bridge Component, then the component of the
          port (Interface) reference must be the same as the bridge and
          component references by the maintenance association group.";
      }
      mandatory true;
      description
        "The interface index of the interface (e.g., Bridge Port) to
        which the MEP is attached.";
      reference
        "Item b) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
    }
    leaf primary-vid {
      type leafref {
        path '../../service-id/vid/vlan-id';
      }
      description
        "An integer indicating the Primary VID of the MEP. It is always
        one of the VIDs assigned to the MEPs MA. If not present, then
        indicates that either the Primary VID is that of the MEPs MA, or
        that the MEPs MA is associated with no VID.";
      reference
        "Item d) in 12.14.7.1.3 of IEEE Std 802.1Q-2022";
    }
  }
}
```

48.6.10 The ieee802-dot1q-cfm-alarm YANG module

```
module ieee802-dot1q-cfm-alarm {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-cfm-alarm;
  prefix dot1q-cfm-alarm;
  import ieee802-dot1q-cfm {
    prefix dot1q-cfm;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "Connectivity Fault Management (CFM) comprises capabilities for
    detecting, verifying, and isolating connectivity failures in Virtual
    Bridged Local Area Networks. These capabilities can be used in
    networks operated by multiple independent organizations, each with
    restricted management access to each other's equipment.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-06-04 {
    description
      "Published as part of IEEE Std 802.1Qcx-2020. Initial version.";
    reference
      "IEEE Std 802.1Qcx-2020, Bridges and Bridged Networks - YANG Data
      Model for Connectivity Fault Management.";
  }

  /* ---------------------------------------------------------------
   *  Augmentations of objects defined in generic CFM YANG module
   *  (ieee802-dot1q-cfm) to define CFM alarms.
   * ---------------------------------------------------------------
   */
  augment "/dot1q-cfm:cfm/dot1q-cfm:maintenance-group/dot1q-cfm:mep" {
    when
      "dot1q-cfm:mep-id";
    description
      "Augment the MEP object defined in the ieee802-dot1q-cfm (CFM MEP)
      YANG module with CFM alarm specific attributes.";
    notification mep-fault-alarm {
      description
        "To alert the Manager to the existence of a fault in a monitored
        MA by issuing a Fault Alarm.";
      reference
        "Item c) in 12.14.7.7.2 of IEEE Std 802.1Q-2022";
      leaf mep-priority-defect {
        type leafref {
          path
            '..'+
            '/..'+
            '/dot1q-cfm:continuity-check'+
```

```
            '/dot1q-cfm:highest-priority-defect';
        }
        config false;
        mandatory true;
        description
          "The highest priority defect that has been present since the
          MEPs Fault Notification Generator state machine was last in
          the FNG_RESET state.";
      }
    }
  }
}
```

48.6.11 The ieee802-dot1q-stream-filters-gates YANG module

```
module ieee802-dot1q-stream-filters-gates {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-stream-filters-gates;
  prefix sfsg;
  import ieee802-dot1q-bridge {
    prefix dot1q;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This module provides management of 802.1Q bridge components that
    support Stream Filters and Stream Gates.

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022. Second version.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-11-06 {
    description
      "Published as part of IEEE Std 802.1Qcr-2020. Initial version.";
    reference
      "IEEE Std 802.1Qcr-2020, Bridges and Bridged Networks -
      Asynchronous Traffic Shaping.";
  }
  feature closed-gate-state {
    description
      "The bridge component supports gate state closed.";
    reference
      "IEEE Std 802.1Q-2022";
  }

  /* Types and groupings */
  typedef priority-spec-type {
    type enumeration {
      enum zero {
        value 0;
        description
          "Priority 0";
      }
      enum one {
        value 1;
        description
          "Priority 1";
      }
      enum two {
        value 2;
        description
          "Priority 2";
      }
      enum three {
        value 3;
```

```
      description
        "Priority 3";
    }
    enum four {
      value 4;
      description
        "Priority 4";
    }
    enum five {
      value 5;
      description
        "Priority 5";
    }
    enum six {
      value 6;
      description
        "Priority 6";
    }
    enum seven {
      value 7;
      description
        "Priority 7";
    }
    enum wildcard {
      description
        "wildcard value";
    }
  }
  description
    "The frame's priority value";
  reference
    "8.6.5.2 of IEEE Std 802.1Q-2022";
}
typedef ipv-spec-type {
  type enumeration {
    enum zero {
      value 0;
      description
        "Priority 0";
    }
    enum one {
      value 1;
      description
        "Priority 1";
    }
    enum two {
      value 2;
      description
        "Priority 2";
    }
    enum three {
      value 3;
      description
        "Priority 3";
    }
    enum four {
      value 4;
      description
        "Priority 4";
    }
    enum five {
      value 5;
      description
        "Priority 5";
    }
    enum six {
      value 6;
      description
        "Priority 6";
    }
    enum seven {
      value 7;
```

```
        description
          "Priority 7";
      }
      enum null {
        description
          "null value";
      }
    }
    description
      "An IPV can be either of the following:
         1) The null value. For a frame that passes through the gate,
            the priority value associated with the frame is used to
            determine the frame's traffic class, using the Traffic Class
            Table as specified in 8.6.6.
         2) An internal priority value. For a frame that passes through
            the gate, the IPV is used, in place of the priority value
            associated with the frame, to determine the frame's traffic
            class, using the Traffic Class Table as specified in 8.6.6.";
    reference
      "8.6.5.2 of IEEE Std 802.1Q-2022";
  }
  typedef gate-state-value-type {
    type enumeration {
      enum closed {
        description
          "Gate closed";
      }
      enum open {
        description
          "Gate open";
      }
    }
    description
      "The gate-state-value-type indicates a gate state, open or closed,
      for the stream gate.";
    reference
      "12.31.3.2.1 of IEEE Std 802.1Q-2022";
  }
  typedef stream-gate-ref {
    type leafref {
      path
        '/dot1q:bridges'+
        '/dot1q:bridge'+
        '/dot1q:component'+
        '/sfsg:stream-gates'+
        '/sfsg:stream-gate-instance-table'+
        '/sfsg:stream-gate-instance-id';
    }
    description
      "This type is used to refer to a stream gate instance.";
  }
  augment "/dot1q:bridges/dot1q:bridge/dot1q:component" {
    description
      "Augments the Bridge component with stream filters and stream
      gates.";
    container stream-filters {
      description
        "This container encapsulates all nodes related to stream
        bilters.";
      reference
        "12.31 of IEEE Std 802.1Q-2022";
      list stream-filter-instance-table {
        key "stream-filter-instance-id";
        description
          "Each list entry contains a set of parameters that defines a
          single stream filter (8.6.5.1) with associated maximum SDU
          size filtering (8.6.5.3.1), as detailed in Table 12-32.
          Entries can be created or removed dynamically in
          implementations that support dynamic configuration of stream
          filters. The value of the stream-handle-spec and priority-spec
          parameters associated with a received frame determine which
          stream filter is selected by the frame, and therefore what
```

```
  combination of filtering and policing actions is applied to
  the frame. If the stream-handle-spec and priority-spec
  parameters associated with a received frame match more than
  one stream filter, the stream filter that is selected is the
  one that appears earliest in the ordered list. If a received
  frame's stream-handle-spec and priority-spec does not match
  any of the stream filters in the list, the frame is processed
  as if stream filters and stream gates would not be supported.";
reference
  "12.31.2 of IEEE Std 802.1Q-2022";
leaf stream-filter-instance-id {
  type uint32;
  mandatory true;
  description
    "An integer index value that determines the place of the
    stream filter in the ordered list of stream filter
    instances. The values are ordered according to their integer
    value; smaller values appear earlier in the ordered list.";
  reference
    "12.31.2.1 of IEEE Std 802.1Q-2022";
}
choice stream-handle-spec {
  description
    "The stream_handle specification data type allows either of
    the following to be represented:
     a) A stream_handle value, represented as an integer.
     b) The wildcard value, which matches any frame";
  reference
    "12.31.2.2 of IEEE Std 802.1Q-2022";

  /* NOTE: The mapping of the wildcard literal is
   *       other than in the MIB definition, where
   *       the wildcard value is mapped to -1.
   */
  case wildcard {
    leaf wildcard {
      type empty;
      description
        "The stream handle specification represents a wildcard
        value.";
    }
  }
  case stream-handle {
    leaf stream-handle {
      type uint32;
      mandatory true;
      description
        "The stream handle specification refers to a
        stream_handle value.";
    }
  }
}
leaf priority-spec {
  type priority-spec-type;
  mandatory true;
  description
    "The priority specification data type allows either of the
    following to be represented:
     a) A priority value, represented as an integer.
     b) The wildcard value, which matches any priority.";
  reference
    "12.31.2.3 of IEEE Std 802.1Q-2022";
}
leaf max-sdu-size {
  type uint32;
  units "octets";
  mandatory true;
  description
    "The allowed maximum SDU size, in octets. If set to 0, any
    SDU size is accepted.";
  reference
    "8.6.5.3.1 of IEEE Std 802.1Q-2022";
```

```
    }
    leaf stream-blocked-due-to-oversize-frame-enabled {
      type boolean;
      default "false";
      description
        "A value of true indicates that
        stream-blocked-due-to-oversize-frame is set to true as soon
        as a frame exceeds max-sdu-size.";
      reference
        "8.6.5.3.1 of IEEE Std 802.1Q-2022";
    }
    leaf stream-blocked-due-to-oversize-frame {
      type boolean;
      default "false";
      description
        "Indicates by value true that frames are permanently
        discarded as a result of an initial frame exceeding
        max-sdu-size. The value of
        stream-blocked-due-to-oversize-frame can be administratively
        reset to false.";
      reference
        "8.6.5.3.1 of IEEE Std 802.1Q-2022";
    }
    leaf stream-gate-ref {
      type stream-gate-ref;
      mandatory true;
      description
        "This node refers to the stream gate (12.31.3) that is
        associated with the stream filter. The relationship between
        stream filters and stream gates is many to one; a given
        stream filter can be associated with only one stream gate,
        but there can be multiple stream filters associated with a
        given stream gate.";
      reference
        "12.31.2.4 of IEEE Std 802.1Q-2022";
    }
  }
  leaf max-stream-filter-instances {
    type uint32;
    config false;
    description
      "The maximum number of stream filter instances supported by
      this Bridge component.";
    reference
      "12.31.1.1, 8.6.5.1 of IEEE Std 802.1Q-2022";
  }
}
container stream-gates {
  description
    "This container encapsulates all nodes related to Stream Gates.";
  list stream-gate-instance-table {
    key "stream-gate-instance-id";
    description
      "Each list entry contains a set of parameters that defines a
      single stream gate (8.6.5.2), as detailed in Table 12-33.
      Entries in the table can be created or removed dynamically in
      implementations that support dynamic configuration of stream
      gates.";
    reference
      "12.31.3 of IEEE Std 802.1Q-2022";
    leaf stream-gate-instance-id {
      type uint32;
      description
        "An integer table index that allows the stream gate to be
        referenced from Stream Filter Instance Table entries.";
      reference
        "12.31.2.5 of IEEE Std 802.1Q-2022";
    }
    leaf gate-enable {
      type boolean;
      default "false";
      description
```

```
            "A Boolean variable that indicates whether the operation of
            the state machines is enabled (TRUE) or disabled (FALSE).
            This variable is set by management. The default value of
            this variable is FALSE.";
          reference
            "8.6.9.4.14 of IEEE Std 802.1Q-2022";
        }
        leaf admin-gate-states {
          type gate-state-value-type;
          default "open";
          description
            "The administratively set gate state of this gate.";
          reference
            "12.31.3.2.1, 8.6.10.4 of IEEE Std 802.1Q-2022";
        }
        leaf admin-ipv {
          type ipv-spec-type;
          default "null";
          description
            "The administratively set internal priority value
            specification.";
          reference
            "12.31.3.3 of IEEE Std 802.1Q-2022";
        }
      }
      leaf max-stream-gate-instances {
        type uint32;
        config false;
        description
          "The maximum number of Stream Gate instances supported by this
          Bridge component.";
        reference
          "12.31.1.2 of IEEE Std 802.1Q-2022";
      }
    }
  }
}
```

48.6.12 The ieee802-dot1q-ats YANG module

```
module ieee802-dot1q-ats {
  yang-version "1.1";
  namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-ats;
  prefix ats;
  import ietf-yang-types {
    prefix yang;
  }
  import ietf-interfaces {
    prefix if;
  }
  import ieee802-dot1q-types {
    prefix dot1qtypes;
  }
  import ieee802-dot1q-bridge {
    prefix dot1q;
  }
  import ieee802-dot1q-stream-filters-gates {
    prefix sfsg;
  }
  organization
    "IEEE 802.1 Working Group";
  contact
    "WG-URL: http://ieee802.org/1/
    WG-EMail: stds-802-1-l@ieee.org

    Contact: IEEE 802.1 Working Group Chair
    Postal: C/O IEEE 802.1 Working Group
            IEEE Standards Association
            445 Hoes Lane
            Piscataway, NJ 08854
            USA

    E-mail: stds-802-1-chairs@ieee.org";
  description
    "This module provides management of 802.1Q bridge components that
    support Asynchronous Traffic Shaping (ATS).

    Copyright (C) IEEE (2022).

    This version of this YANG module is part of IEEE Std 802.1Q; see the
    standard itself for full legal notices.";
  revision 2022-01-19 {
    description
      "Published as part of IEEE Std 802.1Q-2022.";
    reference
      "IEEE Std 802.1Q-2022, Bridges and Bridged Networks.";
  }
  revision 2020-11-06 {
    description
      "Published as part of IEEE Std 802.1Qcr-2020. Initial version.";
    reference
      "IEEE Std 802.1Qcr-2020, Bridges and Bridged Networks -
      Asynchronous Traffic Shaping.";
  }
  typedef scheduler-ref-type {
    type leafref {
      path
        '/dot1q:bridges'+
        '/dot1q:bridge'+
        '/dot1q:component'+
        '/ats:schedulers'+
        '/ats:scheduler-instance-table'+
        '/ats:scheduler-instance-id';
    }
    description
      "This type is used to refer to an ATS scheduler instance.";
  }
  typedef scheduler-group-ref-type {
    type leafref {
```

```
    path
      '/dot1q:bridges'+
      '/dot1q:bridge'+
      '/dot1q:component'+
      '/ats:scheduler-groups'+
      '/ats:scheduler-group-instance-table'+
      '/ats:scheduler-group-instance-id';
  }
  description
    "This type is used to refer to an ATS scheduler group instance.";
}
augment
  "/dot1q:bridges"+
  "/dot1q:bridge"+
  "/dot1q:component"+
  "/sfsg:stream-filters"+
  "/sfsg:stream-filter-instance-table" {
  description
    "Augments the Bridge component stream filter for ATS schedulers.";
  container scheduler {
    description
      "Enapsulates ATS scheduler nodes.";
    leaf scheduler-ref {
      type ats:scheduler-ref-type;
      description
        "A reference to the ATS scheduler associated with this stream
        filter.";
    }
    leaf scheduler-enable {
      type boolean;
      default "false";
      description
        "If TRUE, this stream filter has an associated ATS scheduler
        referenced by scheduler-ref. If FALSE, no ATS scheduler is
        associated with this stream filter (scheduler-ref is ignored).";
    }
  }
}
augment "/if:interfaces/if:interface/dot1q:bridge-port" {
  description
    "Augments Bridge Ports by ATS per-Port parameters.";
  container ats-port-parameters {
    description
      "This container comprises all ATS per-Port parameters.";
    leaf discarded-frames-count {
      type yang:counter64;
      config false;
      description
        "A counter of frames discarded by ATS scheduler instances
        associated with the Bridge Port.";
      reference
        "12.31.7.3 of IEEE Std 802.1Q-2022";
    }
  }
}
augment "/dot1q:bridges/dot1q:bridge/dot1q:component" {
  description
    "Augments the Bridge component by
     a) ATS schedulers
     b) ATS scheduler groups";
  container schedulers {
    description
      "This container comprises all nodes related to an ATS
      schedulers.";
    list scheduler-instance-table {
      key "scheduler-instance-id";
      description
        "Each list entry comprises a set of parameters that defines a
        single ATS scheduler instance, as detailed in Table 12-33.";
      reference
        "12.31.5 of IEEE Std 802.1Q-2022";
      leaf scheduler-instance-id {
```

```
        type uint32;
        mandatory true;
        description
          "A unique index identifying this ATS scheduler instance.";
        reference
          "12.31.5.1, 8.6.5.6 of IEEE Std 802.1Q-2022";
      }
      leaf committed-information-rate {
        type uint64;
        units "bits/second";
        mandatory true;
        description
          "The committed information rate parameter of this ATS
          scheduler instance.";
        reference
          "12.31.5.3, 8.6.5.6 of IEEE Std 802.1Q-2022";
      }
      leaf committed-burst-size {
        type uint32;
        units "bits";
        mandatory true;
        description
          "The committed burst size parameter of this ATS scheduler
          instance.";
        reference
          "12.31.5.3, 8.6.5.6 of IEEE Std 802.1Q-2022";
      }
      leaf scheduler-group-ref {
        type ats:scheduler-group-ref-type;
        mandatory true;
        description
          "A reference to the scheduler group (12.32.5) associated
          with this ATS scheduler instance. Multiple ATS scheduler
          instances can be associated to one scheduler group, as
          detailed in 8.6.5.6.";
        reference
          "12.31.6 of IEEE Std 802.1Q-2022";
      }
    }
    leaf max-scheduler-instances {
      type uint32;
      config false;
      description
        "The maximum number of ATS scheduler instances supported by
        this Bridge component.";
      reference
        "12.31.1.5 of IEEE Std 802.1Q-2022";
    }
  }
  container scheduler-groups {
    description
      "This container comprises all ATS scheduler group related nodes.";
    list scheduler-group-instance-table {
      key "scheduler-group-instance-id";
      description
        "Each list entry comprises a set of parameters that defines a
        single ATS scheduler group instance.";
      reference
        "12.31.6, 8.6.5.6 of IEEE Std 802.1Q-2022";
      leaf scheduler-group-instance-id {
        type uint32;
        description
          "A unique index identifying this ATS scheduler group
          instance.";
        reference
          "12.31.6, 8.6.5.6 of IEEE Std 802.1Q-2022";
      }
      leaf max-residence-time {
        type uint32;
        units "nanoseconds";
        mandatory true;
        description
```

```
      "The maximum residence time parameter of the ATS scheduler
      group.";
    reference
      "8.6.11.2.13, 8.6.5.6 of IEEE Std 802.1Q-2022";
  }
}
leaf max-scheduler-group-instances {
  type uint32;
  config false;
  description
    "The maximum number of ATS scheduler group instances supported
    by this Bridge component.";
  reference
    "12.31.1.6, 8.6.5.6 of IEEE Std 802.1Q-2022";
}
container scheduler-timing-characteristics {
  description
    "This container comprises all ATS scheduler timing
    characteristics related nodes.";
  list scheduler-timing-characteristics-table {
    key "reception-port transmission-port";
    config false;
    description
      "Each list entry comprises the timing characteristics of a
      reception Port transmission Port pair, as detailed in Table
      12-36.";
    reference
      "12.31.8, 8.6.11 of IEEE Std 802.1Q-2022";
    leaf reception-port {
      type dot1qtypes:port-number-type;
      config false;
      mandatory true;
      description
        "A reference to the associated reception Port.";
      reference
        "12.31.8.1 of IEEE Std 802.1Q-2022";
    }
    leaf transmission-port {
      type dot1qtypes:port-number-type;
      config false;
      mandatory true;
      description
        "A reference to the associated transmission Port.";
      reference
        "12.31.8.2 of IEEE Std 802.1Q-2022";
    }
    leaf clock-offset-variation-max {
      type uint32;
      units "nanoseconds";
      config false;
      mandatory true;
      description
        "The maximum clock offset variation associated with the
        reception Port transmission Port pair.";
      reference
        "12.31.8.3 of IEEE Std 802.1Q-2022";
    }
    leaf clock-rate-deviation-max {
      type uint32;
      units "ppm";
      config false;
      mandatory true;
      description
        "The maximum clock rate deviation associated with the
        reception Port transmission Port pair.";
      reference
        "12.31.8.4 of IEEE Std 802.1Q-2022";
    }
    leaf arrival-recognition-delay-max {
      type uint32;
      units "nanoseconds";
      config false;
```

```
            mandatory true;
            description
              "The maximum arrival time recognition delay associated
              with the reception Port transmission Port pair.";
            reference
              "12.31.8.5 of IEEE Std 802.1Q-2022";
          }
          leaf processing-delay-min {
            type uint32;
            units "nanoseconds";
            config false;
            mandatory true;
            description
              "The minimum processing delay associated with the
              reception Port transmission Port pair.";
            reference
              "12.31.8.6 of IEEE Std 802.1Q-2022";
          }
          leaf processing-delay-max {
            type uint32;
            units "nanoseconds";
            config false;
            mandatory true;
            description
              "The maximum processing delay associated with the
              reception Port transmission Port pair.";
            reference
              "12.31.8.7 of IEEE Std 802.1Q-2022";
          }
        }
      }
    }
  }
}
```

Annex A

(normative)

PICS proforma—Bridge implementations[55]

A.1 Introduction

The supplier of a protocol implementation that is claimed to conform to this standard shall complete the following Protocol Implementation Conformance Statement (PICS) proforma.

A completed PICS proforma is the PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. The PICS can have a number of uses, including use:

a) By the protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight.
b) By the supplier and acquirer—or potential acquirer—of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma.
c) By the user—or potential user—of the implementation, as a basis for initially checking the possibility of interworking with another implementation (note that, while interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PICSs).
d) By a protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

A.2 Abbreviations and special symbols

A.2.1 Status symbols

M	mandatory
O	optional
O.n	optional, but support of at least one of the group of options labeled by the same numeral n is required
X	prohibited
pred:	conditional-item symbol, including predicate identification: see A.3.4
¬	logical negation, applied to a conditional item’s predicate

A.2.2 General abbreviations

N/A	not applicable
PICS	Protocol Implementation Conformance Statement

[55] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

A.3 Instructions for completing the PICS proforma

A.3.1 General structure of the PICS proforma

The first part of the PICS proforma, implementation identification and protocol summary, is to be completed as indicated with the information necessary to identify fully both the supplier and the implementation.

The main part of the PICS proforma is a fixed-format questionnaire, divided into several subclauses, each containing a number of individual items. Answers to the questionnaire items are to be provided in the rightmost column, either by simply marking an answer to indicate a restricted choice (usually Yes or No) or by entering a value or a set or range of values. (Note that there are some items where two or more choices from a set of possible answers can apply; all relevant choices are to be marked.)

Each item is identified by an item reference in the first column. The second column contains the question to be answered; the third column records the status of the item—whether support is mandatory, optional, or conditional: see also A.3.4. The fourth column contains the reference or references to the material that specifies the item in the main body of this standard, and the fifth column provides the space for the answers.

A supplier may also provide (or be required to provide) further information, categorized as either Additional Information or Exception Information. When present, each kind of further information is to be provided in a further subclause of items labeled Ai or Xi, respectively, for cross-referencing purposes, where i is any unambiguous identification for the item (e.g., simply a numeral). There are no other restrictions on its format and presentation.

A completed PICS proforma, including any Additional Information and Exception Information, is the Protocol Implementation Conformation Statement for the implementation in question.

NOTE—Where an implementation is capable of being configured in more than one way, a single PICS may be able to describe all such configurations. However, the supplier has the choice of providing more than one PICS, each covering some subset of the implementation's configuration capabilities, in case that makes for easier and clearer presentation of the information.

A.3.2 Additional information

Items of Additional Information allow a supplier to provide further information intended to assist the interpretation of the PICS. It is not intended or expected that a large quantity will be supplied, and a PICS can be considered complete without any such information. Examples might be an outline of the ways in which a (single) implementation can be set up to operate in a variety of environments and configurations, or information about aspects of the implementation that are outside the scope of this standard but that have a bearing on the answers to some items.

References to items of Additional Information may be entered next to any answer in the questionnaire and may be included in items of Exception Information.

A.3.3 Exception information

It may occasionally happen that a supplier will wish to answer an item with mandatory status (after any conditions have been applied) in a way that conflicts with the indicated requirement. No preprinted answer will be found in the Support column for this item. Instead, the supplier shall write the missing answer into the Support column, together with an *Xi* reference to an item of Exception Information, and shall provide the appropriate rationale in the Exception item itself.

An implementation for which an Exception item is required in this way does not conform to this standard.

NOTE—A possible reason for the situation described previously is that a defect in this standard has been reported, a correction for which is expected to change the requirement not met by the implementation.

A.3.4 Conditional status

A.3.4.1 Conditional items

The PICS proforma contains a number of conditional items. These are items for which both the applicability of the item itself, and its status if it does apply—mandatory or optional—are dependent on whether certain other items are supported.

Where a group of items is subject to the same condition for applicability, a separate preliminary question about the condition appears at the head of the group, with an instruction to skip to a later point in the questionnaire if the "Not Applicable" answer is selected. Otherwise, individual conditional items are indicated by a conditional symbol in the Status column.

A conditional symbol is of the form "**pred:** S" where **pred** is a predicate as described in A.3.4.2 below, and S is a status symbol, M or O.

If the value of the predicate is true (see A.3.4.2), the conditional item is applicable, and its status is indicated by the status symbol following the predicate: The answer column is to be marked in the usual way. If the value of the predicate is false, the "Not Applicable" (N/A) answer is to be marked.

A.3.4.2 Predicates

A predicate is one of the following:

a) An item-reference for an item in the PICS proforma: The value of the predicate is true if the item is marked as supported and is false otherwise.
b) A predicate-name, for a predicate defined as a boolean expression constructed by combining item-references using the boolean operator OR: The value of the predicate is true if one or more of the items is marked as supported.
c) The logical negation symbol "¬" prefixed to an item-reference or predicate-name: The value of the predicate is true if the value of the predicate formed by omitting the "¬" symbol is false, and vice versa.

Each item whose reference is used in a predicate or predicate definition, or in a preliminary question for grouped conditional items, is indicated by an asterisk in the Item column.

A.4 PICS proforma for IEEE Std 802.1Q—Bridge implementations

A.4.1 Implementation identification

Supplier	
Contact point for queries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification, e.g., name(s) and version(s) of machines and/or operating system names	
NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirement for full identification. NOTE 2—The terms “Name” and “Version” should be interpreted appropriately to correspond with a supplier’s terminology (e.g., Type, Series, Model).	

A.4.2 Protocol summary, IEEE Std 802.1Q

Identification of protocol specification	IEEE Std 802.1Q-2022, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks
Identification of amendments and corrigenda to the PICS proforma that have been completed as part of the PICS	Amd. : Corr. : Amd. : Corr. :
Have any Exception items been required? (See A.3.3: the answer “Yes” means that the implementation does not conform to IEEE Std 802.1Q)	No [ ] Yes [ ]

Date of Statement	

A.5 Major capabilities

Item	Feature	Status	References	Support
	If the implementation is an end station implementation, mark "N/A" and continue at Annex B.			N/A [ ]
MAC	Do the implementations of MAC technologies and support of the MAC Internal Sublayer Service (ISS) conform to MAC standards as specified in IEEE Std 802.1AC? (If support of a specific MAC technology is claimed, any PICS proforma(s) required by the standard specifying that technology shall also be completed.)	M	A.6, IEEE Std 802.1AC	Yes [ ]
LLC	Is a class of LLC supporting Type 1 operations supported on all Bridge Ports in conformance with ISO/IEC 8802-2? (The PICS proforma required by ISO/IEC 8802-2 shall also be completed.)	M	8.2, 8.3, 8.1.3, ISO/IEC 8802-2	Yes [ ]
RLY	Does the implementation relay and filter frames as specified?	M	8.5, 8.6, 8.7, 6.12, 8.8, A.7	Yes [ ]
BFS	Does the implementation maintain the information required to make frame filtering decisions and support Basic Filtering Services?	M	8.1, 8.5, 8.7, 8.8, A.8	Yes [ ]
ADDR	Does the implementation conform to the provisions for addressing?	M	8.13, A.9	Yes [ ]
MBRIDGE	Can the Bridge be configured to operate as a VLAN-unaware MAC Bridge	O.2	5.14	Yes [ ] No [ ]
TPMR	Can the Bridge be configured to operate as a Two Port MAC Relay?	O.2	5.16	Yes [ ] No [ ]
MSP	Is the operation of the MAC Status Propagation Entity (MSPE) supported?	TPMR: M	Clause 23	Yes [ ] N/A [ ]
RSTP	Is RSTP implemented?	¬TPMR:O.1 TPMR:X	Clause 5, Clause 13, Clause 14, A.10	Yes [ ] No [ ]
BPDU	Are transmitted Bridge Protocol Data Units (BPDUs) encoded and received BPDUs validated as specified?	¬TPMR:M TPMR:X	A.11, 13.29.27, 13.29.28, 13.29.29, Clause 14	Yes [ ] No [ ]
IMP	Are the required implementation parameters included in this completed PICS?	M	8.8, A.12	Yes [ ]
PERF	Are the required performance parameters included in this completed PICS? (Operation of the Bridge within the specified parameters shall not violate any of the other conformance provisions of this standard.)	M	8.5, A.13	Yes [ ]
MGT	Is management of the Bridge supported?	O PBBTE OR TPMR OR SRRM:M	Clause 5, A.14	Yes [ ] No [ ]

A.5 Major capabilities *(continued)*

Item	Feature	Status	References	Support
RMGT	Is a remote management protocol supported?	MGT:O PBBTE OR TPMR OR SRRM:M	Clause 5, A.15	Yes [ ] No [ ]
MIB	Does the system implementation support management operations using SMIv2 MIB modules?	MGT:O	8.12, Clause 17	Yes [ ] No [ ] N/A [ ]
TC	Are multiple traffic classes supported for relaying frames?	O	8.6.6, 8.6.7, 8.6.8, A.16	Yes [ ] No [ ]
EFS	Are Extended Filtering Services supported for relaying and filtering frames?	¬TPMR:O TPMR:X	A.17, 6.12	Yes [ ] No [ ]
MMRP	Is the operation of the Multiple MAC Registration Protocol supported?	EFS:M	5.4.1, A.20	Yes [ ] N/A [ ]
VLAN	Does the implementation support the ability to insert tag headers into, modify tag headers in, and remove tag headers from relayed frames?	¬(MBRIDGE OR TPMR):M (MBRIDGE OR TPMR):X	5.4, 6.3, 6.8, 6.9, 8.6, 6.12, Clause 9	Yes [ ] No [ ]
VTR	Does the implementation support a VLAN Identifier (VID) translation table?	¬(TPMR OR MBRIDGE):O (MBRIDGE OR TPMR):X	6.9	Yes [ ] No [ ]
MVRP	Is automatic configuration and management of VLAN topology using MVRP supported?	¬(TPMR OR MBRIDGE):M TPMR:X	5.4, A.21	Yes [ ] No [ ]
MRP	Is the Multiple Registration Protocol (MRP) implemented in support of MRP Applications?	MMRP:M MVRP:M	Clause 10, A.20, A.21, A.22	Yes [ ] N/A [ ]
MRP1	Does the MRP implementation support operation of the Full Participant?	MRP:O.4	Clause 10, A.22	Yes [ ] No [ ] N/A [ ]
MRP2	Does the MRP implementation support operation of the Full Participant, point-to-point subset?	MRP:O.4	Clause 10, A.22	Yes [ ] No [ ] N/A [ ]
MSTP	Is MSTP implemented?	¬TPMR:O.1 TPMR:X	Clause 5, Clause 7, 8.4, 8.6.1, 8.8.8, 8.9, 8.10, 8.13.7, 11.2.3.1.2, Clause 13, Clause 14, A.18	Yes [ ] No [ ]
VMGT	Does the implementation support VLAN management operations?	¬(TPMR OR MBRIDGE) AND MGT:O (MBRIDGE OR TPMR):X	5.4.1, 12.10.2, 12.10.3	Yes [ ] No [ ] N/A [ ]
CB	Can the Bridge be configured to operate as a C-VLAN Bridge, recognizing and using C-TAGs?	O.2	5.9	Yes [ ] No [ ]
PB	Can the Bridge be configured to operate as a Provider Bridge, recognizing and using S-TAGs?	O.2	5.10	Yes [ ] No [ ]

A.5 Major capabilities *(continued)*

Item	Feature	Status	References	Support
PEB	Can the Bridge be configured to operate as a Provider Edge Bridge with one or more Ports operating as Customer Edge Ports (CEPs)?	PB:O	5.10.2	Yes [ ] No [ ] N/A [ ]
RCSI	Can the Bridge be configured to operate as a Provider Edge Bridge with one or more Ports operating as Remote Customer Access Ports (RCAPs)?	PEB:O	5.10.2	Yes [ ] No [ ] N/A [ ]
PB-2	State which Ports support the following values for the Provider Bridge Port Type: — PNP — CNP — CEP — RCAP	PB:M	5.10	Ports: _____ Ports: _____ Ports: _____ Ports: _____
CFM	Is Connectivity Fault Management (CFM) implemented?	O PBBTE: M	5.4.1.4, Clause 19, Clause 20, Clause 21, Clause 22	Yes [ ] No [ ]
CFM-T	Does the implementation support a CFM MD-level zero MIP on each Port?	TPMR:M	5.15, Clause 18–Clause 22	Yes [ ] N/A [ ] N/A [ ]
BRG	Is this system a Bridge, and not a Station, for the purposes of CFM?	CFM: O	22.4	Yes [ ] No [ ]
BEB	Can the Bridge be configured to operate as a Backbone Edge Bridge, recognizing and using I-TAGs?	O.2	5.12	Yes [ ] No [ ] N/A [ ]
BEB-B	Can the Bridge be configured to operate as a Backbone Edge Bridge with one or more Ports operating as a Customer Backbone Ports (CBPs)?	BEB: O.3	5.12	Yes [ ] No [ ] N/A [ ]
BEB-I	Can the Bridge be configured to operate as a Backbone Edge Bridge with one or more Ports operating as a Provider Instance Port (PIP)?	BEB: O.3	5.12	Yes [ ] No [ ] N/A [ ]
BEB-1	State which Ports support the following values for the Backbone Edge Bridge Port Type: — PIP — CNP — PNP — CBP — CEP — RCAP	BEB: M	5.11	PIP: _____ CNP: _____ PNP: _____ CBP: _____ CEP: _____ RCAP: _____
DDCFM	Is management of data-driven and data-dependent connectivity faults implemented?	O	Clause 19, Clause 29	Yes [ ] No [ ]
PBBTE	Can the Bridge be configured by an external agent to provide TESIs?	O	8.4, 8.9, 25.10	Yes [ ] No [ ]
EXAG	Is the active topology, learning and forwarding of the TESIs under the control of an external agent?	PBBTE: O.1	8.4, 8.9	Yes [ ] No [ ] N/A [ ]

A.5 Major capabilities *(continued)*

Item	Feature	Status	References	Support
ESPVID	Are the VIDs associated with ESPs, the ESP-VIDs, allocated to the TE-MSTID?	PBBTE: M	8.9	Yes [ ] N/A [ ]
ESPFID	Is every ESP-VID allocated to a distinct FID?	PBBTE: M	25.10	Yes [ ] N/A [ ]
BCBTE	Can the Bridge be configured to operate as a Backbone Core Bridge (BCB) that provides TESIs?	PB AND PBBTE: O.5	5.10, 5.6.2	Yes [ ] N/A [ ] N/A [ ]
BEBTE	Can the Bridge be configured to operate as a Backbone Edge Bridge that provides TESIs?	BEB AND PBBTE: O.5	5.8.2, 5.12.1	Yes [ ] No[ ] N/A [ ]
PS	Is protection switching supported?	BEBTE: M	5.8.2, 26.10.3	Yes [ ] N/A [ ]
FQTSS	Does the implementation support Forwarding and Queuing Enhancements for time-sensitive streams?	O	5.4.1.5, Clause 34	Yes [ ] No [ ]
CN	Is congestion notification implemented?	O	5.4.3, Clause 30, Clause 31, Clause 32, Clause 33	Yes [ ] No [ ]
BRG1	Is this system a Bridge, and not an end station, for the purposes of congestion notification?	CN: O		Yes [ ] No [ ] N/A [ ]
SRP	Does the implementation support the Stream Reservation Protocol?	O	Clause 35	Yes [ ] No [ ]
MIRP	Is the Multiple I-SID Registration Protocol supported?	BEB-I OR BEB-B: O	5.7.1 item e), 5.8.1 item e)	Yes [ ] No [ ] N/A [ ]
PFC	Is Priority-based Flow Control implemented?	O	5.11, Clause 36	Yes [ ] No [ ]
ETS	Does the implementation support bandwidth management using ETS?	O	Clause 37	Yes [ ] No [ ]
DCBX	Does the implementation support configuration management via DCBX?	O	Clause 38	Yes [ ] No [ ]
IPS	Is Infrastructure Protection Switching supported?	PBBTE: O	5.6.2, 5.8.2, 26.11	Yes [ ] No [ ] N/A [ ]
SPB	Is Shortest Path Bridging supported?	O.1	5.4.5, Clause 27	Yes [ ] No [ ]
EVB-B	Does the implementation support the functionality of an EVB Bridge?	O	5.23	Yes [ ] No [ ]
EVB-S	Does the implementation support the functionality of an EVB station?	O	5.24	Yes [ ] No [ ]
ECMP	Is Equal Cost Multiple Paths supported?	SPBM:O	5.4.5.1, 44.1	Yes [ ] No [ ] N/A [ ]
FF	Is flow filtering supported, including inserting, modifying, and removing F-TAGs from relayed frames?	ECMP:O	5.4.5.2, 44.2	Yes [ ] No [ ]
FF-S	Does the S-VLAN component support F-TAG processing on each PNP?	PB AND FF:M	5.6.4, 44.2.2	Yes [ ] N/A [ ]
FF-B	Does the B-component support F-TAG processing on each CBP and PNP?	BEB AND FF:M	5.8.4, 44.2.2	Yes [ ] N/A [ ]
PCR	Is Path Control and Reservation supported?	O	Clause 45	Yes [ ] No [ ]

A.5 Major capabilities *(continued)*

Item	Feature	Status	References	Support
SCHED	Does the implementation support scheduled traffic?	O	5.4.1, 5.13.1, 8.6.8, 8.6.9, 12.29, 17.7.22	Yes [ ] No [ ]
PRE	Does the implementation support frame preemption?	O	5.4.1, 5.13.1, 6.7.2, 8.6.8, 12.30, 17.7.23	Yes [ ] No [ ]
PSFP	Does the implementation support PSFP?	O	8.6.5.2.1, 8.6.6 items d) and e), 8.6.10, 12.31	Yes [ ] No [ ]
ATS	Does the implementation support Asynchronous Traffic Shaping?	O	5.4.1.10, 5.13.1.3, 8.6.5.2.2, 8.6.6 items d) and e), 8.6.8, 8.6.8.5, 8.6.11, 12.31	Yes [ ] No [ ]
CQF	Does the implementation support cyclic queuing and forwarding?	O	5.4.1.9, 5.13.1.2	Yes [ ] No [ ]
YANG	Does the implementation support management operations using the YANG modules?	MGMT:O	8.12, 48	Yes [ ] No [ ] N/A [ ]
SRRM	Does the implementation support Stream reservation remote management?	O	5.4.1.10, 12.32, A.48	Yes [ ] No [ ]
CNC-S	Does the implementation support the functionality of a Centralized Network Configuration (CNC) station?	O	5.29, 46.2, A.17	Yes [ ] No [ ]
VDPnNVE	Does the implementation support the VDP NVO3 functionality of an nNVE?	O	5.30.1	Yes [ ] No [ ]
VDPtNVE	Does the implementation support the VDP NVO3 functionality of a tNVE?	O	5.30.2	Yes [ ] No [ ]

A.6 Media access control methods

Item	Feature	Status	References	Support
	Which media access control methods are implemented in conformance with the relevant MAC Standards?		5.4, IEEE Std 802.1AC	
MAC-802.3	Ethernet, IEEE Std 802.3	O.2	IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-802.11-PORT	IEEE 802.11 LAN Portal, IEEE Std 802.11	O.2	G.4.1, IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-PMPN-N	PMPN multiple port, IEEE Std 802.1AC	O.2	G.4.1, IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-PMPN-1	PMPN single port, IEEE Std 802.1AC	O.2	G.4.1, IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-802.20-WB	IEEE 802.20™ Wideband Mode	O.2	IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-802.20-625	IEEE 802.20 625k-MC Mode	O.2	IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-1	Has a PICS been completed for each of the media access control methods implemented as required by the relevant MAC standards?	M		Yes [ ]
MAC-2	Do all the media access control methods implemented support the MAC ISS as specified?	M	IEEE Std 802.1AC	Yes [ ]
MAC-3	Are the adminPointToPointMAC and operPointToPointMAC parameters implemented on all Ports?	M	IEEE Std 802.1AC	Yes [ ]
MAC-4	Does the implementation support the use of the adminEdgePort and operEdgePort parameters on any Ports?	O	13.27.1, 13.27.44	Yes [ ] No [ ]
MAC-4a	State which Bridge Ports support the adminEdgePort and operEdgePort parameters.			Ports_____
MAC-5	Is the priority of received frames set to the Default Priority where specified for the MAC?	M	IEEE Std 802.1AC	Yes [ ]
MAC-6	Can the Default Priority be set for each Port?	O	IEEE Std 802.1AC	Yes [ ] No [ ]
MAC-7	Can the Default Priority be set to any of 0–7?	MAC-6:M	IEEE Std 802.1AC	Yes [ ] N/A [ ]
MAC-12	Is the minimum tagged frame length that can be transmitted on IEEE 802.3 Ports less than 68 (but 64 or more) octets?	MAC-802.3:O	IEEE Std 802.1AC	Yes [ ] No [ ] N/A [ ]

A.7 Relay and filtering of frames

Item	Feature	Status	References	Support
RLY-1	Are received frames with MAC method errors discarded?	M	6.3, 8.5	Yes [ ]
RLY-2	Are user data frames the only type of frame relayed?	M	8.5	Yes [ ]
RLY-3	Is the priority of each frame relayed regenerated as specified?	¬TPMR: M TPMR: O	IEEE Std 802.1AC, 6.9.4, 8.5, 6.20	Yes [ ] No [ ]
RLY-4	Are the default values of the Priority Regeneration Table as specified for each Port?	M	6.9.4, Table 6-4	Yes [ ]
RLY-5	Can the Priority Regeneration Table be modified?	O	6.9.4, Table 6-4	Yes [ ] No [ ]
RLY-6	Can the entries in the Priority Regeneration Table be set independently for each priority and Port and to any of the full range of values?	RLY-5: M	6.9.4, Table 6-4	Yes [ ] N/A [ ]
RLY-7	Are frames transmitted by an LLC User attached at a Bridge Port also submitted for relay?	¬TPMR: M TPMR: X	8.5	Yes [ ] No [ ]
RLY-8	Are correctly received user data frames relayed subject to the conditions imposed by the Forwarding Process?	M	8.6, 8.6.2, 8.6.2, 8.6.3, 8.6.5, 8.6.4, 8.8, Table 8-10, Table 8-11, Table 8-12	Yes [ ]
RLY-9	Is the order of relayed frames preserved as required by the forwarding process?	M	8.6.6	Yes [ ]
RLY-10	Is a relayed frame submitted to a MAC Entity for transmission only once?	M	8.6.7	Yes [ ]
RLY-11	Is a maximum Bridge transit delay enforced for relayed frames?	M	8.6.7	Yes [ ]
RLY-12	Are queued frames discarded if a Port leaves the Forwarding State?	M	8.6.7	Yes [ ]
RLY-13	Is the default algorithm for selecting frames for transmission supported?	M	8.6.8	Yes [ ]
RLY-14	Is the access priority of each transmitted frame as specified for each media access method?	M	6.5.9	Yes [ ]
RLY-15	Is the Frame Check Sequence (FCS) of frames relayed between Ports of the same MAC type preserved?	O	6.9	Yes [ ] No [ ]
RLY-16	Is the undetected frame error rate greater than that achievable by preserving the FCS?	¬RLY-15:X	6.5.7, 6.9	No [ ] N/A [ ]
RLY-17	Are CFM frames discarded if they enter the queue subsequent to the Port leaving the Forwarding state?	CFM: X	8.6.7	No [ ] N/A [ ]

A.7 Relay and filtering of frames *(continued)*

Item	Feature	Status	References	Support
RLY-18	Are CFM frames discarded when the Port leaves the Forwarding state?	CFM: O	8.6.7	Yes [ ] No [ ]
RLY-19	Are received frames discarded (or not discarded) in accordance with the specification of a PIP, CBP, or Backbone Service Instance Multiplex Entity?	BEB: M	6.10.1, 6.11.1, 6.18.1	Yes [ ] N/A [ ]
RLY-20	Is the forwarding process for flow filtering supported?	FF:M	5.4.5.2, 44.2.3	Yes [ ] N/A [ ]

A.8 Basic Filtering Services

Item	Feature	Status	References	Support
BFS-1	Are correctly received user data frames submitted to the Learning Process if the learning variable is set?	¬TPMR: M TPMR: X	8.6, 8.7, 5.15	Yes [ ] No [ ]
BFS-2	Are correctly received frames of types other than user data frames submitted to the Learning Process?	¬TPMR: O TPMR: X	8.6, 8.7, 5.15	Yes [ ] No [ ]
BFS-3	Does the Filtering Database (FDB) support creation and update of Dynamic Filtering Entries by the Learning Process?	¬TPMR: M TPMR: X	8.7, 8.8, 8.8.3, 5.15	Yes [ ] No [ ]
BFS-4	Are Dynamic Filtering Entries created and updated if and only if the Port State permits?	M	8.7, 8.8.3	Yes [ ]
BFS-5	Are Dynamic Filtering Entries created on receipt of frames with a group source address?	X	8.7, 8.8.3	No [ ]
BFS-6	Can a Dynamic Filtering Entry be created that conflicts with an existing Static Filtering Entry?	X	8.7, 8.8, 8.8.2. 8.8.3	No [ ]
BFS-7	Are existing Dynamic Filtering Entries removed to allow creation of a new entry if the FDB is full?	¬TPMR: O TPMR: X	8.7, 8.8.3, 5.15	Yes [ ] No [ ]
BFS-8	Does the FDB contain Static Filtering Entries?	M	8.8.2	Yes [ ]
BFS-9	Are Static Filtering Entries aged out?	X	8.8	No [ ]
BFS-10	Can Static Filtering Entries be created, modified, and deleted by management?	¬(TPMR OR PBBTE): O PBBTE: M TPMR: X	8.8, 5.15	Yes [ ] No [ ]
BFS-11	Can Static Filtering Entries be made for individual and group MAC addresses?	BFS-10:M	8.8.2	Yes [ ] N/A [ ]
BFS-12	Can a Static Filtering Entry be made for the broadcast MAC address?	BFS-10:M	8.8.2	Yes [ ] N/A[ ]
BFS-13	Can a Static Filtering Entry specify a forwarding Port Map?	BFS-10:M	8.8.2	Yes [ ] N/A [ ]

A.8 Basic Filtering Services

Item	Feature	Status	References	Support
BFS-14	Can a Static Filtering Entry specify a filtering Port Map?	BFS-10:M	8.8.2	Yes [ ] N/A [ ]
BFS-15	Does the creation of a Static Filtering Entry remove any conflicting information in a Dynamic Filtering Entry for the same address?	M	8.8.2, 8.8.3	Yes [ ]
BFS-16	Can a separate Static Filtering Entry with a Port Map be created for each inbound Port?	¬TPMR: O TPMR: X	8.8.2, 5.15	Yes [ ] No [ ]
BFS-17	Are Dynamic Filtering Entries aged out of the FDB if not updated?	M	8.8.3	Yes [ ]
BFS-18	Can more than one Dynamic Filtering Entry be created for the same MAC address?	X	8.8.3	No [ ]
BFS-19	Can the Bridge be configured to use the recommended default Ageing Time?	¬TPMR: O TPMR: X	8.8.3, Table 8-9, 5.15	Yes [ ] No [ ]
BFS-20	Can the Bridge be configured to use any value in the range specified for Ageing Time?	¬TPMR: O TPMR: X	8.8.3, Table 8-9, 5.15	Yes [ ] No [ ]
BFS-21	Is the FDB initialized with the entries contained in the Permanent Database?	M	8.8.11	Yes [ ]
BFS-22	Are correctly received user data frames submitted to the Learning Process if they are associated with an ESP-VID?	PBBTE: X	8.4, 8.6.1	No [ ] N/A [ ]
BFS-23	Are correctly received user data frames that are associated with an ESP-VID discarded if their destination MAC address is unknown?	PBBTE: M	8.8.1	Yes [ ] N/A [ ]

A.9 Addressing

Item	Feature	Status	References	Support
ADDR-1	Does each Port have a separate MAC address?	M	8.13.2	Yes [ ]
ADDR-2	Are frames addressed to a MAC address for a Port and received from or relayed to the attached LAN submitted to LLC Service User for the destination LLC Address?	M	8.5, 8.13.2	Yes [ ]
ADDR-3	Are all BPDUs and MRP PDUs transmitted using the Bridge Spanning Tree Protocol LLC Address?	M	8.13.3, Table 8-15	Yes [ ]
ADDR-4	Are PDUs addressed to the Bridge Spanning Tree Protocol Address with an unknown Protocol Identifier (PID) discarded on receipt?	M	14.5	Yes [ ]
ADDR-5	Are all BPDUs generated by a Spanning Tree Protocol Entity associated with a C-VLAN component transmitted to the Bridge Group Address?	CB OR PEB: M	8.13.3, Table 8-1, Table 8-2	Yes [ ] N/A [ ]

A.9 Addressing

Item	Feature	Status	References	Support
ADDR-6	Are all BPDUs generated by a Spanning Tree Protocol Entity associated with an S-VLAN component, I-component, or B-component transmitted to the Provider Bridge Group Address?	PB: M BEB:M	Table 8-1	Yes [ ] N/A [ ]
ADDR-7	Are all MRPDUs transmitted to the group address assigned for the MRP Application?	M	8.13.3, Table 8-1	Yes [ ]
ADDR-8	Is it possible to create entries in the Permanent Database or FDB for unsupported MRP application addresses or delete or modify entries for supported application addresses?	X	8.13.3	No [ ]
ADDR-9	Is the source MAC address of BPDUs and MRPDUs for MRP Applications supported by the Bridge address of the transmitting Port?	M	8.13.3	Yes [ ]
ADDR-10	Is the source MAC address of BPDUs generated by a Spanning Tree Protocol Entity associated with a C-VLAN component of a Provider Edge Bridge the address of the associated CEP?	PEB:M	12.13	Yes [ ] N/A [ ]
ADDR-11	Is Bridge Management accessible through a Port using the MAC address of the Port?	MGT:O	8.13.7	Yes [ ] No [ ] N/A [ ]
ADDR-12	Is an EUI-48 universally administered MAC Address assigned to each Bridge as its Bridge Address?	M	8.13.8	Yes [ ]
ADDR-13	Is the Bridge Address the Address of a Port?	O	8.13.8	Yes [ ] No [ ]
ADDR-14	Is the Bridge Address the Address of Port 1?	ADDR-13: O	8.13.8	Yes [ ] No [ ] N/A [ ]
ADDR-15	Are frames addressed to any of the C-VLAN component Reserved Addresses relayed by a C-VLAN component?	CB or PB:X	8.13.4, Table 8-1	No [ ] N/A [ ]
ADDR-16	Are frames addressed to any of the S-VLAN component Reserved Addresses relayed by an S-VLAN component, I-component, or B-component?	PB:X BEB:X	Table 8-2	No [ ] N/A [ ]
ADDR-17	Is it possible to delete or modify entries in the Permanent Database and FDB for the Reserved Addresses?	X	8.13.4	No [ ]
ADDR-18	Are PIPs capable of filtering frames received with a B-SA matching the PIP MAC address?	BEB-I: O	5.7.1	Yes [ ] No [ ] N/A [ ]
ADDR-19	Is the address of an internal PIP on Backbone Edge Bridge (BEB) supporting a TESI configured to take the value of the MAC address of the connected CBP?	BEBTE:M	25.10	Yes [ ] N/A [ ]

A.10 Rapid Spanning Tree Protocol (RSTP)

Item	Feature	Status	References	Support
	If item RSTP is not supported, mark "N/A" and continue at A.11			N/A [ ]
RSTP-1	Does each Bridge have a unique identifier based on the Bridge Address, and a unique identifier for each Port?	RSTP:M	13.2	Yes [ ]
RSTP-2	Can each Port be configured as an edge port by setting the adminEdgePort parameter?	RSTP:O	13.4	Yes [ ] No [ ]
RSTP-3	Can each Port be configured to automatically determine if it is an edge port by setting the autoEdgePort parameter?	RSTP:O	13.4	Yes [ ] No [ ]
RSTP-4	Are learned MAC addresses transferred from a retiring Root Port to a new Root Port?	RSTP:O	13.19	Yes [ ] No [ ]
RSTP-5	Is the Spanning Tree Protocol Entity reinitialized if the Force Protocol Version parameter is modified?	RSTP:M	13.26	Yes [ ]
RSTP-6	Are spanning tree priority vectors and Port Role assignments recomputed if the Bridge Identifier Priority, Port Identifier Priority, or Port Path Costs change?	RSTP:M	13.26	Yes [ ]
RSTP-7	Is the txCount variable for a Port set to zero if the Port's Transmit Hold Count is modified?	RSTP:M	13.26	Yes [ ]
RSTP-8	Are the recommended default values of Migrate Time, Bridge Hello Time, Bridge Max Age, Bridge Forward Delay, and Transmit Hold Count used?	RSTP:O	13.25	Yes [ ] No [ ]
RSTP-9	Can the Bridge Max Age, Bridge Forward Delay, and Transmit Hold Count parameters be set?	RSTP:O	13.25, 13.26	Yes [ ] No [ ]
RSTP-10	Can Bridge Max Age, Bridge Forward Delay, Transmit Hold Count be set to any value in the permitted range?	RSTP-9: M	13.25, 13.30, Table 13-5	Yes [ ] N/A [ ]
RSTP-11	Are the relationships between Bridge Hello Time, Bridge Max Age, and Bridge Forward Delay enforced?	RSTP-9: M	13.25	Yes [ ] N/A [ ]
RSTP-12	Are the recommended values of Bridge Identifier Priority, Port Path Costs, and Port Identifier Priorities used?	RSTP:O	13.18	Yes [ ] No [ ]
RSTP-13	Can the Bridge Identifier Priority, Port Path Costs, and Port Identifier Priorities be set?	RSTP:O	13.1, 13.4.1, 13.18, 13.25, 13.26, 13.27	Yes [ ] No [ ]
RSTP-14	Can the Bridge Identifier Priority and Port Identifier Priorities be set to any of the values in the ranges specified?	RSTP-13: M	13.18	Yes [ ] N/A [ ]
RSTP-15	Can the Port Path Cost for each Port be set to any of the values in the specified range?	RSTP-13: M	13.18	Yes [ ] N/A[ ]
RSTP-16	Are Port Path Costs changed automatically by default if port speeds change?	RSTP:X	13.18	No [ ]

A.10 Rapid Spanning Tree Protocol (RSTP)

Item	Feature	Status	References	Support
RSTP-17	Is one instance of the Port Role Selection state machine implemented for the Bridge; is one instance of each of the Port Timers, Port Receive, Port Protocol Migration, Bridge Detection, Port Transmit, Port Information, Port Role Transition, Port State Transition, and Topology Change state machines implemented per Port; and are the referenced definitions and declarations followed for all machines?	RSTP:M	13.5.2, 13.24, 13.36, 13.30, 13.31, 13.32, 13.33, 13.34, 13.35, 13.37, 13.38, 13.38.2	Yes [ ] N/A [ ]
RSTP-18	Is it possible to set each Port Protocol Migration state machine's mcheck variable?	RSTP:O	13.27.38	Yes [ ] No [ ]
RSTP-19	Is a single instance of each of the timer variables implemented per Port?	RSTP:M	13.30	Yes [ ]
RSTP-20	Are the values for maximum RSTP processing delay and maximum BPDU transmission delay ever exceeded for any of the specified external events, actions, internal events, or transmissions?	RSTP:X	24.3, Table 24-1	No [ ]
RSTP-21	Does each C-VLAN component of a Provider Edge Bridge operate an instance of Rapid Spanning Tree (RST) as modified for CEPs?	RSTP AND PEB:M	13.41	Yes [ ] N/A [ ]
RSTP-22	Does each I-component of a BEB operate an instance of RST as modified for Virtual Instance Ports (VIPs)?	RSTP AND BEB:M	13.42	Yes [ ] N/A [ ]
RSTP-23	Can each Port be configured to support detection of fragile Bridges by setting the autoIsolatePort parameter?	RSTP:O	13.23, 13.27.19	Yes [ ] No [ ]
RSTP-24	Can a port be configured as an L2 Gateway Port by setting the isL2gp parameter?	RSTP:O	13.20, 13.27.26	Yes [ ] No [ ]
RSTP-25	Can the pseudoRootId parameter be set for an L2 Gateway Port?	RSTP-24:M	13.20, 13.27.51	Yes [ ] N/A [ ]
RSTP-26	Is one instance of the L2 Gateway Port state machine implemented for each L2GP port?	RSTP-24:M	13.40	Yes [ ] N/A [ ]

A.11 BPDU encoding

Item	Feature	Status	References	Support
BPDU-1	Do all BPDUs contain an integral number of octets?	M	Clause 14	Yes [ ]
BPDU-2	Are all the following BPDU parameter types encoded as specified?	M	Clause 14	Yes [ ]
	Protocol Identifiers		Clause 14	
	Protocol Version Identifiers		Clause 14	
	BPDU Types		Clause 14	
	Flags		Clause 14	
	Bridge Identifiers		Clause 14	
	Root Path Cost		Clause 14	
	Port Identifiers		Clause 14	
	Timer Values		Clause 14	
BPDU-3	Do Configuration BPDUs have the format, parameters, and parameter values specified?	M	Clause 14	Yes [ ]
BPDU-4	Do Topology Change Notification BPDUs have the format, parameters, and parameter values specified?	M	Clause 14	Yes [ ]
BPDU-5	Do RST BPDUs have the format, parameters, and parameter values specified?	M	Clause 14	Yes [ ]
BPDU-6	Are received BPDUs validated as and only as specified?	M	Clause 14	Yes [ ]
BPDU-7	Does the implementation process BPDUs of prior and possible later protocol versions as specified?	M	Clause 14	Yes [ ]
BPDU-8	Do MST BPDUs have the format, parameters, and parameter values specified?	MSTP:M	14.1	Yes [ ] N/A [ ]

A.12 Implementation parameters

Item	Feature	Status	References	Support
IMP-1	State the Filtering Database Size.	M	8.8	____ entries
IMP-2	State the Permanent Database Size.	M	8.8	____ entries
IMP-3	State the maximum number of VIDs supported by the implementation.	M	5.4, 8.8	_____ VIDs
IMP-4	State the range of VID values supported by the implementation.	M	5.4, 8.8	0 through _____
IMP-5	State the maximum number of FIDs that can be supported by the implementation.	M	8.8.8	____ FIDs
IMP-6	State the maximum number of VIDs that can be allocated to each FID.	M	8.8.8	____ VIDs
IMP-7	State the number of MSTIs supported.	MSTP:M	5.4.1, 8.8.8, 13.14	____ MSTIs N/A [ ]

A.13 Performance

Item	Feature	Status	References	Support
PERF-1	Specify a Guaranteed Port Filtering Rate, and the associated measurement interval *TF*, for each Bridge Port in the format specified below.	M	24.1	
PERF-2	Specify a Guaranteed Bridge Relaying Rate, and the associated measurement interval *TR*, in the format specified below. Supplementary information shall clearly identify the Ports.	M	24.2	

Guaranteed Bridge Relaying Rate	TR
_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)

Port number(s) or other identification	Guaranteed port filtering rate (specify for all ports)	T_F (specify for all ports)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)
	_ _ _ _ _ _ _ _ _ _ _ frames per second	_ _ _ _ _ _ second(s)

A.14 Bridge management

Item	Feature	Status	References	Support
	If item MGT is not supported, or if item TPMR is supported, mark N/A and continue at A.15.			N/A [ ]
MGT-1	Discover Bridge	MGT:M	12.4.1.1	Yes [ ]
MGT-2	Read Bridge	MGT:M	12.4.1.2	Yes [ ]
MGT-3	Set Bridge Name	MGT:M	12.4.1.3	Yes [ ]
MGT-4	Reset Bridge	MGT:M	12.4.1.4	Yes [ ]
MGT-5	Read Port	MGT:M	12.4.2.1	Yes [ ]
MGT-6	Set Port Name	MGT:M	12.4.2.1	Yes [ ]
MGT-7	Read Forwarding Port Counters	MGT:M	12.6.1.1	Yes [ ]
MGT-8	Read Port Default Priority	MGT:M	12.6.2.1	Yes [ ] N/A [ ]
MGT-9	Set Port Default Priority	MGT AND MAC-6:M	12.6.2.2	Yes [ ] N/A [ ]
MGT-10	Read Port Priority Regeneration Table	MGT AND RLY-5:M	12.6.2.3	Yes [ ] N/A [ ]
MGT-11	Set Port Priority Regeneration Table	MGT AND RLY-5:M	12.6.2.4	Yes [ ] N/A [ ]
MGT-12	Read Port Traffic Class Table	MGT AND TC:M	12.6.3.1	Yes [ ] N/A [ ]
MGT-13	Set Port Traffic Class Table	MGT AND TC-3:M	12.6.3.2	Yes [ ] N/A [ ]
MGT-14	Read Port Priority Code Point Selection	MGT and VLAN-29:M	12.6.2.5	Yes [ ] N/A [ ]
MGT-15	Set Port Priority Code Point Selection	MGT AND VLAN-29:M	12.6.2.6	Yes [ ] N/A [ ]
MGT-16	Read Priority Code Point Decoding Table	MGT AND VLAN-29:M	12.6.2.7	Yes [ ] N/A [ ]
MGT-17	Set Priority Code Point Decoding Table	MGT AND VLAN-29:O	12.6.2.8	Yes [ ] No [ ] N/A [ ]
MGT-18	Read Priority Code Point Encoding Table	MGT AND VLAN-29:M	12.6.2.9	Yes [ ] N/A [ ]
MGT-19	Set Priority Code Point Encoding Table	MGT AND VLAN-29:O	12.6.2.10	Yes [ ] No [ ] N/A [ ]
MGT-20	Read Use_DEI parameter	MGT:M	12.6.2.11	Yes [ ] N/A [ ]
MGT-21	Set Use_DEI parameter	MGT:O	12.6.2.12	Yes [ ] No [ ] N/A [ ]
MGT-22	Read Require Drop Encoding parameter	MGT AND VLAN-29:M	12.6.2.13	Yes [ ] N/A [ ]
MGT-23	Set Require Drop Encoding parameter	MGT AND VLAN-29:M	12.6.2.14	Yes [ ] N/A [ ]
MGT-24	Read Service Access Priority Selection	MGT AND VLAN-30:M	12.6.2.15	Yes [ ] N/A [ ]
MGT-25	Set Service Access Priority Selection	MGT AND VLAN-30:M	12.6.2.16	Yes [ ] No [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-26	Read Service Access Priority Table	MGT AND VLAN-30:M	12.6.2.17	Yes [ ] N/A [ ]
MGT-27	Set Service Access Priority Table	MGT AND VLAN-30:O	12.6.2.18	Yes [ ] No [ ] N/A [ ]
MGT-28	Read Filtering Database	MGT:M	12.7.1.1	Yes [ ]
MGT-29	Set Filtering Database Ageing Time	MGT:M	12.7.1.2	Yes [ ]
MGT-30	Read Permanent Database	MGT:M	12.7.6.1	Yes [ ]
MGT-31	Create Filtering Entry	MGT:M	12.7.7.1	Yes [ ]
MGT-32	Delete Filtering Entry	MGT:M	12.7.7.2	Yes [ ]
MGT-33	Read Filtering Entry	MGT:M	12.7.7.3	Yes [ ]
MGT-34	Read Filtering Entry Range	MGT:M	12.7.7.4	Yes [ ]
MGT-35	Read CIST Bridge Protocol Parameters	MGT:M	12.8.1.1	Yes [ ]
MGT-36	Set CIST Bridge Protocol Parameters	MGT:M	12.8.1.3	Yes [ ]
MGT-37	Read CIST Port Parameters	MGT:M	12.8.2.1	Yes [ ]
MGT-38	Set CIST Port Parameters	MGT:M	12.8.2.3	Yes [ ]
MGT-39	Force BPDU Migration Check	MGT:M	12.8.2.5	Yes [ ]
MGT-40	Read MRP Timers	MGT AND MRP:M	12.9.1.1	Yes [ ] N/A [ ]
MGT-41	Set MRP Timers	MGT AND MRP:M	12.9.1.2	Yes [ ] N/A [ ]
MGT-42	Read MRP Protocol Controls	MGT AND MRP:M	12.9.2.1	Yes [ ] N/A [ ]
MGT-43	Set MRP Protocol Controls	MGT AND MRP:M	12.9.2.2	Yes [ ] N/A [ ]
MGT-44	Read MSTI Bridge Protocol Parameters	MGT AND MSTP:M	12.8.1.2	Yes [ ] N/A [ ]
MGT-45	Set MSTI Bridge Protocol Parameters	MGT AND MSTP:M	12.8.1.4	Yes [ ] N/A [ ]
MGT-46	Read MSTI Port Parameters	MGT AND MSTP:M	12.8.2.2	Yes [ ] N/A [ ]
MGT-47	Set MSTI Port Parameters	MGT AND MSTP:M	12.8.2.4	Yes [ ] N/A [ ]
MGT-48	Read Bridge VLAN Configuration	MGT:M	12.10.1.1	Yes [ ] N/A [ ]
MGT-49	Configure PVID values	MGT:M	12.10.1.2	Yes [ ] N/A [ ]
MGT-50	Configure Acceptable Frame Types parameter	MGT AND VLAN-2:M	12.10.1.3	Yes [ ] N/A [ ]
MGT-51	Configure Enable Ingress Filtering parameters	MGT AND VLAN-9:M	12.10.1.4	Yes [ ] N/A [ ]
MGT-52	Reset Bridge	MGT:M	12.10.1.5	Yes [ ] N/A [ ]
MGT-53	Notify VLAN Registration Failure	MGT:M	12.10.1.6	Yes [ ] N/A [ ]
MGT-54	Read VLAN Configuration	MGT:M	12.10.2.1	Yes [ ] N/A [ ]
MGT-55	Create VLAN Configuration	MGT:M	12.10.2.2	Yes [ ] N/A [ ]
MGT-56	Delete VLAN Configuration	MGT:M	12.10.2.3	Yes [ ] N/A [ ]
	If item MSTP is not supported, mark N/A and continue at MGT-68			N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-57	Read MSTI List	MGT AND MSTP:M	12.12.1.1	Yes [ ]
MGT-58	Create MSTI	MGT AND MSTP:M	12.12.1.2	Yes [ ]
MGT-59	Delete MSTI	MGT AND MSTP:M	12.12.1.3	Yes [ ]
MGT-60	Read FID to MSTI allocation	MGT AND MSTP:M	12.12.2.1	Yes [ ]
MGT-61	Set FID to MSTI allocation	MGT AND MSTP:M	12.12.2.2	Yes [ ]
MGT-62	Read MST Configuration Table Element	MGT AND MSTP:M	12.12.3.1	Yes [ ]
MGT-63	Read VIDs assigned to MSTID	MGT AND MSTP:M	12.12.3.2	Yes [ ]
MGT-64	Read MSTI Configuration Identifier	MGT AND MSTP:M	12.12.3.3	Yes [ ]
MGT-65	Set MSTI Configuration Identifier	MGT AND MSTP:M	12.12.3.4	Yes [ ]
MGT-66	Does the implementation support configuration of VID to FID allocations via management?	MGT:O	5.4.1, 8.8.8, 12.10.3	Yes [ ] No [ ] N/A [ ]
MGT-67	Read VID to FID allocations	MGT-62:M	12.10.3.1	Yes [ ] N/A [ ]
MGT-68	Read FID allocation for VID	MGT-62:M	12.10.3.2	Yes [ ] N/A [ ]
MGT-69	Read VIDs allocated to FID	MGT-62:M	12.10.3.3	Yes [ ] N/A [ ]
MGT-70	Set VID to FID allocation	MGT-62:M	12.10.3.4	Yes [ ] N/A [ ]
MGT-71	Delete VID to FID allocation	MGT-62:M	12.10.3.5	Yes [ ] N/A [ ]
MGT-72	Support Bridge management for the Bridge protocol entity in all supported spanning trees	MGT AND MSTP:M	5.4, 12.8	Yes [ ] N/A [ ]
MGT-73	Support independent management of Bridge and port priority and path cost per spanning tree	MGT AND MSTP:M	5.4, 12.8.1	Yes [ ] N/A [ ]
MGT-74	Support VLAN management per spanning tree	MGT AND MSTP:M	5.4, 12.10.1	Yes [ ] N/A [ ]
MGT-75	Support MSTI configuration management	MGT AND MSTP:M	5.4, 12.12	Yes [ ] N/A [ ]
MGT-76	Read Provider Bridge Port Type	MGT AND PB:M MGT AND BEB:M	12.13.1.1	Yes [ ] N/A [ ]
MGT-77	Configure Provider Bridge Port Type	MGT AND PB:O MGT AND BEB:O	12.13.1.2	Yes [ ] No [ ] N/A [ ]
MGT-78	Read VID Translation Table Entry	MGT AND VLAN-31:M	12.10.1.1	Yes [ ] No [ ]
MGT-79	Configure VID Translation Table Entry	MGT AND VLAN-31:M	12.10.1.8	Yes [ ] No [ ]
MGT-80	Read Egress VID Translation Table Entry	MGT AND VLAN-32:M	12.10.1.9	Yes [ ] No [ ]
MGT-81	Configure Egress VID Translation Table Entry	MGT AND VLAN-32:M	12.10.1.8.2	Yes [ ] No [ ]
MGT-82	Read C-VID Registration Table Entry	MGT AND PEB:M	12.13.2.1	Yes [ ] N/A [ ]
MGT-83	Configure C-VID Registration Table Entry	MGT AND PEB:M	12.13.2.2	Yes [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-84	Read Provider Edge Port Configuration	MGT AND PEB:M	12.13.2.3	Yes [ ] N/A [ ]
MGT-85	Set Provider Edge Port Configuration	MGT AND PEB:M	12.13.2.4	Yes [ ] N/A [ ]
MGT-86	Read Service Priority Regeneration Table	MGT AND PEB:M	12.13.2.5	Yes [ ] N/A [ ]
MGT-87	Set Service Priority Regeneration Table	MGT AND PEB:O	12.13.2.6	Yes [ ] No [ ] N/A [ ]
MGT-87a	Read Internal Interface Table Entry	MGT AND RCSI:M	12.13.3.1	Yes [ ] N/A [ ]
MGT-87b	Configure Internal Interface Table Entry	MGT AND RCSI:M	12.13.3.2	Yes [ ] N/A [ ]
MGT-88	Does the Bridge provide control of all of the required CFM managed objects?	BRG AND CFM: M	5.4.1.4 item h), 12.14	Yes [ ] N/A [ ]
MGT-89	Reserved			
	Questions MGT-90 through MGT-115 refer to operations related to CFM managed objects.			
MGT-90	Read Maintenance Domain list	CFM: M	12.14.1.1	Yes [ ]
MGT-91	Create Maintenance Domain managed object	CFM: M	12.14.1.2	Yes [ ]
MGT-92	Delete Maintenance Domain managed object	CFM: M	12.14.1.3	Yes [ ]
MGT-93	Read CFM Stack managed object	CFM: M	12.14.2.1	Yes [ ]
MGT-94	Read Default MD Level managed object	CFM: M	12.14.3.1	Yes [ ]
MGT-95	Write Default MD Level managed object	CFM: M	12.14.3.2	Yes [ ]
MGT-96	Read Configuration Error List managed object	CFM: M	12.14.4.1	Yes [ ]
MGT-97	Read Maintenance Domain managed object	CFM: M	12.14.5.1	Yes [ ]
MGT-98	Write Maintenance Domain managed object	CFM: M	12.14.5.2	Yes [ ]
MGT-99	Create Maintenance Association managed object	CFM: M	12.14.5.3	Yes [ ]
MGT-100	Delete Maintenance Association managed object	CFM: M	12.14.5.4	Yes [ ]
MGT-101	Read Maintenance Association managed object	CFM: M	12.14.6.1	Yes [ ]
MGT-102	Write Maintenance Association managed object	CFM: M	12.14.6.2	Yes [ ]
MGT-103	Create Maintenance association Endpoint managed object	CFM: M	12.14.6.3	Yes [ ]
MGT-104	Delete Maintenance association Endpoint managed object	CFM: M	12.14.6.4	Yes [ ]
MGT-105	Read Maintenance association Endpoint managed object	CFM: M	12.14.7.1	Yes [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-106	Total number of out-of-sequence CCMs received	CFM: O	12.14.7.1.3 item v), 20.16.12	Yes [ ] No [ ]
MGT-107	Total number of LBRs received with data match errors	CFM: O	12.14.7.1.3 item aa)	Yes [ ] No [ ]
MGT-108	Write Maintenance association Endpoint managed object	CFM: M	12.14.7.2	Yes [ ]
MGT-109	Transmit Loopback Messages	CFM: M	12.14.7.3	Yes [ ]
MGT-110	Transmit Linktrace Message	CFM: M	12.14.7.4	Yes [ ]
MGT-111	Read Linktrace Reply	CFM: M	12.14.7.5	Yes [ ]
MGT-112	Read MEP Database	CFM: M	12.14.7.6	Yes [ ]
MGT-113	Read received Port Status TLV	CFM: O	12.14.7.6.3 item f), 20.19.3	Yes [ ] No [ ]
MGT-114	Read received Interface Status TLV	CFM: O	12.14.7.6.3 item g), 20.19.4	Yes [ ] No [ ]
MGT-115	Transmit MEP Fault Alarm	CFM: M	12.14.7.7	Yes [ ]
MGT-116	List of active remote MEPs	CFM: O PBBTE: M	12.14.7.1.3 item ae)	No [ ] N/A [ ] Yes [ ]
MGT-117	Indication on the capability to report the Traffic field bit	PS-5: M	12.14.7.1.3 item af)	Yes [ ] N/A [ ]
MGT-118	Configuration to enable generation of a Fault Alarm based on a mismatch defect	PS-5: M	12.14.7.1.3 item ag)	Yes [ ] N/A [ ]
MGT-119	Indication on the presence of a traffic field mismatch defect	PS-5: M	12.14.7.1.3 item ah), 20.25.2	Yes [ ] N/A [ ]
MGT-120	Indication on the presence of a local mismatch defect	PS-5: M	12.14.7.1.3 item ai), 20.25.5	Yes [ ] N/A [ ]
MGT-121	Indication on the presence of the mismatch defect since the MEP Mismatch Fault Notification Generator state machine was last in the MFNG_RESET state	PS-5: M	12.14.7.1.3 item aj)	Yes [ ] N/A [ ]
MGT-122	Read the current state of the MEP Mismatch Fault Notification Generator state machine	PS-5: M	12.14.7.1.3 item ak), 20.40	Yes [ ] N/A [ ]
MGT-123	Configuration of the Reverse VID on LBM/LTM transmit on MAs associated with point-to-multipoint TESIs	PBBTE: M	12.14.7.3.2 item f), 12.14.7.4.2item e), 21.7.5.2	Yes [ ] N/A [ ]
MGT-124	Read BEB configuration	MGT AND BEB: M	12.16.1.1	Yes [ ] N/A [ ]
MGT-125	Set BEB configuration	MGT AND BEB: M	12.16.1.2	Yes [ ] N/A [ ]
MGT-126	Create BEB component	MGT AND BEB: O	12.16.1.3	Yes [ ] No [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-127	Delete BEB component	MGT AND BEB: O	12.16.1.4	Yes [ ] No [ ] N/A [ ]
MGT-128	Create BEB Bridge Port	MGT AND BEB: O	12.16.1.5	Yes [ ] No [ ] N/A [ ]
MGT-129	Create BEB PIP	MGT AND BEB: O	12.16.1.6	Yes [ ] No [ ] N/A [ ]
MGT-130	Delete BEB Bridge Port	MGT AND BEB: O	12.16.1.7	Yes [ ] No [ ] N/A [ ]
MGT-131	Delete BEB PIP	MGT AND BEB: O	12.16.1.8	Yes [ ] No [ ] N/A [ ]
MGT-132	Read BEB/PB/VLAN Bridge Port configuration	MGT AND BEB: M	12.16.2.1	Yes [ ] N/A [ ]
MGT-133	Read VIP configuration	MGT AND BEB-I: M	12.16.3.1	Yes [ ] N/A [ ]
MGT-134	Set VIP configuration	MGT AND BEB-I: M	12.16.3.2	Yes [ ] N/A [ ]
MGT-135	Read the value of the enableConnectionIdentifier parameter	MGT AND BEB-I: O PBBTE: M	12.14.7.7.2 item f), 6.10	Yes [ ] N/A [ ] No [ ]
MGT-136	Configuration of the enableConnectionIdentifier parameter	MGT AND BEB-I: O PBBTE: M	12.14.7.7.2 item d), 6.10	Yes [ ] N/A [ ] No [ ]
MGT-137	Read PIP configuration	MGT AND BEB-I: M	12.16.4.1	Yes [ ] N/A [ ]
MGT-138	Set PIP configuration	MGT AND BEB-I: O	12.16.4.2	Yes [ ] N/A [ ] No [ ]
MGT-139	Read VIP to PIP mapping	MGT AND BEB-I: M	12.16.4.3	Yes [ ] N/A [ ]
MGT-140	Set VIP to PIP mapping	MGT AND BEB-I: O	12.16.4.4	Yes [ ] N/A [ ] No [ ]
MGT-141	Read PIP Priority Code Point Selection	MGT AND BEB-I: M	12.16.4.5	Yes [ ] N/A [ ]
MGT-142	Set PIP Priority Code Point Selection	MGT AND BEB-I: M	12.16.4.6	Yes [ ] N/A [ ]
MGT-143	Read PIP Priority Code Point Decoding Table	MGT AND BEB-I: M	12.16.4.7	Yes [ ] N/A [ ]
MGT-144	Set PIP Priority Code Point Decoding Table	MGT AND BEB-I: O	12.16.4.8	Yes [ ] N/A [ ] No [ ]
MGT-145	Read PIP Priority Code Point Encoding Table	MGT AND BEB-I: M	12.16.4.9	Yes [ ] N/A [ ]
MGT-146	Set PIP Priority Code Point Encoding Table	MGT AND BEB-I: O	12.16.4.10	Yes [ ] N/A [ ] No [ ]
MGT-147	Read PIP Use_DEI parameter	MGT AND BEB-I: M	12.16.4.11	Yes [ ] N/A [ ]
MGT-148	Set PIP Use_DEI parameter	MGT AND BEB-I: O	12.16.4.12	YES [ ] N/A [ ] No [ ]
MGT-149	Read PIP Require Drop Encoding parameter	MGT AND BEB-I: M	12.16.4.13	Yes [ ] N/A [ ]
MGT-150	Set PIP Require Drop Encoding parameter	MGT AND BEB-I: O	12.16.4.14	Yes [ ] N/A [ ] No [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-151	Read Backbone Service Instance table entry	MGT AND BEB-B: M	12.16.5.1	Yes [ ] N/A [ ]
MGT-152	Set Backbone Service Instance table entry	MGT AND BEB-B: M	12.16.5.2	Yes [ ] N/A [ ]
MGT-153	TESI assignment managed object	PBBTE: M	12.16.5.3	Yes [ ] N/A [ ] No [ ]
MGT-154	Does the Bridge provide control of all the required DDCFM managed objects?	DDCFM:M	12.17	Yes [ ] N/A [ ]
	Questions MGT-155 through MGT-174 refer to operations related to DDCFM managed objects.			
MGT-155	Create Reflection Responder managed object	DDCFM:M	12.17.2.1	Yes [ ] N/A [ ]
MGT-156	Read Reflection Responder managed object	DDCFM:M	12.17.2.3	Yes [ ] N/A [ ]
MGT-157	Write Reflection Responder managed object's attributes	DDCFM:M	12.17.2.2	Yes [ ] N/A [ ]
MGT-158	Delete Reflection Responder managed object	DDCFM:M	12.17.2.4	Yes [ ] N/A [ ]
MGT-159	Activate a Reflection Responder managed object	DDCFM:M	12.17.2.5	Yes [ ] N/A [ ]
MGT-160	Deactivate a Reflection Responder managed object	DDCFM:M	12.17.2.6	Yes [ ] N/A [ ]
MGT-161	Create RFM Receiver managed object	DDCFM:M	12.17.3.1	Yes [ ] N/A [ ]
MGT-162	Delete RFM Receiver managed object	DDCFM:M	12.17.3.2	Yes [ ] N/A [ ]
MGT-163	Create Decapsulator Responder managed object	DDCFM:M	12.17.4.1	Yes [ ] N/A [ ]
MGT-164	Read Decapsulator Responder managed object	DDCFM:M	12.17.4.2	Yes [ ] N/A [ ]
MGT-165	Write Decapsulator Responder managed object's attributes	DDCFM:M	12.17.4.3	Yes [ ] N/A [ ]
MGT-166	Delete Decapsulator Responder managed object	DDCFM:M	12.17.4.4	Yes [ ] N/A [ ]
MGT-167	Activate a Decapsulator Responder managed object	DDCFM:M	12.17.4.5	Yes [ ] N/A [ ]
MGT-168	Deactivate a Decapsulator Responder managed object	DDCFM:M	12.17.4.6	Yes [ ] N/A [ ]
MGT-169	Create SFM Originator managed object	DDCFM:M	12.17.5.1	Yes [ ] N/A [ ]
MGT-170	Read SFM Originator managed object	DDCFM:M	12.17.5.2	Yes [ ] N/A [ ]
MGT-171	Write SFM Originator managed object's attributes	DDCFM:M	12.17.5.4	Yes [ ] N/A [ ]
MGT-172	Delete SFM Originator managed object	DDCFM:M	12.17.5.3	Yes [ ] N/A [ ]
MGT-173	Activate SFM Originator managed object	DDCFM:M	12.17.5.5	Yes [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-174	Deactivate SFM Originator managed object	DDCFM:M	12.17.5.6	Yes [ ] N/A [ ]
MGT-175	Read TE protection group list	PBBTE: M	12.18.1.1	Yes [ ] N/A [ ]
MGT-176	Create TE protection group managed object	PBBTE: M	12.18.1.2	Yes [ ] N/A [ ] N/A [ ]
MGT-177	Delete TE protection group managed object	PBBTE: M	12.18.1.3	Yes [ ] N/A [ ] N/A [ ]
MGT-178	Read TE protection group managed object	PBBTE: M	12.18.2.1	Yes [ ] N/A [ ] N/A [ ]
MGT-179	Write TE protection group managed object	PBBTE: M	12.18.2.2	Yes [ ] N/A [ ] N/A [ ]
MGT-180	TE protection group administrative commands managed object	PBBTE: M	12.18.2.3	Yes [ ] N/A [ ] N/A [ ]
MGT-181	Does the implementation provide control of the TPMR management entity?	MGT AND TPMR: M	12.19.1	Yes [ ] N/A [ ]
MGT-182	Does the implementation provide control of the individual MAC and PHY entities associated with each TPMR Port?	MGT AND TPMR: M		Yes [ ] N/A [ ]
MGT-183	Does the implementation provide control of the Forwarding Process of the MAC Relay Entity?	MGT AND TPMR: M	8.6, 12.19.3	Yes [ ] N/A [ ]
MGT-184	Does the implementation provide control of the MSPE?	MGT AND TPMR: M	23.3, 12.19.4	Yes [ ] N/A [ ]
MGT-185	Read TPMR	TPMR:M	12.19.1.1.1	Yes [ ] N/A [ ]
MGT-186	Set TPMR Name	TPMR:M	12.19.1.1.2	Yes [ ] N/A [ ]
MGT-187	Read Port	TPMR:M	12.19.1.2.1	Yes [ ] N/A [ ]
MGT-188	Set Port Name	TPMR:M	12.19.1.2.2	Yes [ ] N/A [ ]
MGT-189	Read Forwarding Port Counters	TPMR:M	12.19.3.1.1	Yes [ ] N/A [ ]
MGT-190	Read Port Default Priority	TPMR AND TPMR-12:M	12.6.2.1	Yes [ ] N/A [ ]
MGT-191	Set Port Default Priority	TPMR AND TPMR-12:M	12.6.2.2	Yes [ ] N/A [ ]
MGT-192	Read Port Priority Regeneration Table	TPMR AND TPMR-12:M	12.6.2.3	Yes [ ] N/A [ ]
MGT-193	Set Port Priority Regeneration Table	TPMR AND TPMR-12:M	12.6.2.4	Yes [ ] N/A [ ]
MGT-194	Read Port Traffic Class Table	TPMR AND TPMR-10:M	12.6.3.1	Yes [ ] N/A [ ]
MGT-195	Set Port Traffic Class Table	TPMR AND TPMR-10:M	12.6.3.2	Yes [ ] N/A [ ]
MGT-196	Read Port Priority Code Point Selection	TPMR AND TPMR-12:M	12.6.2.5	Yes [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-197	Set Port Priority Code Point Selection	TPMR AND TPMR-12:M	12.6.2.6	Yes [ ] N/A [ ]
MGT-198	Read Priority Code Point Decoding Table	TPMR AND TPMR-12:O	12.6.2.7	Yes [ ] No [ ] N/A [ ]
MGT-199	Read Use_DEI parameter	TPMR AND TPMR-12:M	12.6.2.11	Yes [ ] N/A [ ]
MGT-200	Set Use_DEI parameter	TPMR AND TPMR-12:O	12.6.2.12	Yes [ ] No [ ] N/A [ ]
MGT-201	Does the implementation support the management entities defined in 12.20?	FQTSS: O	5.4.1.5 item e), 12.20, 17.7.12, Clause 34	Yes [ ] N/A [ ]
MGT-202	Does the Bridge support all of the objects in the CN component managed object?	BRG1 AND CN: M	5.4.3 item c), 12.21.1	Yes [ ] N/A [ ]
MGT-203	Does the Bridge support all of the objects in the CN component priority managed object?	BRG1 AND CN: M	5.4.3 item c), 12.21.2	Yes [ ] N/A [ ]
MGT-204	Does the Bridge support all of the objects in the CN Port priority managed object?	BRG1 AND CN: M	5.4.3 item c), 12.21.3	Yes [ ] N/A [ ]
MGT-205	Does the Bridge support all of the objects in the Congestion Point managed object?	BRG1 AND CN: M	5.4.3 item c), 12.21.4	Yes [ ] N/A [ ]
MGT-206	Does the implementation support the management entities defined in 12.22?	SRP: O	12.22	Yes [ ] No [ ] N/A [ ]
MGT-207	Does the BEB support all of the MIRP managed objects?	MIRP AND BEB-I: M	12.16.1	Yes [ ] N/A [ ]
MGT-208	PFC entities	PFC: O	12.22.6	Yes [ ] No [ ] N/A [ ]
MGT-209	ETS Control Entities	ETS:M	12.24	Yes [ ] N/A [ ]
MGT-210	PFC Control Entities	PFC:M	12.22.6	Yes [ ] N/A [ ]
MGT-211	Read IPG list	IPS: M	12.24.1.1	Yes [ ] N/A [ ]
MGT-212	Create IPG managed objects	IPS: M	12.24.1.2	Yes [ ] N/A [ ]
MGT-213	Delete IPG managed objects	IPS: M	12.24.1.3	Yes [ ] N/A [ ]
MGT-214	Read IPG managed objects	IPS: M	12.24.2.1	Yes [ ] N/A [ ]
MGT-215	Write IPG managed objects	IPS: M	12.24.2.2	Yes [ ] N/A [ ]
MGT-216	Apply administrative command to IPG managed objects	IPS: M	12.24.2.3	Yes [ ] N/A [ ]
MGT-217	Does the implementation support the SPB managed objects?	MGT AND SPB:M	5.4.5, 12.25	Yes [ ] N/A [ ]
MGT-218	Discard TTL expired counter	MGT AND FF:M	12.6.1.1.3	Yes [ ] N/A [ ] N/A [ ]
MGT-219	Flow filtering control table	MGT AND FF:M	12.16.5.4, 12.16.5.5	Yes [ ] N/A [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-220	Does the implementation support the managed objects required for PCR? If item PCR is not supported in A.5, mark N/A and continue at MGT-248	MGT AND PCR:M	5.5, 12.26	Yes [ ] N/A [ ] N/A [ ]
MGT-221	Create SPB System managed object	PCR:M	12.25.1.1	Yes [ ] N/A [ ]
MGT-222	Write SPB System managed object	PCR:M	12.25.1.2	Yes [ ] N/A [ ]
MGT-223	Read SPB System managed object	PCR:M	12.25.1.3	Yes [ ] N/A [ ]
MGT-224	Delete SPB System managed object	PCR:M	12.25.1.4	Yes [ ] N/A [ ]
MGT-225	Create SPB MTID Static managed object	PCR:M	12.25.2.1	Yes [ ] N/A [ ]
MGT-226	Write SPB MTID Static managed object	PCR:M	12.25.2.2	Yes [ ] N/A [ ]
MGT-227	Read SPB MTID Static managed object	PCR:M	12.25.2.3	Yes [ ] N/A [ ]
MGT-228	Delete SPB MTID Static managed object	PCR:M	12.25.2.4	Yes [ ] N/A [ ]
MGT-229	Read SPB Topology Instance Dynamic managed object	PCR:M	12.25.3.1	Yes [ ] N/A [ ]
MGT-230	Create SPB ECT Static Entry managed object	PCR:M	12.25.4.1	Yes [ ] N/A [ ]
MGT-231	Read SPB ECT Static Entry managed object	PCR:M	12.25.4.2	Yes [ ] N/A [ ]
MGT-232	Delete SPB ECT Static Entry managed object	PCR:M	12.25.4.3	Yes [ ] N/A [ ]
MGT-233	Read SPB ECT Dynamic Entry managed object	PCR:M	12.25.5.1	Yes [ ] N/A [ ]
MGT-234	Write SPB Adjacency Static Entry managed object	PCR:M	12.25.6.1	Yes [ ] N/A [ ]
MGT-235	Read SPB Adjacency Static Entry managed object	PCR:M	12.25.6.2	Yes [ ] N/A [ ]
MGT-236	Read SPB Adjacency Dynamic Entry managed object	PCR:M	12.25.7.1	Yes [ ] N/A [ ]
MGT-237	Read SPBM BSI Static Entry managed object	BEB AND PCR:M	12.25.8.2	Yes [ ] N/A [ ]
MGT-238	Read SPBM Topology Service Table managed object	BEB AND PCR:M	12.25.12.1	Yes [ ] N/A [ ]
MGT-239	Read SPB Topology Node Table managed object	PCR:M	12.25.9.1	Yes [ ] N/A [ ]
MGT-240	Read SPB Topology ECT Table managed object	PCR:M	12.25.10.1	Yes [ ] N/A [ ]
MGT-241	Read SPB Topology Edge Table managed object	PCR:M	12.25.11.1	Yes [ ] N/A [ ]
MGT-242	Read SPBM Topology Service Table managed object	BEB AND PCR:M	12.25.12.1	Yes [ ] N/A [ ]
MGT-243	Read SPBV Topology Service Table managed object	PCR:M	12.25.13.1	Yes [ ] N/A [ ]

A.14 Bridge management *(continued)*

Item	Feature	Status	References	Support
MGT-244	Create a PCR ECT Static Entry managed object	PCR:O	12.28.1.1	Yes [ ] No [ ] N/A [ ]
MGT-245	Read a PCR ECT Static Entry managed object	PCR:O	12.28.1.2	Yes [ ] No [ ] N/A [ ]
MGT-246	Delete a PCR ECT Static Entry managed object	PCR:O	12.28.1.4	Yes [ ] No [ ] N/A [ ]
MGT-247	Read PCR Topology ECT Table managed object	PCR:O	12.28.2.1	Yes [ ] No [ ] N/A [ ]
MGT-248	Does the implementation support the management entities defined in 12.29?	SCHED OR CQF: M	5.4.1 item ad), 5.4.1.9 item c), 5.13.1.2 item c), 12.29	Yes [ ] N/A [ ]
MGT-249	Does the implementation support the management entities defined in 12.30?	PRE: M	5.4.1 item ae), 12.30	Yes [ ] N/A [ ]
MGT-250	Does the implementation support the management entities defined in 12.31 for PSFP?	PSFP OR CQF: M	5.4.1.9 item e), 5.13.1.2 item e), 8.6.5.2.1, 8.6.10, 12.31	Yes [ ] N/A [ ]
MGT-251	Does the implementation support the management entities defined in 12.31 for ATS?	ATS:M	5.4.1.10 item e), 5.13.1.2 item e), 8.6.5.2.1, 8.6.10, 12.31	Yes [ ] N/A [ ]

A.15 Remote management

Item	Feature	Status	References	Support
	If item RMGT is not supported, mark N/A and continue at A.16.			N/A [ ]
RMGT-1	What Management Protocol standard(s) or specification(s) are supported?	RMGT:M	5.4.1	
RMGT-2	What standard(s) or specifications for Managed Objects and Encodings are supported?	RMGT:M	5.4.1	

A.16 Expedited traffic classes

Item	Feature	Status	References	Support
TC-1	Does the implementation provide more than one transmission queue for (a) Bridge Port(s)?	TC: M	8.6.6	Yes [ ] N/A [ ]
TC-2	Is the recommended mapping of priority to traffic classes supported for each Port?	TC: O	8.6.6	Yes [ ] No [ ] N/A [ ]
TC-3	Can the traffic class tables be managed?	TC: O	8.6.6, Table 8-5	Yes [ ] No [ ] N/A [ ]
TC-4	Is the default algorithm for selecting frames for transmission supported?	M	8.6.8	Yes [ ]
TC-5	Are additional algorithms for selecting frames for transmission supported?	O	8.6.8	Yes [ ] No [ ]

A.17 Extended Filtering Services

Item	Feature	Status	References	Support
EFS-1	Can MAC Address Registration Entries be created, updated, and removed from the FDB by MMRP?	EFS:M	8.8, 8.8.4, Clause 10	Yes [ ] N/A [ ]
EFS-2	Can a Static Filtering Entry be created with an address specification that represents a group address, or All Group Addresses, or All Unregistered Group Addresses, and with a control element for each Port that specifies unconditional forwarding, or unconditional filtering, or the use of dynamic or default group filtering information?	EFS:M	8.8.1	Yes [ ] N/A [ ]
EFS-3	Can a Static Filtering Entry be created with an address specification that represents an individual address and with a control element for each Port that specifies unconditional forwarding, or unconditional filtering?	M	8.8.1	Yes [ ]
EFS-4	Can a Static Filtering Entry be created with an address specification that represents an individual address and with a control element for each Port that specifies unconditional forwarding, or unconditional filtering, or the use of dynamic filtering information?	EFS:O	8.8.1	Yes [ ] No [ ] N/A [ ]

A.18 Multiple Spanning Tree Protocol (MSTP)

Item	Feature	Status	References	Support
	If item MSTP is not supported, mark N/A and continue at the start of A.19.			N/A [ ]
MSTP-1	Support the CIST plus a stated maximum number of MSTIs, where that number is at least 2 and at most 64	MSTP:M	5.4.1, 8.8.8, 13.14	Yes [ ]
MSTP-2	Support at least as many FIDs as MSTIs	MSTP:M	5.4, 5.4.1, 8.8.8	Yes [ ]
MSTP-3	Associate each FID to a spanning tree	MSTP:M	5.4, 8.9.3	Yes [ ]
MSTP-4	Transmit and receive MST Configuration Identifier (MCID) information	MSTP:M	5.4, 8.9.2	Yes [ ]
MSTP-5	Support a set of port state information per spanning tree per port	MSTP:M	5.4, 8.4, 13.38	Yes [ ]
MSTP-6	Support an instance of spanning tree protocol per spanning tree per port	MSTP:M	5.4, 8.10, Clause 13	Yes [ ]
MSTP-7	Use the Bridge Group Address as specified	MSTP:M	5.4, 8.13.2	Yes [ ]
MSTP-8	Support default Bridge Forward Delay and Bridge Priority parameter values as specified	MSTP:M	5.4, 13.26	Yes [ ]
MSTP-9	Provision of identifiers for Bridge and Ports	MSTP:M	13.2	Yes [ ]
MSTP-10	Not exceed the values in 24.3 for max BPDU transmission delay	MSTP:M	24.3, Table 24-1	Yes [ ]
MSTP-11	Inclusion of active Ports in computation of the active topology for a given spanning tree	MSTP:M	13.9	Yes [ ]
MSTP-12	Processing of BPDUs received on Ports included in the computation of the active topology for a given spanning tree	MSTP:M	13.9	Yes [ ]
MSTP-13	Discarding received frames in the Discarding state for a given spanning tree	MSTP:M	13.9	Yes [ ]
MSTP-14	Incorporating station location information to the FDB in the Learning and Forwarding states for a given spanning tree	MSTP:M	13.9	Yes [ ]
MSTP-15	Not incorporating station location information to the FDB in the Discarding state for a given spanning tree	MSTP:M	13.9	Yes [ ]
MSTP-16	Transfer learned MAC addresses from a retiring Root Port to a new Root Port for a given spanning tree	MSTP:O	13.16	Yes [ ] No [ ]
MSTP-17	Instances of state machines per Bridge, per Port, and per spanning tree instance, as specified	MSTP:M	13.24	Yes [ ]
MSTP-18	Port Timers state machine support	MSTP:M	13.25, 13.30	Yes [ ]
MSTP-19	Port Receive state machine support	MSTP:M	13.25, 13.31	Yes [ ]
MSTP-20	Port Protocol Migration state machine support	MSTP:M	13.25, 13.32	Yes [ ]
MSTP-21	Port Transmit state machine support	MSTP:M	13.25, 13.34	Yes [ ]

A.18 Multiple Spanning Tree Protocol (MSTP) *(continued)*

Item	Feature	Status	References	Support
MSTP-22	Port Information state machine support	MSTP:M	13.25, 13.35	Yes [ ]
MSTP-23	Port Role Selection state machine support	MSTP:M	13.25, 13.36	Yes [ ]
MSTP-24	Port Role Transitions state machine support	MSTP:M	13.25, 13.37	Yes [ ]
MSTP-25	Port State Transition state machine support	MSTP:M	13.25, 13.38	Yes [ ]
MSTP-26	Topology Change state machine support	MSTP:M	13.25, 13.39	Yes [ ]
MSTP-27	Are the values of Migrate Time, Bridge Hello Time, Bridge Max Age, Bridge Forward Delay, Transmit Hold Count, and Max Hops within the permitted range?	MSTP:M	13.25, Table 13-5	Yes [ ]
MSTP-28	Enforcement of parameter relationships	MSTP:M	13.25, Table 13-5	Yes [ ]
MSTP-29	Range and granularity of priority values	MSTP:M	13.18	Yes [ ]
MSTP-30	Range and granularity of path cost values	MSTP:M	13.18	Yes [ ]
MSTP-31	Are all PNPs capable of supporting the L2GP spanning tree protocol?	PB: O	13.40	Yes [ ] N/A [ ] No [ ]
MSTP-32	Are PIPs capable of supporting the encapsulation/decapsulation of BPDUs?	BEB-I: O	5.7.1	Yes [ ] N/A [ ] No [ ]
MSTP-33	Can each Port be configured to support detection of fragile Bridges by setting the autoIsolatePort parameter?	MSTP:O	13.23, 13.27.19	Yes [ ] No [ ]
MSTP-34	Can a port be configured as an L2 Gateway Port by setting the isL2gp parameter?	MSTP:O	13.20, 13.27.26	Yes [ ] No [ ]
MSTP-35	Can the pseudoRootId parameter be set for an L2 Gateway Port for the CIST and for each MSTI?	MSTP-34:M	13.20, 13.27.51	Yes [ ] N/A [ ]
MSTP-36	Is one instance of the L2 Gateway Port state machine implemented for each L2GP port?	MSTP-34:M	13.40	Yes [ ] N/A [ ]

A.19 VLAN support

Item	Feature	Status	References	Support
VLAN-1	Does the implementation support, on each Port, one or more of the permissible combinations of values for the Acceptable Frame Types parameter?	M	5.4, 6.9	Yes [ ]
VLAN-2	Does the implementation support, on each Provider Bridge Port, the *Admit All Frames* value for the Acceptable Frame Types Parameter?	PB:M	5.6, 6.9	Yes [ ] N/A [ ]
VLAN-3	State which Ports support the following values for the Acceptable Frame Types parameter: — *Admit Only VLAN-tagged frames* — *Admit Only Untagged and Priority Tagged frames* — *Admit All frames*	M	5.4, 6.9	Ports: _____ Ports: _____ Ports: _____
VLAN-4	On Ports that support both values for the Acceptable Frame Types parameter, is the parameter configurable via management?	M	5.4, 6.9, 12.10	Yes [ ] N/A [ ]
VLAN-5	Does the implementation support the ability for the FDB to contain static and dynamic configuration information for at least one VID, by means of Static and Dynamic VLAN Registration Entries?	M	5.4, 8.8	Yes [ ]
VLAN-6	Does the implementation support at least one FID?	M	5.4, 8.8.3, 8.8.8, 8.8.9	Yes [ ]
VLAN-7	Can the implementation allocate at least one VID to each FID supported?	M	5.4, 8.8.3, 8.8.8, 8.8.9	Yes [ ]
VLAN-8	Does the implementation take account of the allocation of VIDs to FIDs when making forwarding decisions relative to group MAC addresses?	O	8.8.9	Yes [ ] No [ ]
VLAN-9	On Ports that support untagged and priority-tagged frames, does the implementation support:		5.4, 6.9, 8.8.2,	
VLAN-9.1	— A PVID value?	M	12.10	Yes [ ] N/A [ ]
VLAN-9.2	— The ability to configure one VID whose untagged set includes that Port?	M		Yes [ ] N/A [ ]
VLAN-9.3	— Configuration of the PVID value via management operations?	M		Yes [ ] N/A [ ]
VLAN-9.4	— Configuration of Static Filtering Entries via management operations?	M		Yes [ ] N/A [ ]
VLAN-9.5	— The ability to configure more than one VID whose untagged set includes that Port?	O		Yes [ ] No [ ] N/A [ ]
VLAN-10	Does the implementation support the ability to enable and disable Ingress Filtering?	CB:O PB:M BEB:M	5.4.1, 5.6, 8.6.3	Yes [ ] No [ ] N/A [ ]
VLAN-11	Can the PVID or the VID in any member of the VID Set for any Port be assigned the value of the null VID?	X	6.9, Table 9-2	No [ ]
VLAN-12	Are frames discarded (or not discarded) in accordance with the settings of the Acceptable Frame Types parameters?	M	6.9	Yes [ ]
VLAN-13	Are all frames received classified as belonging to exactly one VID, as defined in the ingress rules?	M	6.9	Yes [ ]
VLAN-14	Is Ingress Filtering performed in accordance with the value of the Enable Ingress Filtering parameter?	M	8.6.2	Yes [ ]

A.19 VLAN support *(continued)*

Item	Feature	Status	References	Support
VLAN-15	Are all frames that are not discarded as a result of the application of the ingress rules submitted to the Forwarding Process and to the Learning Process?	M	8.6.2	Yes [ ]
VLAN-16	Does the implementation support Port-and-Protocol-based classification of frames on any or all Ports?	O	6.12	Yes [ ] No [ ]
VLAN-16.1	State which Ports support Port-and-Protocol- based classification rules.	VLAN-16:M	6.12	Ports: _____
VLAN-16.2	For each Port that supports Port-and-Protocol-based classification rules, is a VID Set supported?	VLAN-16:M	6.12	Port: _____ Yes [ ] N/A [ ]
VLAN-16.3	For each Port that supports Port-and-Protocol-based classification rules, state how many entries are supported in the VID Set.	VLAN-16:M	6.12	Port: _____ _____ Entries
VLAN-16.4	For each Port that supports Port-and-Protocol-based classification rules, is the VID Set configurable via management?	VLAN-16:M	12.10.1.2	Port: _____ Yes [ ] N/A [ ]
VLAN-17	Does the implementation support a Protocol Group Database?	VLAN-16:M	6.12.3	Yes [ ] N/A [ ]
VLAN-17.1	State how many entries are supported in the Protocol Group Database.	VLAN-17:M	6.12.3	Entries _____
VLAN-17.2	Is the Protocol Group Database configurable via management?	VLAN-17:O	12.10.2.1	Yes [ ] No [ ] N/A [ ]
VLAN-17.3	Does the Protocol Group Database support entries of format Ethernet?	VLAN-17:O	6.12.3	Yes [ ] No [ ] N/A [ ]
VLAN-17.4	Does the Protocol Group Database support entries of format RFC_1042?	VLAN-17:O	6.12.3	Yes [ ] No [ ] N/A [ ]
VLAN-17.5	Does the Protocol Group Database support entries of format SNAP_8021H?	VLAN-17:O	6.12.3	Yes [ ] No [ ] N/A [ ]
VLAN-17.6	Does the Protocol Group Database support entries of format SNAP_Other?	VLAN-17:O	6.12.3	Yes [ ] No [ ] N/A [ ]
VLAN-17.7	Does the Protocol Group Database support entries of format LLC_Other?	VLAN-17:O	6.12.3	Yes [ ] No [ ] N/A [ ]
VLAN-17.8	Does the Protocol Group Database support entries of at least one of the following formats: Ethernet, RFC_1042, SNAP_8021H, SNAP_Other, LLC_Other?	VLAN-17: M	6.12.3	Yes [ ] N/A [ ]
VLAN-18	Are frames discarded if the transmission Port is not present in the member set for the frame's VID?	M	6.9.2, 8.8.10	Yes [ ]
VLAN-19	Are frames transmitted as VLAN-tagged frames or as untagged frames in accordance with the value of the untagged set for the frame's VID?	M	8.8.2	Yes [ ]
VLAN-20	Does the implementation support Static VLAN Registration Entries as defined in 8.8.2?	M	8.8.2	Yes [ ]
VLAN-21	Does the implementation support the creation of a separate Static VLAN Registration Entry with a distinct Port Map for each VID from which frames are received by the Forwarding Process?	O	8.8.2	Yes [ ] No [ ]

A.19 VLAN support *(continued)*

Item	Feature	Status	References	Support
VLAN-22	Does the implementation support Dynamic VLAN Registration Entries as defined in 8.8.5?	M	8.8.5	Yes [ ]
VLAN-23	Does the implementation support the creation of a separate Dynamic VLAN Registration Entry with a distinct Port Map for each VID from which frames are received by the Forwarding Process?	O	8.8.5	Yes [ ] No [ ]
VLAN-24	Does the implementation allocate VIDs to FIDs in accordance with the specification in 8.8.8?	M	8.8.8	Yes [ ]
VLAN-25	Does the implementation correctly detect Learning Constraint violations?	M	8.8.8	Yes [ ]
VLAN-26	Is determination of the member set and the untagged set for a given VID achieved as defined in 8.8.10?	M	8.8.10	Yes [ ]
VLAN-27	Do VLAN-tagged frames transmitted by the Bridge conform to the format defined in Clause 9 for the MAC type on which they are transmitted?	M	Clause 9	Yes [ ]
VLAN-28	Are all BPDUs transmitted untagged?	M	8.13.9	Yes [ ]
VLAN-29	Is encoding of the drop_eligible parameter in the PCP field of the VLAN tag supported?	CB:O PB:M BEB:M	5.5.1, 5.6, 6.9.3, 9.6	Yes [ ] No [ ] N/A [ ]
VLAN-30	Is Service Access Priority Selection supported?	CB:O PB:X BEB:X	5.5.1, 5.6, 6.13	Yes [ ] No [ ] N/A [ ]
VLAN-31	Is the VID translation table supported?	¬SPBV:O SPBV:M	5.4.1, 5.4.5, 6.9	Yes [ ] No [ ]
VLAN-32	Is the Egress VID translation table supported?	¬VLAN-31:X ¬SPBV AND VLAN-31:O SPBV:M	5.4.1, 5.4.5, 6.9	Yes [ ] No [ ] N/A [ ]
VLAN-33	Is the VIP-ISID parameter supported?	BEB-I: M	6.10	Yes [ ] N/A [ ]
VLAN-34	Is the default Backbone Destination supported?	BEB-I: M BEBTE: M	6.10	Yes [ ] N/A [ ]
VLAN-35	Is the adminPointToPointMAC supported?	BEB-I: O	6.10	Yes [ ] No [] N/A [ ]
VLAN-36	Is the Backbone-SID field in the Backbone Service Instance table supported?	BEB-B: M	6.11	Yes [ ] N/A [ ]
VLAN-37	Is the B-VID field in the Backbone Service Instance table supported?	BEB-B: O BEBTE: M	6.11	Yes [ ] No [ ] N/A [ ]
VLAN-38	Is the Local-SID field in the Backbone Service Instance table supported?	BEB-B: O	6.11	Yes [ ] No [ ] N/A [ ]
VLAN-39	Is the Default Backbone Destination field in the Backbone Service Instance table supported?	BEB-B: O BEBTE: M	6.11	Yes [ ] No [ ] N/A [ ]
VLAN-40	Is many-to-one S-VID to I-SID mapping supported?	BEB-I: O	5.7.1	Yes [ ] No [ ] N/A [ ]

A.20 Multiple MAC Registration Protocol (MMRP)

Item	Feature	Status	References	Support
	If MMRP is not supported, mark N/A and continue at A.21			N/A [ ]
MMRP1	Does the implementation support the exchange of Multiple MAC Registration Protocol Data Units (MMRPDUs), using the generic MRPDU format defined in 10.8 to exchange MMRP-specific information, as defined in 10.12?	M	5.4.1.3, 10.8, 10.12	Yes [ ]
MMRP2	Is the MMRP Application supported as defined in 10.12?	M	5.4.1.3, 10.12	Yes [ ]
MMRP3	Does the implementation propagate registration information in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 10.3.1?	M	5.4.1.3, 10.3.1	Yes [ ]
MMRP4	Does the implementation forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6?	M	5.4.1.3, 8.13.6	Yes [ ]
MMRP5	Is the MAP Context Identifier used to identify a VLAN Context equal to the VID used to identify the corresponding VLAN?	M	10.12.1.1	Yes [ ]
MMRP6	Is the set of Ports of a Bridge defined to be part of the active topology for a given VLAN Context as specified in 10.12.1.1?	M	10.12.1.1	Yes [ ]
MMRP7	Is the group MAC address used as the destination address for MRPDUs destined for MMRP Participants the group MAC address identified in Table 10-1 as “Customer and Provider Bridge MMRP address”?	M	10.12.1.3	Yes [ ]
MMRP8	Is the EtherType used for MRPDUs destined for MMRP Participants the MMRP EtherType identified in Table 10-2?	M	10.12.1.4, Table 10-2	Yes [ ]
MMRP9	Does the ProtocolVersion used for the implementation of MMRP take the hexadecimal value 0x00?	M	10.12.1.5	Yes [ ]
MMRP10	Are the Attribute Type values used in the implementation as specified in 10.12.1.6?	M	10.12.1.6	Yes [ ]
MMRP11	Does the implementation encode the values in FirstValue fields in accordance with the definition in 10.12.1.7?	M	10.12.1.7	Yes [ ]
MMRP12	Is management of the Restricted_MAC_Address_Registration control parameter supported?	O	10.12.2	Yes [ ] No [ ]
MMRP13	If management of the Restricted_MAC_Address_Registration control parameter is not supported, is the value of this parameter FALSE for all Ports?	¬MMRP12:M	10.12.2	Yes [ ] N/A [ ]

A.20 Multiple MAC Registration Protocol (MMRP) *(continued)*

Item	Feature	Status	References	Support
MMRP14	Does the implementations maintain state information for all attribute values that support the Group service requirement registration?	M	10.10.2	Yes [ ]
MMRP15	Is the implementation capable of supporting any attribute value in the range of possible values that can be registered using Group membership and individual MAC address registration?	M	10.12.4	Yes [ ]
MMRP16	State the number of Group membership and individual MAC address state values that can be supported on each Port.	M	10.12.4	Number_____

A.21 Multiple VLAN Registration Protocol (MVRP)

Item	Feature	Status	References	Support
	If MVRP is not supported, mark N/A and continue at A.22			N/A [ ]
MVRP1	Does the implementation support the exchange of MVRPDUs, using the generic MRPDU format defined in 10.8 to exchange MVRP-specific information, as defined in 11.2?	M	5.4.2, 10.8, 11.2	Yes [ ]
MVRP2	Is the MVRP Application supported as defined in 11.2?	M	5.4.2, 11.2	Yes [ ]
MVRP3	Does the implementation propagate registration information in an MST Bridge, in accordance with the operation of MAP for multiple spanning tree contexts, as specified in 11.2.3.1.2?	MSTP:M	5.4.2, 11.2.3.1.2	Yes [ ] N/A [ ]
MVRP4	Does the implementation propagate registration information in an SST Bridge, in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 10.3.1?	¬MSTP:M	5.4.2, 10.3.1	Yes [ ] N/A [ ]
MVRP5	Does the implementation forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6?	M	5.4.2, 8.13.6	Yes [ ]
MVRP6	If a VID translation table is in use, does the implementation translate VIDs in MVRPDUs as specified in 11.2.4?	VTR:M	11.2.4	Yes [ ]
MVRP7	Is the group MAC address used as the destination address for MRPDUs destined for MVRP Participants as defined in 11.2.3.1.3?	M	11.2.3.1.3	Yes [ ]
MVRP8	Is the EtherType used for MRPDUs destined for MVRP Participants the MVRP EtherType identified in Table 10-2?	M	11.2.3.1.4, Table 10-2	Yes [ ]
MVRP9	Does the ProtocolVersion used for the implementation of MVRP take the hexadecimal value 0x00?	M	11.2.3.1.5	Yes [ ]
MVRP10	Are the Attribute Type values used in the implementation as specified in 11.2.3.1.6?	M	11.2.3.1.6	Yes [ ]

A.21 Multiple VLAN Registration Protocol (MVRP) *(continued)*

Item	Feature	Status	References	Support
MVRP11	Does the implementation encode the values in FirstValue fields in accordance with the definition in 11.2.3.1.7?	M	11.2.3.1.7	Yes [ ]
MVRP12	Is the implementation of MVRP capable of supporting all attribute values in the range of possible values that can be registered using MVRP?	M	11.2.7	Yes [ ]
MVRP13	Is the implementation capable of maintaining current state information for all attributes in the range of possible values?	M	11.2.7	Yes [ ]
MVRP14	Does the Bridge support an MVRP New-Only Participant?	O	11.2.6	Yes [ ] No [ ]
MVRP15	Does the MVRP Participant transmit the Attribute value 0 as specified in 11.2.3.1.7?	MVRP14: M	11.2.3.1.7	Yes [ ]
MVRP16	Does the Bridge interpret the Attribute value 0 in an MVRP message as the PVID for the Port?	M	11.2.3.1.7	Yes [ ]
MVRP17	Does MVRP ignore New messages in MVRPDUs for VLANs not Registration Fixed (New propagated) when configured for New propagated?	MVRP14: M	11.2.6	Yes [ ]

A.22 Multiple Registration Protocol (MRP)

Item	Feature	Status	References	Support
MRP1	Does the implementation of MRP meet all of the requirements for interoperability stated in 10.5 that apply to Bridge operation?	M	10.5	Yes [ ]
MRP2	Does the implementation support the operation of the complete Applicant state machine?	MRP1:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP3	Does the implementation support the operation of the point-to-point subset of the Applicant state machine?	MRP2:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP4	Does the implementation support the operation of the Registrar state machine?	M	10.7, 10.7.8	Yes [ ]
MRP5	Does the implementation support the operation of the LeaveAll state machine?	M	10.7, 10.7.9	Yes [ ]
MRP6	Does the implementation support the operation of the PeriodicTransmission state machine?	M	10.7, 10.7.10	Yes [ ]

A.23 Connectivity Fault Management (CFM)

Item	Feature	Status	References	Support
CFM-1	Does the Bridge support the creation of Maintenance Domains at eight MD Levels, with multiple Maintenance Domains at each MD Level?	BRG AND CFM: M	5.4.1.4 item a)	Yes [ ] N/A [ ]
CFM-2	Does the Bridge support the creation of a Maintenance Association (MA) on each VID supported by the Bridge for each MD Level?	BRG AND CFM: M	5.4.1.4 item b)	Yes [ ] N/A [ ]
CFM-3	Does the Bridge support the creation of a single MIP for each Maintenance Domain on each Port, all MIPs being at the same MD Level?	BRG AND CFM: M	5.4.1.4 item c)	Yes [ ] N/A [ ]
CFM-4	Does the Bridge support the creation of eight Up MEPs on each VID on each Port, each MEP at a different MD Level?	BRG AND CFM: M	5.4.1.4 item d)	Yes [ ] N/A [ ]
CFM-5	Does the Bridge support the creation of eight Down MEPs on each VID on each Port, each MEP at a different MD Level?	BRG AND CFM: M	5.4.1.4 item e)	Yes [ ] N/A [ ]
CFM-6	Does the Bridge support the creation of eight Down MEPs associated with no VID on each Port, each MEP at a different MD Level?	BRG AND CFM: M	5.4.1.4 item f)	Yes [ ] N/A [ ]
CFM-7	Does the Bridge support the maintenance of a MEP CCM Database?	BRG AND CFM: M	5.4.1.4 item g)	Yes [ ] N/A [ ]
CFM-8	Does the Bridge conform to the state machines and procedures in Clause 20?	BRG AND CFM: M	5.4.1.4 item i), Clause 20	Yes [ ] N/A [ ]
CFM-9	Does the Bridge transmit and accept frames in the formats specified in Clause 21?	BRG AND CFM: M	5.4.1.4 item j)	Yes [ ] N/A [ ]
CFM-10	Does the Bridge support the creation of MIPs at different MD Levels on a single Port?	BRG AND CFM: O	5.4.1.4 item k), 22.3	Yes [ ] No [ ] N/A [ ]
CFM-11	Does the Bridge support the creation of MEPs at MD Levels equal to or higher than the MD Levels of MIPs on other VIDs on the same Port?	BRG AND CFM: O	5.4.1.4 item l), 22.3	Yes [ ] No [ ] N/A [ ]
CFM-12	Does the Bridge support the maintenance of a MIP CCM Database in MIPs and MEPs?	BRG AND CFM: O	5.4.1.4 item m), 19.3, 19.2.8	Yes [ ] No [ ] N/A [ ]
CFM-13	Does the Bridge support the creation of MAs that are associated with more than one VID?	BRG AND CFM: O	5.4.1.4 item o)	Yes [ ] No [ ] N/A [ ]
CFM-14	Does the Station support the creation of Maintenance Domains at eight MD Levels, with multiple Maintenance Domains at each MD Level?	¬BRG AND CFM: M	5.4.5 item a), 5.19	Yes [ ] N/A [ ]
CFM-15	Does the Station support the creation of an MA on each VID supported by the Bridge for each MD Level?	¬BRG AND CFM: M	5.4.5 item b), 5.19	Yes [ ] N/A [ ]
CFM-16	Does the Station support the creation of MIPs?	¬BRG AND CFM: X	22.4 item b)	No [ ] N/A [ ]
CFM-17	Does the Station support the creation of Up MEPs?	¬BRG AND CFM: X	22.4 item b)	No [ ] N/A [ ]
CFM-18	Does the Station support the creation of eight Down MEPs on each VID on each Port, each MEP at a different MD Level?	¬BRG AND CFM: M	5.4.5 item c), 5.19	Yes [ ] N/A [ ]

A.23 Connectivity Fault Management (CFM) *(continued)*

Item	Feature	Status	References	Support
CFM-19	Does the Station support the creation of eight Down MEPs associated with no VID on each Port, each MEP at a different MD Level?	¬BRG AND CFM: M	5.4.5 item d), 5.19	Yes [ ] N/A [ ]
CFM-20	Does the Station support the maintenance of a MEP CCM Database?	¬BRG AND CFM: M	5.4.5 item e), 5.19	Yes [ ] N/A [ ]
CFM-21	Does the Station conform to the state machines and procedures in Clause 20?	¬BRG AND CFM: M	5.4.5 item g), 5.19, Clause 20	Yes [ ] N/A [ ]
CFM-22	Does the Station transmit and accept frames in the formats specified in Clause 21?	¬BRG AND CFM: M	5.4.5 item h), 5.19	Yes [ ] N/A [ ]
CFM-23	Does the Station support the creation of MAs that are associated with more than one VID?	¬BRG AND CFM: O	5.4.5 item k), 5.19	Yes [ ] No [ ] N/A [ ]
CFM-24	Does the MP Level Demultiplexer discard frames that are too short to contain an MD Level header field?	CFM: M	19.2.6, 20.51.4.1	Yes [ ] N/A [ ]
CFM-25	Is an LBM always discarded, and not replied to, if its source_address is a Group address?	CFM: M	20.2.2	Yes [ ] N/A [ ]
CFM-26	Are the contents of an LBM, except for the source_address and OpCode, ignored and not interpreted by a non-PBB-TE receiver?	¬CFM-93 AND CFM: M	20.2.2	Yes [ ] N/A [ ]
CFM-27	Is the LTFwhile timer implemented?	CFM:M	20.5, 20.5.1	Yes [ ] N/A [ ]
CFM-28	Are the per-MEP timers CCIwhile, errorCCMwhile, xconCCMwhile, LBIwhile, and FNGwhile implemented?	CFM:M	20.5, 20.5.2, 20.5.3, 20.5.4, 20.5.5, 20.5.6	Yes [ ] N/A [ ]
CFM-29	Is the per-MEP per-remote MEP timer rMEPwhile implemented?	CFM:M	20.5, 20.5.10	Yes [ ] N/A [ ]
CFM-30	Can a MEP set rMEPCCMdefect within (3.25 × CCMtime(CCMinterval)) seconds of the receipt of a CCM?	X	20.5.10	No [ ]
CFM-31	Can a MEP take longer to set rMEPCCMdefect than (3.5 × CCMtime(CCMinterval)) seconds of the receipt of the last CCM?	CFM: X	20.5.10	No [ ] N/A [ ]
CFM-32	Does the system transmit a nonzero value for the CCM Interval in CCMs?	CFM: M	20.8.1, 20.11.1 item g)	Yes [ ] N/A [ ]
CFM-33	Does the Bridge transmit all CFM PDU fixed header fields in conformance with this standard?	CFM: M	20.51.2	Yes [ ] N/A [ ]
CFM-34	Does the Bridge transmit all reserved bits and fields in CFM PDUs as 0?	CFM: M	20.51.2	Yes [ ] N/A [ ]
CFM-35	Does the Bridge transmit additional fixed header fields not defined in this standard in CFM PDUs?	X	20.51.2	No [ ]
CFM-36	Does the Bridge transmit code points in any field that are reserved, either by this standard or by ITU-T G.8013/Y.1731?	X	20.51.2	No [ ]
CFM-37	Does the Bridge transmit additional fields in any CFM PDU in any TLV defined by this standard?	X	20.51.2	No [ ]

A.23 Connectivity Fault Management (CFM) *(continued)*

Item	Feature	Status	References	Support
CFM-38	Does the Bridge determine the validity of those CFM PDUs that are validated, in a manner indistinguishable, by external observation of the Bridge, from the procedures described in this standard?	CFM: M	20.51.3	Yes [ ] N/A [ ]
CFM-39	Is the version by which each PDU is processed selected correctly, and are the prohibited validation criteria not applied, by the System?	CFM: M	20.17.1, 20.17.2, 20.28.1, 20.33.1, 20.51.4.2	Yes [ ] N/A [ ]
CFM-40	Does the System determine the validity of a CFM PDU in the manner defined by this standard?	CFM: M	20.17.1, 20.17.2, 20.28.1, 20.33.1, 20.51.4.1, 20.51.4.3	Yes [ ] N/A [ ]
CFM-41	Are all CFM PDUs transmitted with an integral number of octets?	CFM: M	21.1	Yes [ ] N/A [ ]
CFM-42	Does the Bridge transmit Organization-Specific TLVs?	CFM: O	20.51.2, 21.5.2	Yes [ ] No [ ]
CFM-43	Does the Bridge transmit an Organization-Specific TLV that requires it or the receiver to violate any requirement of this standard?	X	21.5.2	No [ ]
CFM-44	Is the information transmitted in an Organization-Specific TLV independent from information in a TLV received from any other port?	CFM-42: M	21.5.2	Yes [ ] N/A [ ]
CFM-45	Do Organization-Specific TLV(s) transmitted by the Bridge provide a means for sending messages that are larger than would fit within a single CFM PDU?	X	21.5.2	No [ ]
CFM-46	Do the Organization-Specific TLV(s) transmitted by the Bridge conform to the validation and versioning rules of 20.51?	CFM-42: M	21.5.2	Yes [ ] N/A [ ]
CFM-47	Does the Management Address Domain field in the Sender ID TLV(s) transmitted by the Bridge (if any) conform to section 8.19 of ITU-T X.690 (2002)?	CFM: M	21.5.3.5	Yes [ ] N/A [ ]
CFM-48	Can a MEP in a multiple spanning tree environment not statically restricted to a single MSTI generate a Port Status TLV?	X	21.5.4	No [ ]
CFM-49	Does the Bridge, in any case except when receiving an LBR, interpret the contents of the Data TLV?	X	21.5.6	No [ ]
CFM-50	Can the Bridge transmit the Data TLV in an LBM?	CFM: O	21.5.6	Yes [ ] No [ ] N/A [ ]
CFM-51	Is the Bridge able to receive and process all valid CCM PDUs that are 128 octets or less in length (from MD Level through End TLV)?	CFM: M	21.6	Yes [ ] N/A [ ]
CFM-52	Does the Bridge discard, as invalid, CCM PDUs that exceed 128 octets in length?	CFM: O	21.6	Yes [ ] No [ ] N/A [ ]
CFM-53	Can the Bridge transmit a CCM PDU that is longer than 128 octets in length?	X	21.6	No [ ]

A.23 Connectivity Fault Management (CFM) *(continued)*

Item	Feature	Status	References	Support
CFM-54	Is the length of the Maintenance Association Identifier (MAID) transmitted in a CCM exactly 48 octets?	CFM: M	21.6.5	Yes [ ] N/A [ ]
CFM-55	Is the field Defined by ITU-T G.8013/Y.1731 always transmitted as 0?	CFM: M	21.6.6	Yes [ ] N/A [ ]
CFM-56	Does the First TLV Offset field contain the value as specified for the OpCode for each CFM message transmitted?	CFM: M	21.4.5, 21.6.2, 21.7.2, 21.8.2, 21.9.2	Yes [ ] N/A [ ]
CFM-57	Does every transmitted LTM contain an LTM Egress Identifier TLV?	CFM: M	21.8.7	Yes [ ] N/A [ ]
CFM-58	Does every transmitted LTR contain an LTR Egress Identifier TLV?	CFM: M	21.9.6	Yes [ ] N/A [ ]
CFM-59	Does the receiving Bridge behave differently if the order of TLVs in a CFM PDU, other than the End TLV, or TLVs in an LBR, is altered?	X	21.6.7, 21.9.6	No [ ]
CFM-60	Does the Bridge support the creation of MPs at one or more MD Level on every Port?	CFM: M	22.3	Yes [ ] N/A [ ]
CFM-61	Is every Down MEP on a Bridge Port assigned a MAC address different than any Down MEP on any other Bridge Port?	CFM: M	19.4	Yes [ ] N/A [ ]
CFM-62	Does the Provider Edge Bridge support the creation of a Down MEP on the interface corresponding to a CEP?	PEB AND BRG AND CFM: M	22.6.1	Yes [ ] N/A [ ]
CFM-63	Does the Provider Edge Bridge support the creation of a Down MEP on the interface corresponding to a RCAP?	RCSI AND BRG AND CFM: M	22.6.4	Yes [ ] No [ ]
CFM-64	Does the Provider Edge Bridge support the creation of a Down MEP on the interface corresponding to a CEP connected to a Provider Access Port (PAP)?	RCSI AND BRG AND CFM: M	22.6.4	Yes [ ] No [ ]
CFM-65	If the MIP CCM Database has insufficient resources to record a new entry, does it preferentially remove the oldest entry to make room for the new one?	BRG AND CFM-12: O	20.1.3	Yes [ ] No [ ] N/A [ ]
CFM-66	Does the Bridge transmit successive integer values in the Sequence Number field of a CCM?	CFM: O	20.1, 20.11.1 item i)	Yes [ ] No [ ] N/A [ ]
CFM-67	Does the Bridge transmit neither successive integer values nor 0 in the Sequence Number field of a CCM?	X	20.1, 20.11.1	No [ ]
CFM-68	Does the Bridge keep track of received CCMs' Sequence Number fields in the MEP CCM Database, and count out-of-sequence CCMs in CCMsequenceErrors?	CFM: O	20.1, 20.17.1	Yes [ ] N/A [ ] N/A [ ]
CFM-69	Does the Bridge check the validity of every received LTM, and LTR?	CFM: M	20.33.1, 20.44.1, 20.47.1	Yes [ ] N/A [ ]
CFM-70	Does the Bridge check the validity of every received CCM?	CFM: O	20.17.1, 20.17.2	Yes [ ] No [ ] N/A [ ]
CFM-71	Does the Bridge check the validity of every received LBM?	CFM: O	20.2.2, 20.28.1	Yes [ ] No [ ] N/A [ ]

A.23 Connectivity Fault Management (CFM) *(continued)*

Item	Feature	Status	References	Support
CFM-72	Does the Bridge check the validity of every received LBR?	CFM: O	20.2.2, 20.33.1	Yes [ ] No [ ] N/A [ ]
CFM-73	Does the Bridge compare the received LBR bit-by-bit against the original LBM?	CFM: O	20.2.3, 20.33.1	Yes [ ] No [ ] N/A [ ]
CFM-74	Can the Bridge transmit LBMs at a rate fast enough to overflow output queues in the absence of other data traffic?	X	20.2.1	No [ ]
CFM-75	Can a high rate of incoming CFM PDUs increase the probability that the Bridge fails to protect the network against forwarding loops?	BRG: X	20.51.5	No [ ] N/A [ ]
CFM-76	Are the Optional CCM TLVs included in every CCM?	CFM: O	21.6.7	Yes [ ] No [ ] N/A [ ]
CFM-77	Are Organization-Specific TLVs included in CCMs?	CFM: O	21.6.7	Yes [ ] No [ ] N/A [ ]
CFM-78	Is the Sender ID TLV included in every LBM?	CFM:O	21.5.3, 21.7.4	Yes [ ] N/A [ ] N/A [ ]
CFM-79	Is the Management Address included in the Sender ID TLV?	CFM-78: O	21.5.3	Yes [ ] No [ ] N/A [ ]
CFM-80	Are Organization-Specific TLVs included in LBMs?	CFM: O	21.7.4	Yes [ ] No [ ] N/A [ ]
CFM-81	Does the Station discard, and not process, all CFM PDUs not discarded or processed by its MEPs?	¬BRG AND CFM: M	22.4 item c)	Yes [ ] N/A [ ]
CFM-82	Does the Station create entries in the Configuration Error List managed object other than CFMleak errors?	X	22.4 item d), 12.14.4	No [ ]
CFM-83	Can CFM monitor backbone service instances using Backbone Service Instance Multiplex Entities placed back-to-back?	BEB: O	5.7.1, 5.8.1	Yes [ ] No [ ] N/A [ ]
CFM-84	Does the Bridge support the creation of an MA on each TESI supported by the Bridge for each MD Level?	BEBTE: M	5.8.2, 26.9	Yes [ ] N/A [ ]
CFM-85	Does the Bridge support the creation of an Up MEP on each TESI on each CBP?	BEBTE: M	5.8.2, 6.19, 26.9.3	Yes [ ] N/A [ ]
CFM-86	Does the Bridge support the creation of eight Up MEPs on each TESI on each CBP, each MEP at a different MD Level?	BEBTE: O	5.8.2	Yes [ ] No [ ] N/A [ ]
CFM-87	Does the Bridge support the creation of MIPs on TESIs?	PBBTE: O	5.6.2, 5.8.2	Yes [ ] No [ ] N/A [ ]
CFM-88	Is the PBB-TE MIP TLV included in every LBM that is targeting a PBB-TE MIP?	BEBTE: M	20.2, 21.7.5	Yes [ ] N/A [ ]
CFM-89	Is the PBB-TE MIP TLV included in every LTM that is associated with a PBB-TE MA?	BEBTE: M	20.3, 21.7.5	Yes [ ] N/A [ ]
CFM-90	Is the PBB-TE MIP TLV included in LBMs that are targeting a PBB-TE MEP?	BEBTE: X	20.2, 21.7.5	No [ ] N/A [ ]
CFM-91	Is the PBB-TE MIP TLV the first TLV in an LBM targeting a PBB-TE MIP?	CFM-88: M	20.2, 21.7.5	Yes [ ] N/A [ ]

A.23 Connectivity Fault Management (CFM) *(continued)*

Item	Feature	Status	References	Support
CFM-92	Is the Reverse MAC field included in the PBB-TE MIP TLVs required by LBMs/LTMs that are associated with Point-to- Multipoint PBB-TE MAs?	CFM-88 OR CFM-89: M	20.2, 20.3, 21.7.5	Yes [ ] N/A [ ]
CFM-93	Does the PBB-TE MEP check the MAID in received CCMs?	BEBTE: O	20.1.3, 20.17.1	Yes [ ] No [ ] N/A [ ]
CFM-94	Does the PBB-TE MEP set the Traffic field bit in the transmitted CCMs and process it in the received CCMs	PS-5: M	20.11.1, 20.17.1, 21.6.1.4	Yes [ ] N/A [ ]
CFM-95	Does the Bridge keep track of the Traffic field bit in received CCMs?	PS-5: M	20.16.3, 20.17.1, 21.6.1.4	Yes [ ] N/A [ ]
CFM-96	Are the per-PBB MEP timers mmCCMwhile, mmLocwhile, and mmFNGwhile implemented?	PS-5: M	20.5.7	Yes [ ] N/A [ ]
CFM-97	Are the per-PBB MEP mismatch defect related, MEP Traffic Field Mismatch state machine, MEP Local Mismatch state machine and MEP Mismatch Fault Notification Generator state machine implemented?	PS-5: M	20.24, 20.40	Yes [ ] N/A [ ]
CFM-98	Are SPBM VID MAs supported?	SPBM:O	27.18, Clause 20	Yes [ ] No [ ] N/A [ ]
CFM-99	Are SPBM group MAs supported?	SPBM:O	27.18, Clause 20	Yes [ ] No [ ] N/A [ ]
CFM-100	Are SPBM path MAs supported?	SPBM:O	27.18, Clause 20	Yes [ ] No [ ] N/A [ ]
CFM-101	Are ECMP path MAs supported?	FF:O	44.2.5, Clause 20	Yes [ ] No [ ] N/A [ ]

A.24 Management Information Base (MIB)

Item	Feature	Status	References	Support
	If item MIB is not supported, mark N/A.			N/A [ ]
MIB-1	Is the IEEE8021-TC-MIB module supported?	MIB:M	17.7.1	Yes [ ] No [ ]
MIB-2	Is the IEEE8021-BRIDGE-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB:M	17.7.2	Yes [ ] No [ ]
MIB-3	Is the IEEE8021-SPANNING-TREE-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB:O	17.7.3	Yes [ ] No [ ]
MIB-5	Is the IEEE8021-Q-BRIDGE-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB:M	17.7.4	Yes [ ] No [ ]
MIB-6	Is the IEEE8021-PB-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND PB:O	17.7.5	Yes [ ] No [ ]
MIB-7	Is the IEEE8021-MST-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND MSTP:O	17.7.6	Yes [ ] No [ ] N/A [ ]
MIB-8	Is the IEEE8021-CFM-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND CFM:O	17.7.7	Yes [ ] No [ ]

A.24 Management Information Base (MIB) *(continued)*

Item	Feature	Status	References	Support
	What method is used by the Bridge to provide control of all of the required CFM managed objects?			
MIB-9	The CFM MIB module defined in 17.7.7?	CFM: O.3	5.4.1.4 item n), 17.3.7, 17.7.7	Yes [ ] No [ ] N/A [ ]
MIB-10	Some other method than the MIB module defined in 17.7.7?	CFM: O.3	17.3.7	Yes [ ] No [ ] N/A [ ]
MIB-11	If by some other method, what method is used?	MIB-10: M	17.3.7	_____
MIB-12	Does the Station provide control of all of the required CFM managed objects?	¬BRG AND CFM: M	5.4.5 item f), 12.14	Yes [ ] No [ ] N/A [ ]
	What method is used by the Station to provide control of all of the required CFM managed objects?			
MIB-13	The CFM MIB module defined in 17.7.7?	¬BRG AND CFM: O.4	5.4.5 item i), 17.3.7, 17.7.7	Yes [ ] No [ ] N/A [ ]
MIB-14	Some other method than the MIB module defined in 17.7.7?	¬BRG AND CFM: O.4	17.3.7	Yes [ ] No [ ] N/A [ ]
MIB-15	If by some other method, what method is used?	MIB-14: M	17.3.7	_____
MIB-16	Is an entire C-tagged service interface given a single row in the IETF RFC 2863 IF-MIB?	PEB AND CFM: O	17.3.7	Yes [ ] No [ ] N/A [ ]
MIB-17	Is every Bridge Port assigned its own conceptual row in the IETF RFC 2863 IF-MIB with its own unique ifIndex?	MIB-13: M	17.3.7	Yes [ ] N/A [ ]
MIB-18	Does the Bridge support IEEE 802.1AX Link Aggregation?	CFM: O	17.3.7, IEEE Std 802.1AX	Yes [ ] No [ ] N/A [ ]
MIB-19	Does every IEEE 802.3 MAC, when aggregated via IEEE 802.1AX Link Aggregation, have its own unique ifIndex, separate from the ifIndex of the Bridge Port as a whole?	MIB-18: M	17.3.7	Yes [ ] N/A [ ]
MIB-20	Is the IEEE8021-PBB-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND BEB:O	17.7.8	Yes [ ] No [ ] N/A [ ]
MIB-21	Is the IEEE8021-DDCFM-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND DDCFM:O	17.7.9	Yes [ ] No [ ] N/A [ ]
MIB-22	Is the IEEE8021-PBBTE-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND PBBTE: O	17.7.10	Yes [ ] No [ ] N/A [ ]
MIB-23	Is the IEEE8021-TPMR-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND TPMR:O	17.7.11	Yes [ ] No [ ] N/A [ ]
MIB-24	Is the IEEE8021-FQTSS-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND FQTSS: O	5.4.1.5 item e), 12.20, 17.7.12, Clause 34	Yes [ ] No [ ] N/A [ ]
MIB-25	Does the system implement the IEEE8021-CN-MIB?	MIB AND CN: O	5.4.3 item j), 5.21 item n)	Yes [ ] No [ ] N/A [ ]
MIB-26	Does the system implement the System Group and Interfaces Group of the SNMPv2-MIB?	MIB-25: M	17.3.7.1	Yes [ ]

A.24 Management Information Base (MIB) *(continued)*

Item	Feature	Status	References	Support
MIB-27	Does the system implement the clarifications of the Interfaces group supplied in the descriptions of ieee8021CnEpIfIndex, ieee8021CnPortPriIfIndex, ieee8021CnCpIfIndex, and ieee8021CnCpidToIfIfIndex?	MIB-25: M	17.3.7.1, 17.7.13	Yes [ ] N/A [ ]
MIB-28	Does the system assign the same conceptual row in the IF-MIB to both an aggregated port and to one of the ports being aggregated?	MIB-25: M	17.3.7.1	No [ ] N/A [ ]
MIB-29	Does the system assign a conceptual row in the IF-MIB to the individual aggregated?	MIB-25: O	17.3.7.1	Yes [ ] No [ ] N/A [ ]
MIB-30	Does the system allow more than seven rows to be created in the ieee8021CnCompntPriTable?	MIB-25: M	17.7.13	No [ ] N/A [ ]
MIB-31	Is the minimum value for ieee8021CnRpgMaxRate supported by the system at least equal to the required value?	MIB-25: M	17.7.13, 32.11.5	Yes [ ] N/A [ ]
MIB-32	Is the minimum value for ieee8021CnRpgMinRate supported by the system at least equal to the required value?	MIB-25: M	17.7.13, 32.11.10	Yes [ ] N/A [ ]
MIB-33	Is the IEEE8021-SRP-MIB module fully supported (per its MODULE-COMPLIANCE)?	SRP: O	17.2, 35	Yes [ ] No [ ] N/A [ ]
MIB-34	Is the IEEE8021-MVRPX-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIRP AND MIB: M	17.7.15	Yes [ ] N/A [ ]
MIB-35	Is the IEEE8021-MIRP-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIRP AND MIB: M	17.7.16	Yes [ ] No [ ] N/A [ ]
MIB-36	Is the IEEE8021-PFC-MIB module fully supported (per its MODULE-COMPLIANCE)?	PFC AND MIB: O	17.7.17	Yes [ ] No [ ] N/A [ ]
MIB-37	Is the IEEE8021-TEIPS-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB: O	17.7.10	Yes [ ] No [ ] N/A [ ]
MIB-38	Is the IEEE8021-SPB-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND SPB:O	5.4.5, 17.7.19	Yes [ ] No [ ] N/A [ ]
MIB-39	Are the IEEE8021-ECMP-MIB module objects ieee8021EcmpEctStaticTable and ieee8021EcmpTopSrvTable supported?	MIB AND ECMP:O	5.4.5.1, 17.7.10	Yes [ ] No [ ] N/A [ ]
MIB-40	Is the IEEE8021-ECMP-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND FF:O	5.4.5.2, 17.7.21	Yes [ ] No [ ] N/A [ ]
MIB-41	Are PCR objects in the IEEE8021-SPB-MIB supported per ieee8021PcrCompliance ?	MIB AND PCR:O	5.5, 17.7.19	Yes [ ] No [ ] N/A [ ]
MIB-42	Is the IEEE8021-ST-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND (SCHED OR CQF): O	5.4.1 item ad), 5.4.1.9 item c), 5.13.1.2 item c), 12.29, 17.7.22	Yes [ ] No [ ] N/A [ ]
MIB-43	Is the IEEE8021-Preemption-MIB module fully supported (per its MODULE-COMPLIANCE)?	PRE: O	5.4.1 item ae), 12.30, 17.7.23	Yes [ ] No [ ] N/A [ ]
MIB-44	Is the IEEE8021-PSFP-MIB module fully supported (per its MODULE-COMPLIANCE)?	PSFP OR CQF: O	5.4.1.9 item e), 5.13.1.2 item e), 8.6.5.2, 8.6.10, 12.31, 17.7.24	Yes [ ] No [ ] N/A [ ]

A.25 Protection Switching (PS)

Item	Feature	Status	References	Support
	If item PS is not supported, mark N/A and continue at the subsequent subclause.			N/A [ ]
PS-1	Is 1:1 protection switching supported?	PS: M	5.8.2, 26.10.3	Yes [ ]
PS-2	Are the operator commands Forced Switch (FS), Lockout of Protection (LoP), Manual Switch to Working, and Manual Switch to Protection implemented?	PS-1: M	26.10.3.3	Yes [ ]
PS-3	Is the hold-off timer implemented?	PS-1: O	26.10.3.2.2	Yes [ ] No [ ]
PS-4	Is protection switching with load sharing supported?	PS: O	5.8.2, 12.14.1.2	Yes [ ] No [ ]
PS-5	Is the detection of mismatch defects supported?	PS: O	26.12	Yes [ ] No [ ]

A.26 Data-driven and data-dependent connectivity fault management (DDCFM)

Item	Feature	Status	References	Support
DDCFM-1	Does the Bridge support the Reflection Responder (RR) function?	DDCFM:M	29.2.2	Yes [ ] N/A [ ]
DDCFM-2	Does the Bridge support the RFM Receiver function?	DDCFM:M	29.2.4	Yes [ ] N/A [ ]
DDCFM-3	Does the Bridge support the Decapsulator Responder (DR) function?	DDCFM:M	29.2.6	Yes [ ] N/A [ ]
DDCFM-4	Does the Bridge support the SFM Originator function?	DDCFM:M	29.2.7	Yes [ ] N/A [ ]

A.27 Two-Port MAC Relay (TPMR)

Item	Feature	Status	References	Support
	If TPMR is not supported, mark N/A and continue at A.28.			N/A [ ]
TPMR-1	Does the TPMR comprise a single TPMR component?	TPMR:M	5.15	Yes [ ]
TPMR-2	Is each TPMR Port capable of attaching directly to an IEEE 802 LAN?	TPMR:M	5.16	Yes [ ]
TPMR-3	Does the implementation support exactly two externally-accessible Bridge Ports?	TPMR:M	5.15	Yes [ ]
TPMR-4	Does the implementation support the operation of the Bridge Port Transmit and Receive process, using the TPMR Port connectivity rules?	TPMR:M	5.15, 8.5, 8.5.2	Yes [ ]
TPMR-5	Does the Forwarding Process support frame filtering, queuing frames, queue management, and transmission selection?	TPMR:M	5.15, 8.6.3, 8.6.6, 8.6.7, 8.6.8	Yes [ ]
TPMR-6	Does the implementation support at least one traffic class on each externally accessible Port?	TPMR:M	5.15	Yes [ ]

A.27 Two-Port MAC Relay (TPMR) *(continued)*

Item	Feature	Status	References	Support
TPMR-7	Does the implementation support the management functionality specified in 12.19?	TPMR:M	12.19	Yes [ ]
TPMR-8	Does the implementation support remote management via one of the externally accessible Ports?	TPMR:M	5.15, 8.13.7	Yes [ ]
TPMR-9	Does the implementation support Static Filtering Entries in accordance with the requirements stated in 5.15:f?	TPMR:M	5.15, 8.13.7, Table 8-3	Yes [ ]
TPMR-10	Does the implementation support multiple traffic classes on each externally accessible Port?	TPMR:O	5.15	Yes [ ] No [ ]
TPMR-11	Does the implementation support remote management via one or both of the externally accessible Ports, using IETF RFC 4789, and the TPMR MIB module?	TPMR:O	5.15, IETF RFC 4789, 8.13.7, 17.7.11	Yes [ ] No [ ]
TPMR-12	Does the implementation support signaled priority?	TPMR: O	6.20	Yes [ ] No [ ]

A.28 MAC Status Protocol (MSP)

Item	Feature	Status	References	Support
	If MSP is not supported, mark N/A.			N/A [ ]
MSP-1	Does the implementation support the operation of the Status Transmission state machine (STM)?	MSP:M	23.8	Yes [ ]
MSP-2	Does the implementation support the operation of the Status Notification state machine (SNM)?	MSP:M	23.9	Yes [ ]
MSP-3	Does the Receive Process receive and validate MSPDUs as specified?	MSP:M	23.10, 23.16	Yes [ ]
MSP-4	Does the Transmit Process identify, address, structure, encode, and transmit MSPDUs as specified?	MSP:M	23.11, 23.13, 23.14, 23.15	Yes [ ]
MSP-5	Does the implementation allow performance parameters to be read by management?	MSP:O	23.12	Yes [ ] No [ ]
MSP-6	Does the implementation allow performance parameters to be modified by management?	MSP:O	23.12	Yes [ ] No [ ]
MSP-7	Does the implementation maintain the specified counts for at least one Port of the TPMR?	MSP:O	23.12	Yes [ ] No [ ]
MSP-8	Does the implementation maintain the specified counts for both ports of the TPMR?	MSP:O	23.12	Yes [ ] No [ ]

A.29 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)

Item	Feature	Status	References	Support
	If forwarding and queuing for time-sensitive streams (FQTSS in A.6) is not supported, mark N/A and ignore the remainder of this table.		5.4.1.5, Clause 34	N/A [ ]
FQTSSE1	Support a minimum of two traffic classes, of which one supports the strict priority algorithm and the other is an SR class.	FQTSS:M	5.4.1.5, 8.6.8.1, Clause 34	Yes [ ] N/A [ ]
FQTSSE2	Support the operation of the credit-based shaper algorithm on all Ports as the transmission selection algorithm used for the SR class.	FQTSS:M	5.4.1.5, 8.6.8.2, Clause 34	Yes [ ] N/A [ ]
FQTSSE3	Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class “B.”	FQTSS:M	5.4.1.5, 6.9.4, Table 6-5, Clause 34	Yes [ ] N/A [ ]
FQTSSE4	Support the tables and procedures for mapping priorities to traffic classes as defined in 34.5.	FQTSS:M	5.4.1.5, Clause 34, 34.5	Yes [ ] N/A [ ]
FQTSSE5	Support two or more SR classes (a maximum of seven), and support the operation of the credit-based shaper algorithm on all Ports as the transmission selection algorithm used for those SR classes. The number of SR classes supported shall be stated in the PICS.	FQTSS:O	5.4.1.5, 8.6.8.2, 34.6	Yes [ ] No [ ] Number____
FQTSSE6	Support SRP domain boundary port priority regeneration override as defined in 6.9.4, and the default priority regeneration override value defined in Table 6-5, for SR class “A.” If more than two SR classes are supported, the default priority regeneration override values used for the additional SR classes shall be stated in the PICS.	FQTSS:O	5.4.1.5, 6.9.4, Table 6-5, 34.6	Yes [ ] No [ ] Priority override values_____

A.30 Congestion notification

Item	Feature	Status	References	Support
CN-1	Does the system conform to the required provisions of IEEE Std 802.1AB?	CN: M	5.4.3 item e), 5.21 item f)	Yes [ ] N/A [ ]
CN-2	Does the system support the use of the Congestion Notification TLV in LLDP?	CN: M	5.4.3 item f), 5.21 item g)	Yes [ ] N/A [ ]
CN-3	Does the system transmit more than one Congestion Notification TLV in a single LLDPDU?	CN: M	D.2.7	No [ ] N/A [ ]
CN-4	Does the system transmit a Congestion Notification TLV with 0 in all of the Per-priority CNPV indicators?	CN: M	D.2.7	No [ ] N/A [ ]
CN-5	Does the system implement the Congestion Notification Domain (CND) defense variables, procedures, and state machine?	CN: M	32.4, 32.5, 32.6	Yes [ ] N/A [ ]
CN-6	Does the Bridge support the creation of at least one CP on at least one Port?	BRG1 AND CN: M	5.4.3 item a)	Yes [ ] N/A [ ]

A.30 Congestion notification *(continued)*

Item	Feature	Status	References	Support
CN-7	Does the Bridge support the creation of more than one CP on at least one Port?	BRG1 AND CN: O	5.4.3 item i)	Yes [ ] No [ ] N/A [ ]
CN-8	Does the Bridge support the creation of more than seven CPs on any Port?	BRG1 AND CN: M	5.4.3 item i)	No [ ] N/A [ ]
CN-9	Does every CP on the Bridge support all four defense modes separately on each CNPV?	BRG1 AND CN: M	5.4.3 item d), 31.1.1, 32.2.1	Yes [ ] N/A [ ]
CN-10	Is each CP on the Bridge able to remove CN-TAGs?	BRG1 AND CN: M	5.4.3 item b)	Yes [ ] N/A [ ]
CN-11	Does the PIP perform CNM translation on the return path?	BEB-I AND CN:M	5.4.3 item g)	Yes [ ] N/A [ ]
CN-12	Does the Provider Edge Port (PEP) perform CNM translation on the return path?	PEB AND CN:M	5.4.3 item h)	Yes [ ] N/A [ ]
CN-13	Is each CP on the system able to generate CNMs?	BRG1 AND CN: M	5.4.3 item b)	Yes [ ] N/A [ ]
CN-14	Does the Bridge override the priority of a frame entering a port on a CNPV when in mode cptEdge?	BRG1 AND CN: M	32.2.1	Yes [ ] N/A [ ]
CN-15	Does the Bridge allow any other priority to be remapped to a CNPV when in any mode other than cptDisabled?	BRG1 AND CN: M	32.2.1	No [ ] N/A [ ]
CN-16	Do the system's CPs implement the specified variables and procedures?	BRG1 AND CN: M	32.7 item a), 32.8, 32.9	Yes [ ] N/A [ ]
CN-17	Is the CP's Random() function initialized to a different value each time the system is reset?	BRG1 AND CN: M	32.9.1	Yes [ ] N/A [ ]
CN-18	Does a system's CP interpret a CN-TAG to any degree beyond simply copying it to the CNM?	BRG1 AND CN: M	33.2.1	No [ ] N/A [ ]
CN-19	Does the CP transmit a 0 in the CNM's Version field?	BRG1 AND CN: M	33.4.1	Yes [ ] N/A [ ]
CN-20	Does the CP transmit a 0 in the CNM's ReservedV field?	BRG1 AND CN: M	33.4.2	Yes [ ] N/A [ ]

A.31 Stream Reservation Protocol (SRP)

Item	Feature	Status	References	Support
	If SRP (in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
SRP-1	Does the implementation support the exchange of Multiple Stream Registration Protocol Data Units (MSRPDUs), using the generic Multiple Registration Protocol Data Unit (MRPDU) format defined in 10.8 to exchange MSRP-specific information, as defined in 35.2.2.8.1, 35.2.2.9.1, and 35.2.2.10.1?	M	10.8, 35.2.2.8.1, 35.2.2.9.1, 35.2.2.10.1	Yes [ ]

A.31 Stream Reservation Protocol (SRP) *(continued)*

Item	Feature	Status	References	Support
SRP-2	Is the MSRP Application supported as defined in Clause 35?	M	Clause 35	Yes [ ]
SRP-3	Does the implementation propagate registration information in accordance with the operation of MAP for the Base Spanning Tree Context, as specified in 35.2.4?	M	35.2.4	Yes [ ]
SRP-4	Does the implementation forward, filter, or discard MAC frames carrying any MRP Application address as the destination MAC address in accordance with the requirements of 8.13.6?	M	8.13.6	Yes [ ]
SRP-5	Is the group MAC address used as the destination address for MRPDUs destined for MSRP Participants the group MAC address identified in Table 8-1, Table 8-2, and Table 8-3 as “Individual LAN Scope group address, Nearest Bridge group address”?	M	35.2.2.1, Table 8-1, Table 8-2, Table 8-3	Yes [ ]
SRP-6	Is the EtherType used for MRPDUs destined for MSRP Participants the MSRP EtherType identified in Table 10-2?	M	35.2.2.2, Table 10-2	Yes [ ]
SRP-7	Does the ProtocolVersion used for the implementation of MSRP take the hexadecimal value 0x01?	M	35.2.2.3	Yes [ ]
SRP-8	Are the Attribute Type values used in the implementation as specified in 35.2.2.4 and Table 35-1?	M	35.2.2.4, Table 35-1	Yes [ ]
SRP-9	Are the Attribute Length values used in the implementation as specified in 35.2.2.5 and Table 35-2?	M	35.2.2.5, Table 35-2	Yes [ ]
SRP-10	Are the MSRP Vector FourPackedEvents values used in the implementation as specified in 35.2.2.7.2 and Table 35-3?	M	35.2.2.7.2, Table 35-3	Yes [ ]
SRP-11	Does the implementation encode the values in FirstValue fields in accordance with the definition in 35.2.2.8, 35.2.2.9, and 35.2.2.10?	M	35.2.2.8, 35.2.2.9, 35.2.2.10	Yes [ ]
SRP-12	Does the implementation update Accumulated Latency as the Talker attributes propagate through the Bridge?	M	35.2.2.8.6, 35.2.2.10.10	Yes [ ]
SRP-13	Does the implementation update failure information in the event of insufficient bandwidth or resources through a Bridge?	M	35.2.2.8.7, 35.2.2.10.9, 35.2.2.10.12	Yes [ ]

A.31 Stream Reservation Protocol (SRP) *(continued)*

Item	Feature	Status	References	Support
SRP-14	Does the implementation propagate a Talker Advertise as a Talker Failed in the event of insufficient bandwidth or resources through a Bridge?	M	35.2.4.3, Table 35-9	Yes [ ]
SRP-15	Is talkerPruning and MMRP supported?	O	35.2.4.3.2	Yes [ ] No [ ]
SRP-16	Are Listener attributes merged and propagated as described in 35.2.4.4?	M	35.2.4.4, Table 35-12, Table 35-15	Yes [ ]
SRP-17	Does the implementation support updates to the Dynamic Reservation Entries as described in 35.2.4.4.2?	M	8.8 item k), 35.2.4.4.2, Table 35-13	Yes [ ]
SRP-18	Does the implementation support updates to operIdleSlope as defined in 35.2.4.4.2?	M	35.2.4.4.2, Table 35-14	Yes [ ]
SRP-19	Does the implementation support the automatic modifications to stream reservations as described in 35.2.6?	M	35.2.6	Yes [ ] No [ ]
SRP-20	Are MSRPDUs transmitted on all ports?	M	35.2	Yes [ ]
SRP-21	State the number of Talker registrations values that can be supported on each Port.	M	35.2.7	Number _____
SRP-22	State the number of Listener registrations values that can be supported on each Port.	M	35.2.7	Number _____
SRP-23	Can the SR_PVID for any Port be assigned the value of the null VID or VID FFF (hexadecimal)?	X	35.2.1.4 item i), Table 9-2	No [ ]
SRP-24	Does the device support changing the SR_PVID value from the default value shown in Table 9-2?	O	35.2.1.4 item i), Table 9-2	Yes [ ] No [ ]
SRP-25	Does the implementation support both original and enhanced attribute types?	M	35.1	Yes [ ]
SRP-26	Does the implementation detect domain boundaries?	M	35.2.4.3	Yes [ ]
SRP-27	Does the implementation support Stream transformation in Bridge?	O	35.2.2.10.5	Yes [ ] No [ ]
SRP-28	Does the implementation support protocol version translation for Talker attributes?	M	35.2.4.3.1	Yes [ ]
SRP-29	Does the implementation support protocol version translation for Listener attributes?	M	35.2.4.4.4	Yes [ ]
SRP-30	Does the implementation declare the Domain attribute prior to Talker/Listener attributes?	M	35.2.2.9	Yes [ ]
SRP-31	Is talker pruning per Port supported?	O	35.2.4.3.3	Yes [ ] No [ ]

A.31 Stream Reservation Protocol (SRP) *(continued)*

Item	Feature	Status	References	Support
SRP-32	Is talker VLAN pruning supported?	O	35.2.4.3.4	Yes [ ] No [ ]
SRPMDCSN	Does this device support media-dependent Coordinated Shared Networking (CSN) functionality on one or more ports?	SRPMDMOCA:M OR: SRPMDDOT11:M	Annex C	Yes [ ] No [ ]
SRPMDMOCA	Does this device support media-dependent Multimedia over Coax Alliance (MoCA) functionality on one or more ports?	O:1	C.2	Yes [ ] No [ ]
SRPMDDOT11	Does this device support media-dependent IEEE 802.11 Access Point (AP) functionality on one or more ports?	O:1	C.3	Yes [ ] No [ ]
SRPMDCSN-1	Does this device support a single Designated MSRP Node (DMN)?	SRPMDCSN:M	35.1.1	Yes [ ] N/A [ ]
SRPMDMOCA-1	Does this device support DMN Device Attribute Information Element to L2ME message?	SRPMDMOCA:M	C.2.1.2	Yes [ ] N/A [ ]
SRPMDMOCA-2	Does this device support DMN selection?	SRPMDMOCA:M	C.2.1.3	Yes [ ] N/A [ ]
SRPMDMOCA-3	Does this device support MSRP Attribute Declaration as specified in Table C-1	SRPMDMOCA:M	C.2.2, Table C-1	Yes [ ] N/A [ ]
SRPMDDOT11-1	Does this device support EDCA-AC?	SRPMDDOT11:M	Table C-5	Yes [ ] N/A [ ]
SRPMDDOT11-2	Is the DMN and the QAP of the IEEE 802.11 BSS co-located in the same device?	SRPMDDOT11:M	C.3.2	Yes [ ] N/A [ ]
SRPMDDOT11-3	Does the device support MLME primitives specified in Table C-4?	SRPMDDOT11:M	C.3.3, Table C-4	Yes [ ] N/A [ ]
SRPMDDOT11-4	Does the device support VLAN tag encapsulation/de-encapsulation on the IEEE 802.11 interface?	SRPMDDOT11:M	C.3.3.1	Yes [ ] N/A [ ]
SRPMDDOT11-5	Is the reservation process an atomic operation?	SRPMDDOT11:M	C.3.1, Figure C-11, Figure C-12, Figure C-13	Yes [ ] N/A [ ]

A.32 Multiple I-SID Registration Protocol (MIRP)

Item	Feature	Status	References	Support
MIRP-1	Does the Bridge allow both MIRP and MVRP to be enabled on the same VIP?	MIRP AND BEB-I: X	12.9.2.2.2	No [ ] N/A [ ]
MIRP-2	Does the I-component implement MIRP as specified in Table 39.2?	MIRP AND BEB-I: M	39.1.1 item a)	Yes [ ] N/A [ ]
MIRP-3	Does the I-component propagate attributes freely between MVRP and MIRP Participants?	MIRP AND BEB-I AND MVRP: M	39.1.1 item b)	Yes [ ] N/A [ ]
MIRP-4	Does the I-component support operation as an MRP New-Only Participant?	MIRP AND BEB-I: M	39.1.1 item c)	Yes [ ] N/A [ ]
MIRP-5	Does the B-component implement the MIRP application as specified?	MIRP AND BEB-I: M	39.1.2 item a)	Yes [ ] N/A [ ]
MIRP-6	Does the B-component support operation as an MRP New-Only Participant?	MIRP AND BEB-I: M	39.1.2 item b)	Yes [ ] N/A [ ]
MIRP-7	Does the B-component translate I-SIDs in MIRPDUs as required?	MIRP AND BEB-I: M	39.2.1.2	Yes [ ] N/A [ ]
MIRP-8	Does the I-component transmit every MIRPDU with the Nearest Customer Bridge group address?	MIRP AND BEB-I: M	39.2.1.5	Yes [ ] N/A [ ]
MIRP-9	Does the I-component or B-component transmit MIRPDUs with the MIRP EtherType from Table 10-2?	MIRP: M	39.2.1.7	Yes [ ] N/A [ ]
MIRP-10	Does the I-component or B-component use 1 as the attribute type in MIRPDUs?	MIRP: M	39.2.1.9	Yes [ ] N/A [ ]
MIRP-11	Does the I-component or B-component encode the I-SIDs in the MIRPDU as 3-octet binary values?	MIRP: M	39.2.1.10	Yes [ ] N/A [ ]
MIRP-12	Does the I-component or B-component support the full range of attribute values in MIRPDUs?	MIRP: M	39.2.4	Yes [ ] N/A [ ]
MIRP-13	Does the I-component support at least 4094 attribute values?	MIRP AND BEB-I: M	39.2.4	Yes [ ] N/A [ ]
MIRP-14	Does the B-component support at least as many attribute values as supported by its Backbone Service Instance table?	MIRP AND BEB-B: M	39.2.4	Yes [ ] N/A [ ]
MIRP-15	Does the B-component transmit at least one MIRPDU for each distinct pair of destination MAC address and VID identified by the managed variables?	MIRP AND BEB-B: M	39.2.1.6	Yes [ ] N/A [ ]

A.33 Priority-based Flow Control (PFC)

Item	Feature	Status	References	Support
PFC-1	Enabling PFC on at least one priority	PFC: M	36.1.2	Yes [ ] N/A [ ]
PFC-2	Processing PFC Requests	PFC: M	36.1.3.1	Yes [ ] N/A [ ]
PFC-3	Processing PFC Indications	PFC: M	36.1.3.2	Yes [ ] N/A [ ]
PFC-4	PFC delay constraints	PFC: M	36.1.3.3	Yes [ ] N/A [ ]
PFC-5	PFC-aware system queue functions	PFC: M	36.2	Yes [ ] N/A [ ]
PFC-6	DCBX	PFC: M	5.11	Yes [ ] N/A [ ]
PFC-7	Enabling PFC on up to eight priorities	PFC: O	36.1.2	Yes [ ] No [ ] N/A [ ]
PFC-8	PFC not enabled for traffic classes using the credit-based shaper algorithm	PFC: M	8.6.8.2	Yes [ ] N/A [ ]

A.34 Enhanced Transmission Selection (ETS)

Item	Feature	Status	References	Support
ETS-1	Support at least 3 traffic classes	ETS:M	37.3	Yes [ ] N/A [ ]
ETS-2	Support bandwidth configuration with a granularity of 1% or finer	ETS:M	37.3	Yes [ ] N/A [ ]
ETS-3	Support bandwidth allocation with a precision of 10%	ETS:M	37.3	Yes [ ] N/A [ ]
ETS-4	Support allocation of a portion of available bandwidth to each traffic class	ETS:M	37.3	Yes [ ] N/A [ ]
ETS-5	Support DCBX.	ETS:M	Clause 38	Yes [ ] N/A [ ]

A.35 Data Center Bridging eXchange protocol (DCBX)

Item	Feature	Status	References	Support
DCBX-1	Support LLDP	DCBX:M	IEEE Std 802.1AB	Yes [ ] N/A [ ]
DCBX-2	Support the DCBX ETS Configuration TLV	DCBX:M	D.2.8	Yes [ ] N/A [ ]
DCBX-3	Support the ETS Recommendation TLV	DCBX:M	D.2.9	Yes [ ] N/A [ ]
DCBX-4	Support the Priority-based Flow Control Configuration TLV	DCBX:M	D.2.10	Yes [ ] N/A [ ]
DCBX-5	Support the Application Priority TLV	DCBX:M	D.2.11	Yes [ ] N/A [ ]
DCBX-6	Support the DCBX asymmetric state machine	DCBX:M	38.4.1	Yes [ ] N/A [ ]
DCBX-7	Support the DCBX symmetric state machine	DCBX:M	38.4.2	Yes [ ] N/A [ ]
DCBX-8	Support the Application VLAN TLV	DCBX:M	D.2.14	Yes [ ] N/A [ ]

A.36 Infrastructure Protection Switching (IPS)

Item	Feature	Status	References	Support
	If IPS is not supported, mark N/A and continue at A.37.			N/A [ ]
IPS-1	Is 1:1 IPS supported?	IPS: M	26.11.2	Yes [ ]
IPS-2	Is M:1 IPS supported?	IPS: O	26.11.5	Yes [ ] No [ ] N/A [ ]
IPS-3	Are the operator commands Forced Switch (FS), Lockout of Protection (LoP), Manual Switch to Working, and Manual Switch to Protection implemented?	IPS: M	26.11.2.5	Yes [ ]
IPS-4	Is the hold-off timer implemented?	IPS: O	26.11.2.3	Yes [ ] No [ ]
IPS-5	Is the M:1 wait-to-restore (MWTR) timer implemented?	IPS-2: O	26.11.5.4.7	Yes [ ] No [ ] N/A [ ]

A.37 Shortest Path Bridging (SPB)

Item	Feature	Status	References	Support
SPB-1	Does the Bridge support IS-IS Link State Protocol with procedures to ensure Loop Prevention?	SPB:M	5.4.5, Clause 28	Yes [ ] N/A [ ]
SPB-2	Encode, decode, and validate IS-IS Hello PDUs or SPT BPDUs for the Agreement Protocol (AP) and support AP logic in IS-IS?	SPB:M	5.4.5, Clause 28	Yes [ ] N/A [ ]
SPB-3	State the maximum number of FIDs supported. Minimum is three for SPB	SPB:M	5.4.5	_____FIDs
SPB-4	Support VLAN Registration and filtering of frames with unregistered VIDs	SPB:O	5.4.5	Yes [ ] No [ ] N/A [ ]
SPBV	Is Shortest Path Bridging VID mode supported?	SPB: O.6	5.4.5	Yes [ ] No [ ] N/A [ ]
SPBM	Is Shortest Path Bridging MAC mode supported?	SPB: O.6	5.4.5	Yes [ ] No [ ] N/A [ ]

A.38 EVB Bridge

Item	Feature	Status	References	Support
	If EVB Bridge functionality (EVB-B in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
EVB-B-1	Does the implementation comprise a single conformant C-VLAN component?	EVB-B:M	5.5, 5.6, 5.23	Yes [ ]
EVB-B-2	Is each externally accessible port capable of being configured as either a C-VLAN Bridge Port or a Station Facing Bridge Port (SBP)?	EVB-B:M	5.23, Clause 40	Yes [ ]
EVB-B-3	Does the implementation support the functionality of a C-VLAN component?	EVB-B:M	5.5, 5.23	Yes [ ]
EVB-B-4	Does the implementation support at least one SBP on the C-VLAN component?	EVB-B:M	5.23, Clause 40	Yes [ ]
EVB-B-5	Does the implementation support the EVB status parameters for EVBMode = EVB Bridge?	EVB-B:M	5.23, 40.4	Yes [ ]
EVB-B-6	Does the implementation support an LLDP nearest Customer Bridge database including the EVB TLV on each SBP?	EVB-B:M	5.23, D.2.12	Yes [ ]
EVB-B-7	Does the implementation support ECP on each SBP?	EVB-B:M	5.23, Clause 43	Yes [ ]
EVB-B-8	Does the implementation support the Bridge role of VDP on each SBP?	EVB-B:M	5.23, Clause 41	Yes [ ]
EVB-B-9	Does the implementation support at least one Port-mapping S-VLAN component and associated UAP configured as specified in 40.22 (a)–(d)?	EVB-B:O	5.23, 22.6.4, 40.2 items a)–d)	Yes [ ] No [ ]
EVB-B-10	Is each externally accessible port capable of being configured as an Uplink Access Port (UAP)?	EVB-B:O	5.23, Clause 40	Yes [ ] No [ ]
EVB-B-11	Does the implementation support CDCP, as specified in Clause 42, operating in Bridge mode?	EVB-B-9: M	Clause 42, 42.3	Yes [ ] N/A [ ]

A.38 EVB Bridge *(continued)*

Item	Feature	Status	References	Support
EVB-B-12	Does the implementation support the enhanced filtering utility criteria and not support the default filtering utility criteria (8.7)?	EVB-B-9: M	8.7	Yes [ ] N/A [ ]
EVB-B-13	Does the implementation support configuration of reflective relay on each SBP of the C-VLAN component?	EVB-B:O	5.23, 40.4, 8.6.1	Yes [ ] No [ ]
EVB-B-14	Does the implementation support management for the EVB components?	EVB-B:O	5.23, 12.4–12.12,12.26	Yes [ ] No [ ]
EVB-B-15	Does the implementation support an Simple Network Management Protocol (SNMP) management MIB module?	EVB-B:O	5.23, 17.7.20	Yes [ ] No [ ]
EVB-B-16	Does the implementation support assignment of VIDs to GroupIDs?	EVB-B:O	5.23, 41.2.9	Yes [ ] No [ ]
EVB-B-17	Does the implementation support the use of the M and S bits in VDP?	EVB-B:O	5.23, 41.2.3	Yes [ ] No [ ]
EVB-B-18	Does the Bridge reserve the S-channel Identifier (SCID) value 1 and S-VID value 1 for the exclusive use as the un-S-tagged default S-channel?	EVB-B:M	42.1	Yes [ ]

A.39 EVB station

Item	Feature	Status	References	Support
	If EVB station functionality (EVB-S in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
EVB-S-1	Does the EVB station comprise one or more conformant ER components?	EVB-S:M	5.6, 5.24.1	Yes [ ]
EVB-S-2	Is each externally accessible port capable of being configured as at least one of – A UAP – An uplink relay port (URP)?	EVB-S:M	5.24, Clause 40	Yes [ ]
EVB-S-3	Is each DRP capable of attaching its ER to one or more VSIs?	EVB-S:M	5.24, Clause 40	Yes [ ]
EVB-S-4	Is each URP capable of attaching its ER to a point-to-point LAN connecting the URP to a CAP, or to the LAN connecting to an EVB Bridge in the case where no Port-mapping S-VLAN component is present?	EVB-S:M	5.24, Clause 40	Yes [ ]
EVB-S-5	Does the implementation support at least one ER?	EVB-S:M	5.24, Clause 40	Yes [ ]
EVB-S-6	Does the implementation support at least one accessible URP?	EVB-S:M	5.24, Clause 40	Yes [ ]
EVB-S-7	Does the implementation support the EVB status parametersEVB-S: for EVBMode = EVB station on each URP?	EVB-S:M	5.24, 40.4	Yes [ ]
EVB-S-8	Does the implementation support an LLDP Nearest Customer Bridge database including the EVB TLV on each URP of each ER?	EVB-S:M	5.24, D.2.12	Yes [ ]
EVB-S-9	Does the implementation support ECP on each URP of each ER?	EVB-S:M	5.24, Clause 43	Yes [ ]

A.39 EVB station *(continued)*

Item	Feature	Status	References	Support
EVB-S-10	Does the implementation support the station role of VDP for each URP of each ER?	EVB-S:M	5.24, Clause 41	Yes [ ]
EVB-S-11	Does the implementation support a Port-mapping S-VLAN component on each Port configured as a UAP, configured as specified in 40.2 (a)–(d)?	EVB-S:O	5.24, 22.6.4, 40.2 items a)–d)	Yes [ ] No [ ]
EVB-S-12	Does the implementation support CDCP, as specified in Clause 42, operating in Station mode?	EVB-S-11: M	Clause 42, 42.3	Yes [ ] N/A [ ]
EVB-S-13	Does the implementation support the enhanced filtering utility criteria (8.7.2) and not support the default filtering utility criteria (8.7.1)?	EVB-S-11: M	8.7.1, 8.7.2	Yes [ ] N/A [ ]
EVB-S-14	Does the implementation support multiple ERs?	EVB-S:O	5.24, Clause 40	Yes [ ] No [ ]
EVB-S-15	Does the implementation support management for the EVB components?	EVB-S:O	5.24, 12.26	Yes [ ] No [ ]
EVB-S-16	Does the implementation support an EVB station SNMP management MIB module?	EVB-S:O	5.24, 17.7.20	Yes [ ] No [ ]
EVB-S-17	Does the implementation support assignment of VIDs to GroupIDs?	EVB-S:O	5.24, 41.2.9	Yes [ ] No [ ]
EVB-S-18	Does the implementation support Support the use of the M and S bits in VDP?	EVB-S:O	5.24, 41.2.3	Yes [ ] No [ ]

A.40 Edge relay (ER)

Item	Feature	Status	References	Support
	If EVB station functionality (EVB-S in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
ERC-1	Does the ER conform to the relevant standard for the MAC technology implemented at each Port in support of the MAC ISS, as specified in IEEE Std 802.1AC, and 6.14?	EVB-S:M	IEEE Std 802.1AC , 6.14	Yes [ ]
ERC-2	Does the ER support the MAC Enhanced Internal Sublayer Service (EISS) at each Port, as specified in 6.8 and 6.9?	EVB-S:M	6.8, 6.9	Yes [ ]
ERC-3	Does the ER recognize and use C-TAGs?	EVB-S:M	6.9	Yes [ ]
ERC-4	Does the ER relay and filter frames as described in 8.1 and specified in 8.5, 8.6, 8.7, and 8.8?	EVB-S:M	8.5, 8.6, 8.8	Yes [ ]
ERC-5	Does the ER support a PVID value, and configuration of at least one VID whose untagged set includes that Port, on each DRP that supports untagged and priority-tagged frames?	EVB-S:M	6.9, 8.8.2	Yes [ ]
ERC-6	Does the ER support setting the Acceptable Frame Types parameter to *Admit Only VLAN-tagged Frames* on the URP?	EVB-S:M	5.24.1, 6.9	Yes [ ]

A.40 Edge relay (ER) *(continued)*

Item	Feature	Status	References	Support
ERC-7	Does the ER allow tag headers to be inserted, modified, and removed from relayed frames, as specified in 8.2 and Clause 9, as required by the value(s) of the Acceptable Frame Types parameter supported on each Port, and by the ability of each Port to transmit VLAN-tagged and/or untagged frames?	EVB-S:M	8.1, Clause 9	Yes [ ]
ERC-8	Does the ER support at least one FID?	EVB-S:M	IEEE Std 802.1AC, 8.8.3, 8.8.8, 8.8.9	Yes [ ]
ERC-9	Does the ER allow allocation of at least one VID to each FID that is supported?	EVB-S:M	IEEE Std 802.1AC, 8.8.3, 8.8.8, 8.8.9	Yes [ ]
ERC-10	Does the ER support exactly one URP supporting the parameters of 40.4 for EVBMode = EVB station?	EVB-S:M	5.24.1, 40.4, Clause 40	Yes [ ]
ERC-11	Does the ER support one or more DRPs each supporting access to VSIs?	EVB-S:M	5.24.1, Clause 40	Yes [ ]
ERC-12	Does the ER filter the reserved MAC addresses?	EVB-S:M	5.24.1, Table 8-1	Yes [ ]
ERC-13	Does the ER support more than one DRP?	EVB-S:O	5.24.1	Yes [ ] No [ ]
ERC-14	Does the ER support setting the Enable Ingress Filtering parameter (8.6.2) on each DRP?	ERC-13:M	5.24.1, 8.6.2	Yes [ ] N/A [ ]
ERC-15	Does the ER support setting the Enable Ingress Filtering parameter (8.6.2) on each URP?	ERC-13:M	5.24.1, 8.6.2	Yes [ ] N/A [ ]
ERC-16	Does the ER support the requirements of either a VEB ER or a VEPA ER?	ERC-13:M	5.24.1, 5.24.1.1, 5.24.1.2	Yes [ ]
ERC-17	Does the ER support a PVID value, and configuration of at least one VID whose untagged set includes that Port, if the URP supports untagged and priority-tagged frames?	EVB-S:O	6.9, 8.8.2	Yes [ ]
ERC-18	Does the ER comprise a single conformant C-VLAN component?	EVB-S:O	5.4	Yes [ ] No [ ]
ERC-19	Does the ER support disabling of learning on each DRP?	EVB-S:O	5.24.1, 8.6.1	Yes [ ] No [ ]
ERC-20	Does the ER support discarding frames with unregistered source addresses at each DRP?	EVB-S:O	5.24.1, 8.8.1	Yes [ ] No [ ]
ERC-21	Does the ER support the operation of the learning process?	EVB-S:O	8.7	Yes [ ] No [ ]

A.41 VEB and VEPA ER components

Item	Feature	Status	References	Support
	If EVB station functionality (EVB-S in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
VERC-1	Does the ER component support VEB functionality?	EVB-S:O.6	5.24.1.1	Yes [ ] No [ ]
VERC-2	Does the ER component support VEPA functionality?	EVB-S:O.6	5.24.1.2	Yes [ ] No [ ]
VERC-3	Does the ER component request that reflective relay service not be provided by setting adminReflectiveRelayRequest to FALSE?	VERC-1:M	5.24.1.1	Yes [ ] N/A [ ]
VERC-4	Does the VEPA ER disable learning on the URP?	VERC-2:M	5.24.1.2, 8.6.1	Yes [ ] N/A [ ]
VERC-5	Does the VEPA ER filter frames received at each URP that are destined to a DRP that originated the frame?	VERC-2:M	5.24.1.2, 8.6.1	Yes [ ] N/A [ ]
VERC-6	Does the VEPA ER request reflective relay service by setting adminReflectiveRelayRequest to True?	VERC-2:O	5.24.1.2, 40.4	Yes [ ] N/A [ ]
VERC-7	Does the ER filter frames received at each DRP that are destined for the URP until reflective relay is enabled?	VERC-2:O	5.24.1.2, 8.6.1.1	Yes [ ] No [ ] N/A [ ]
VERC-8	Does the ER forward frames as specified in 8.6.3.1?	VERC-2:M	5.24.1.2, 8.6.3.1	Yes [ ] N/A [ ]

A.42 VDP, CDCP, and ECP

Item	Feature	Status	References	Support
	If neither EVB station functionality (EVB-S in A.5) nor EVB Bridge functionality (EVB-B in A.5) is supported, mark N/A and ignore the remainder of this table.			N/A [ ]
VDP-1	Does the implementation support the Bridge VDP state machine as specified in Clause 41?	EVB-B:M	Clause 41, 41.5.2	Yes [ ]
VDP-2	Does the implementation support the Station VDP state machine as specified in Clause 41?	EVB-S:M	Clause 41, 41.5.3	Yes [ ]
CDCP-1	Does the implementation support the CDCP configuration state machine for the Bridge role, as specified in Clause 42?	EVB-B AND EVB-B-9: M	Clause 42, 42.3	Yes [ ] N/A [ ]
CDCP-2	Does the implementation support the CDCP configuration state machine for the station role, as specified in Clause 42?	EVB-S AND EVB-S-11: M	Clause 42, 42.3	Yes [ ] N/A [ ]
ECP-1	Does the implementation support the ECP transmit state machine as specified in Clause 43?	EVB-S AND EVB-B:M	Clause 43, 43.3.4	Yes [ ]
ECP-2	Does the implementation support the ECP receive state machine as specified in Clause 43?	EVB-S AND EVB-B:M	Clause 43, 43.3.5	Yes [ ]

A.43 Path Control and Reservation

Item	Feature	Status	References	Support
	If Path Control and Reservation (PCR in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
PCR-1	Does the Bridge support the ISIS-PCR protocol?	PCR:M	Clause 45	Yes [ ]
PCR-2	Does the Bridge support the SPB Link Metric sub-TLV?	PCR:M	28.12.7	Yes [ ]
PCR-3	Does the Bridge support the SPB Base VLAN-Identifiers sub TLV?	PCR:M	28.12.4	Yes [ ]
PCR-4	Does the Bridge support the SPB Instance sub-TLV?	PCR:M	28.12.5	Yes [ ]
PCR-5	Does the Bridge support the SPBV MAC address sub-TLV?	PCR:M	28.12.9	Yes [ ]
PCR-6	Does the Bridge support the SPBM Service Identifier and Unicast Address sub-TLV?	BEB AND PCR:M	28.12.10	Yes [ ] N/A [ ]
PCR-7	Does the Bridge support the Topology sub-TLV?	PCR:M	45.1.9	Yes [ ]
PCR-8	Does the Bridge support the Hop sub-TLV?	PCR:M	45.1.10	Yes [ ]
PCR-9	Does the Bridge support the ST ECT Algorithm?	PCR:M	45.1.2	Yes [ ]
PCR-10	Does the Bridge support the LT ECT Algorithm?	PCR:O	45.1.2	Yes [ ] No [ ]
PCR-11	Does the Bridge support the LTS ECT Algorithm?	PCR:O	45.1.2	Yes [ ] No [ ]
PCR-12	Does the Bridge support the MRT ECT Algorithm?	PCR:O	45.1.2, 45.3.3	Yes [ ] No [ ]
PCR-13	Does the Bridge support the MRTG ECT Algorithm?	PCR:O	45.1.2, 45.3.4	Yes [ ] No [ ]
PCR-14	Does the Bridge support the Extended IS Reachability TLV?	PCR:O	45.1.8, IETF RFC 5305	Yes [ ] No [ ]
PCR-15	Does the Bridge support the Unidirectional Link Delay sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-16	Does the Bridge support the Min/Max Unidirectional Link Delay sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-17	Does the Bridge support the Unidirectional Delay Variation sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-18	Does the Bridge support the Unidirectional Link Loss sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-19	Does the Bridge support the Unidirectional Residual Bandwidth sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-20	Does the Bridge support the Unidirectional Available Bandwidth sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]
PCR-21	Does the Bridge support the Unidirectional Utilized Bandwidth sub-TLV?	PCR:O	45.1.8, IETF RFC 7810	Yes [ ] No [ ]

A.43 Path Control and Reservation *(continued)*

Item	Feature	Status	References	Support
PCR-22	Does the Bridge support the Shared Risk Link Group TLV?	PCR:O	45.1.8, IETF RFC 5307	Yes [ ] No [ ]
PCR-23	Does the Bridge support the Administrative Group sub-TLV?	PCR:O	45.1.11	Yes [ ] No [ ]
PCR-24	Does the Bridge support the Bandwidth Constraint sub-TLV?	PCR:O	45.1.12	Yes [ ] No [ ]
PCR-25	Does the Bridge support the Bandwidth Assignment sub-TLV?	PCR:O	45.2.1	Yes [ ] No [ ]
PCR-26	Does the Bridge support the Timestamp sub-TLV?	PCR:O	45.2.2	Yes [ ] No [ ]
PCR-27	Does the Bridge support Loop-Free Alternates for unicast data flows supported by SPBM?	SPBM:O PCR:O	45.3.1	Yes [ ] No [ ] N/A [ ]
PCR-28	Does the Bridge support relaxed ingress checking?	SPBM:O PCR:O	8.4, 8.6.1, 8.8.3, 45.3.1	Yes [ ] No [ ] N/A [ ]

A.44 Scheduled traffic

Item	Feature	Status	References	Support
	If neither scheduled traffic (SCHED in A.5) nor cyclic queuing and forwarding (CQF in A.5) are supported, mark N/A and ignore the remainder of this table.		5.4.1, 5.13.1, 8.6.8, 8.6.9, 12.29, 17.7.22	N/A [ ]
SCHED1	Does the implementation support the state machines and associated definitions specified in 8.6.9	SCHED OR CQF:M	5.4.1, 5.13.1, 8.6.8, 8.6.9	Yes [ ] N/A [ ]
SCHED2	Does the implementation support the management entities defined in 12.29?	SCHED OR CQF:M	5.4.1 item ad), 5.4.1.9 item c), 5.13.1.2 item c), 12.29	Yes [ ] N/A [ ]
SCHED3	Is the IEEE8021-ST-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND (SCHED OR CQF):O	5.4.1 item ad), 5.4.1.9 item c), 5.13.1.2 item c), 12.29, 17.7.22	Yes [ ] N/A [ ] No [ ]

A.45 Frame preemption

Item	Feature	Status	References	Support
	If frame preemption (PRE in A.5) is not supported, mark N/A and ignore the remainder of this table.		5.4.1, 5.13.1, 6.7.2, 8.6.8, 12.30, 17.7.23	N/A [ ]
PRE1	Does the implementation support the functionality of frame preemption as specified in 6.7.2 and 8.6.8?	PRE: M	5.4.1, 5.13.1, 6.7.2, 8.6.8	Yes [ ] N/A [ ]

A.46 Per-Stream Filtering and Policing

Item	Feature	Status	References	Support
	If neither Per-Stream Filtering and Policing (PSFP in A.5) nor cyclic queuing and forwarding (CQF in A.5) are supported, mark N/A and ignore the remainder of this table.		5.4.1.9, 5.13.1.2, 8.6.5.2, 8.6.10, 12.31, 17.7.24	N/A[ ]
PSFP1	Does the implementation support the state machines and associated definitions as specified in 8.6.10?	PSFP OR CQF:M	5.4.1.9 item b), 5.13.1.2 item b), 8.6.5, 8.6.10	Yes [ ] N/A [ ]
PSFP2	Does the implementation support the management entities defined in 12.31?	PSFP OR CQF:M	5.4.1.9 item e), 5.13.1.2 item e), 8.6.5.2, 8.6.10, 12.31	Yes [ ] N/A [ ]
PSFP3	Is the IEEE8021-PSFP-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND (PSFP OR CQF):O	5.4.1.9 item e), 5.13.1.2 item e), 12.31, 17.7.24	Yes [ ] N/A [ ] No [ ]

A.47 YANG

Item	Feature	Status	References	Support
	If item YANG is not supported, mark N/A			N/A [ ]
YANG-802-TYPES	Is the *ieee802-types* module supported?	M	48.6.1	Yes [ ]
YANG-Q-TYPES	Is the *ieee802-dot1q-types* module supported?	M	48.6.2	Yes [ ]
YANG-TSN-TYPES	Is the *ieee802-dot1q-tsn-types* module supported?	O	48.6.3	Yes [ ] No [ ]
YANG-QBRIDGE	Is the *ieee802-dot1q-bridge* module supported?	M	48.6.4	Yes [ ] N/A [ ]
YANG-TPMR	Is the *ieee802-dot1q-tpmr* module supported?	TPMR:O	48.6.5	Yes [ ] No [ ] N/A [ ]
YANG-PB	Is the *ieee802-dot1q-pb* module supported?	PB:O	48.6.6	Yes [ ] No [ ] N/A [ ]
YANG-CFM-TYPES	Is the *ieee802-dot1q-cfm-types* module supported?	CFM:O	48.6.7	Yes [ ] No [ ] N/A [ ]
YANG-CFM	Is the *ieee802-dot1q-cfm* module supported?	CFM:O	48.6.8	Yes [ ] No [ ] N/A [ ]
YANG-CFM-BRIDGE	Is the *ieee802-dot1q-cfm-bridge* module supported?	CFM:O	48.6.9	Yes [ ] No [ ] N/A [ ]
YANG-CFM-ALARM	Is the *ieee802-dot1q-cfm-alarm* module supported?	CFM:O	48.6.10	Yes [ ] No [ ] N/A [ ]
YANG-STREAMS	Is the *ieee802-dot1q-stream-filters-gates* module supported?	ATS:O	48.6.11	Yes [ ] No [ ] N/A [ ]
YANG-ATS	Is the *ieee802-dot1q-ats* module supported?	ATS:O	48.6.12	Yes [ ] No [ ] N/A [ ]

A.48 Stream reservation remote management (SRRM)

Item	Feature	Status	References	Support
	If Stream reservation remote management functionality (SRRM of A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
SRRM-1	What management protocol standard(s) or specification(s) are supported (server side)?	M	5.4.1.10(b)	_____ _____ _____
SRRM-2	Does the implementation report delay through the Bridge?	M	12.32.1	Yes [ ]
SRRM-3	Does the implementation report propagation delay?	M	12.32.2	Yes [ ]
SRRM-4	Does the implementation support Static Trees for static configuration of spanning trees?	M	5.4.1.10 item c), 12.32.3	Yes [ ]
SRRM-5	Does the implementation support MRP External Control for the MSRP application?	O SRP: M	12.32.4	Yes [ ] No [ ] N/A [ ]
SRRM-6	Does the implementation support MRP External Control for the MVRP application?	O MVRP: M	12.32.4	Yes [ ] No [ ] N/A [ ]
SRRM-7	Does the implementation support MRP External Control for the MMRP application?	O MMRP: M	12.32.4	Yes [ ] No [ ] N/A [ ]
SRRM-8	Does the implementation support queue reservation for traffic classes using the strict priority algorithm, through configuration of adminIdleSlope?	M	5.4.1.10 item e), 12.20.1, 34.3	Yes [ ]

A.49 TSN Centralized Network Configuration (CNC) station

Item	Feature	Status	References	Support
	If the functionality of a Centralized Network Configuration station (CNC-S of A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
CNC-S-1	What management protocol standard(s) or specification(s) are supported (client side)?	M	5.29 item a)	_____ _____ _____
CNC-S-2	Does the implementation support the managed object definitions and encodings for Stream reservation remote management?	M	5.29 item b), 12.32	Yes [ ]
CNC-S-3	Does the implementation support the managed object definitions and encodings for scheduled traffic?	O	12.29	Yes [ ] No [ ]
CNC-S-4	Does the implementation support the managed object definitions and encodings for frame preemption?	O	12.30	Yes [ ] No [ ]
CNC-S-5	Does the implementation support the managed object definitions and encodings for IEEE Std 802.1AS?	O	IEEE Std 802.1AS	Yes [ ] No [ ]
CNC-S-6	Does the implementation support the managed object definitions and encodings for IEEE Std 802.1CB?	O	IEEE Std 802.1CB	Yes [ ] No [ ]
CNC-S-7	Does the implementation support MRP External Control for the MSRP application?	O	12.32.4	Yes [ ] No [ ]
CNC-S-8	Does the implementation support MRP External Control for the MVRP application?	O	12.32.4	Yes [ ] No [ ]
CNC-S-9	Does the implementation support MRP External Control for the MMRP application?	O	12.32.4	Yes [ ] No [ ]
CNC-S-10	What user/network configuration protocol standard(s) or specification(s) are supported?	M	5.29 item c), 46.2.2	_____ _____ _____
CNC-S-11	Does the implementation conform to the conditional requirements for use of a YANG-based protocol?	M	5.29 item d), 46.2, 46.3	Yes [ ]
CNC-S-13	Does the implementation conform to the conditional requirements for use of SRP?	M	5.29 item e), 46.2, 12.32.4	Yes [ ]

A.50 VDP for NVO3 nNVE Devices

Item	Feature	Status	References	Support
	If VDP-NVO3 nNVE functionality (VDP-NVO3-nNVE in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
VDP-nNVE-1	Does the implementation support the Bridge role of VDP on each SBP?	M	5.30.1, Clause 41	Yes [ ]
VDP-nNVE-2	Does the implementation support the Bridge VDP state machine as specified in Clause 41?	M	Clause 41, 41.5.2	Yes [ ]
VDP-nNVE-3	Does the implementation support assignment of VIDs to GroupIDs?	M	5.30.1, 41.2.9	Yes [ ]
VDP-nNVE-4	Does the implementation support at least one SBP on the nNVE?	M	5.30.1, Clause 40	Yes [ ]
VDP-nNVE-5	Does the implementation support an LLDP nearest Customer Bridge database including the EVB TLV on each SBP?	O	5.30.1, D.2.12	Yes [ ] No [ ]
VDP-nNVE-6	Does the implementation support the EVB status parameters for EVBMode = NVO3 and NVERole = nNVE for the nNVE role?	O	5.30.1, 40.4, 40.5	Yes [ ] No [ ]
VDP-nNVE-7	Does the implementation support the EVB Bridge status parameters for IPv4 address capability?	VDP-nNVE-6:M	D.2.12.3.5	Yes [ ] No [ ]
VDP-nNVE-8	Does the implementation support the EVB Bridge status parameters for IPv6 address capability?	VDP-nNVE-6:M	D.2.12.3.4	Yes [ ] No [ ]
VDP-nNVE-9	Does the implementation support ECP on each SBP?	O	5.30.1, Clause 43	Yes [ ] No [ ]
VDP-nNVE-10	Does the implementation support the use of M, S, and N bits in VDP?	O	5.30.1, 41.2.3	Yes [ ] No [ ]
VDP-nNVE-11	Does the implementation support the use of IPv4 addresses in VDP filter info format?	O	5.30.1, 41.2.9	Yes [ ] No [ ]
VDP-nNVE-12	Does the implementation support the use of IPv6 addresses in VDP filter info format?	O	5.30.1, 41.2.9	Yes [ ] No [ ]
VDP-nNVE-13	Does the implementation support an LLDP database addressed by a unicast MAC address including the EVB TLV on each SBP?	O	5.30.1, D.2.12	Yes [ ] No [ ]

A.51 VDP for NVO3 tNVE Devices

Item	Feature	Status	References	Support
	If VDP-NVO3 tNVE functionality (VDP-NVO3-tNVE in A.5) is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
VDP-tNVE-1	Does the implementation support the Station role of VDP on each URP?	M	5.30.1, Clause 41	Yes [ ]
VDP-tNVE-2	Does the implementation support the Station VDP state machine as specified in Clause 41?	M	Clause 41, 41.5.3	Yes [ ]
VDP-tNVE-3	Does the implementation support an LLDP nearest Customer Bridge database including the EVB TLV on each URP?	O	5.30.2, D.2.12	Yes [ ] No [ ]
VDP-tNVE-4	Does the implementation support the EVB status parameters for EVBMode = NVO3 and NVERole = tNVE for the tNVE role?	O	5.30.2, 40.4, 40.5	Yes [ ] No [ ]
VDP-tNVE-5	Does the implementation support the EVB Bridge status parameters for IPv4 address capability?	VDP-tNVE-4:M	D.2.12.4.5	Yes [ ] No [ ]
VDP-tNVE-6	Does the implementation support the EVB Bridge status parameters for IPv6 address capability?	VDP-tNVE-4:M	D.2.12.4.4	Yes [ ] No [ ]
VDP-tNVE-7	Does the implementation support ECP on each URP?	O	5.30.2, Clause 43	Yes [ ] No [ ]
VDP-tNVE-8	Does the implementation support the use of M, S, and N bits in VDP?	O	5.30.2, 41.2.3	Yes [ ] No [ ]
VDP-tNVE-9	Does the implementation support the use of IPv4 addresses in VDP filter info format?	O	5.30.2, 41.2.9	Yes [ ] No [ ]
VDP-tNVE-10	Does the implementation support the use of IPv6 addresses in VDP filter info format?	O	5.30.2, 41.2.9	Yes [ ] No [ ]
VDP-tNVE-11	Does the implementation support an LLDP database addressed by a unicast MAC address including the EVB TLV on each URP?	O	5.30.2, D.2.12	Yes [ ] No [ ]
VDP-tNVE-12	Does the RRREQ in EVB station status parameters set to FALSE to make reflective relay always disabled?	VDP-tNVE-4:M	D.2.12.4	Yes [ ] No [ ]

A.52 Asynchronous Traffic Shaping

Item	Feature	Status	References	Support
	If Asynchronous Traffic Shaping (ATS in Table A.5) is not supported, mark N/A and ignore the remainder of this table.		5.4.1.10, 5.13.1.3, 8.6.5.2.2, 8.6.6 items d) and e), 8.6.8.5, 8.6.8, 8.6.8.5, 8.6.11, 12.31	N/A [ ]
ATS-1	Does the implementation support the ATS per-stream classification and metering for ATS as specified in 8.6.5.2.2?	ATS:M	5.4.1.10, 5.13.1.3, 8.6.5.2.2	Yes [ ]
ATS-2	Does the implementation support the ATS transmission selection algorithm as specified in 8.6.8.5?	ATS:M	5.4.1.10, 5.13.1.3, 8.6.8.5	Yes [ ]
ATS-3	Does the implementation support the ATS scheduler state machines as specified in 8.6.11?	ATS:M	5.4.1.10, 5.13.1.3, 8.6.11	Yes [ ]
ATS-4	Does the implementation support the management entities defined in 12.31 for ATS?	ATS:M	5.4.1.10, 5.13.1.3, 12.31	Yes [ ]

Annex B

(normative)

PICS proforma—End station implementations[56]

B.1 Introduction

The supplier of a protocol implementation that is claimed to conform to this standard shall complete the following Protocol Implementation Conformance Statement (PICS) proforma.

A completed PICS proforma is the PICS for the implementation in question. The PICS is a statement of which capabilities and options of the protocol have been implemented. The PICS can have a number of uses, including use:

a) By the protocol implementor, as a checklist to reduce the risk of failure to conform to the standard through oversight.
b) By the supplier and acquirer—or potential acquirer—of the implementation, as a detailed indication of the capabilities of the implementation, stated relative to the common basis for understanding provided by the standard PICS proforma.
c) By the user—or potential user—of the implementation, as a basis for initially checking the possibility of interworking with another implementation (note that, while interworking can never be guaranteed, failure to interwork can often be predicted from incompatible PICSs).
d) By a protocol tester, as the basis for selecting appropriate tests against which to assess the claim for conformance of the implementation.

B.2 Abbreviations and special symbols

B.2.1 Status symbols

M	mandatory
O	optional
O.n	optional, but support of at least one of the group of options labeled by the same numeral n is required
X	prohibited
pred:	conditional-item symbol, including predicate identification: see B.3.4
¬	logical negation, applied to a conditional item’s predicate

B.2.2 General abbreviations

N/A	not applicable
PICS	Protocol Implementation Conformance Statement

[56] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

B.3 Instructions for completing the PICS proforma

B.3.1 General structure of the PICS proforma

The first part of the PICS proforma, implementation identification and protocol summary, is to be completed as indicated with the information necessary to identify fully both the supplier and the implementation.

The main part of the PICS proforma is a fixed-format questionnaire, divided into several subclauses, each containing a number of individual items. Answers to the questionnaire items are to be provided in the rightmost column, either by simply marking an answer to indicate a restricted choice (usually Yes or No), or by entering a value or a set or range of values. (Note that there are some items where two or more choices from a set of possible answers can apply; all relevant choices are to be marked.)

Each item is identified by an item reference in the first column. The second column contains the question to be answered; the third column records the status of the item—whether support is mandatory, optional, or conditional: see also B.3.4 below. The fourth column contains the reference or references to the material that specifies the item in the main body of this standard, and the fifth column provides the space for the answers.

A supplier may also provide (or be required to provide) further information, categorized as either Additional Information or Exception Information. When present, each kind of further information is to be provided in a further subclause of items labeled Ai or Xi, respectively, for cross-referencing purposes, where i is any unambiguous identification for the item (e.g., simply a numeral). There are no other restrictions on its format and presentation.

A completed PICS proforma, including any Additional Information and Exception Information, is the Protocol Implementation Conformation Statement for the implementation in question.

NOTE—Where an implementation is capable of being configured in more than one way, a single PICS may be able to describe all such configurations. However, the supplier has the choice of providing more than one PICS, each covering some subset of the implementation's configuration capabilities, in case that makes for easier and clearer presentation of the information.

B.3.2 Additional information

Items of Additional Information allow a supplier to provide further information intended to assist the interpretation of the PICS. It is not intended or expected that a large quantity will be supplied, and a PICS can be considered complete without any such information. Examples might be an outline of the ways in which a (single) implementation can be set up to operate in a variety of environments and configurations, or information about aspects of the implementation that are outside the scope of this standard but that have a bearing upon the answers to some items.

References to items of Additional Information may be entered next to any answer in the questionnaire, and may be included in items of Exception Information.

B.3.3 Exception information

It may occasionally happen that a supplier will wish to answer an item with mandatory status (after any conditions have been applied) in a way that conflicts with the indicated requirement. No preprinted answer will be found in the Support column for this: instead, the supplier shall write the missing answer into the Support column, together with an *Xi* reference to an item of Exception Information, and shall provide the appropriate rationale in the Exception item itself.

An implementation for which an Exception item is required in this way does not conform to this standard.

NOTE—A possible reason for the situation described previously is that a defect in this standard has been reported, a correction for which is expected to change the requirement not met by the implementation.

B.3.4 Conditional status

B.3.4.1 Conditional items

The PICS proforma contains a number of conditional items. These are items for which both the applicability of the item itself, and its status if it does apply—mandatory or optional—are dependent upon whether certain other items are supported.

Where a group of items is subject to the same condition for applicability, a separate preliminary question about the condition appears at the head of the group, with an instruction to skip to a later point in the questionnaire if the "Not Applicable" answer is selected. Otherwise, individual conditional items are indicated by a conditional symbol in the Status column.

A conditional symbol is of the form "**pred:** S" where **pred** is a predicate as described in B.3.4.2 below, and S is a status symbol, M or O.

If the value of the predicate is true (see B.3.4.2), the conditional item is applicable, and its status is indicated by the status symbol following the predicate: the answer column is to be marked in the usual way. If the value of the predicate is false, the "Not Applicable" (N/A) answer is to be marked.

B.3.4.2 Predicates

A predicate is one of the following:

a) An item-reference for an item in the PICS proforma: the value of the predicate is true if the item is marked as supported, and is false otherwise.
b) A predicate-name, for a predicate defined as a Boolean expression constructed by combining item-references using the Boolean operator OR: the value of the predicate is true if one or more of the items is marked as supported.
c) The logical negation symbol "¬" prefixed to an item-reference or predicate-name: the value of the predicate is true if the value of the predicate formed by omitting the "¬" symbol is false, and vice versa.

Each item whose reference is used in a predicate or predicate definition, or in a preliminary question for grouped conditional items, is indicated by an asterisk in the Item column.

B.4 PICS proforma for IEEE Std 802.1Q—End station implementations

B.4.1 Implementation identification

Supplier	
Contact point for queries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) of machines and/or operating system names	
NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirement for full identification. NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

B.4.2 Protocol summary, IEEE Std 802.1Q

Identification of protocol specification	IEEE Std 802.1Q-2022, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks
Identification of amendments and corrigenda to the PICS proforma that have been completed as part of the PICS	Amd. : Corr. : Amd. : Corr. :
Have any Exception items been required? (See A.3.3: the answer Yes means that the implementation does not conform to IEEE Std 802.1Q)	No [ ] Yes [ ]

Date of Statement	

B.5 Major capabilities

Item	Feature	Status	References	Support
MRPAP	Does the implementation support any MRP applications? If “No” is marked, continue at FQTSSE.	O	5.18.1	Yes [ ] No [ ]
MMRP	Is the operation of MMRP supported?	O.1	5.18.1, B.6	Yes [ ] No [ ]
MVRP	Is automatic configuration and management of VLAN topology using MVRP supported?	O.1	5.18.1, B.7	Yes [ ] No [ ]
MSRP	Is the operation of MSRP supported?	O.1	5.18.3, B.10	Yes [ ] No [ ]
MRP	Is the Multiple Registration Protocol implemented in support of MRP Applications?	M	Clause 10, B.6, B.7, B.8	Yes [ ]
SPRU	Does the implementation support Source Pruning?	O	5.18, 10.10.3, 11.2.1.1	Yes [ ] No [ ]
MRP1	Does the MRP implementation support operation of the Full Participant?	SPRU:O.2 ¬SPRU:O.3	Clause 10, B.8	Yes [ ] No [ ]
MRP2	Does the MRP implementation support operation of the Full Participant, point-to-point subset?	SPRU:O.2 ¬SPRU:O.3	Clause 10, B.8	Yes [ ] No [ ]
MRP3	Does the MRP implementation support operation of the Applicant-Only Participant?	¬SPRU:O.3	Clause 10, B.8	Yes [ ] No [ ]
MRP4	Does the MRP implementation support operation of the Simple-Applicant Participant, point-to-point subset?	¬SPRU:O.3	Clause 10, B.8	Yes [ ] No [ ]
FQTSSE	Does the implementation support forwarding and queuing for time-sensitive streams?	O	5.20, 34.6, B.9	Yes [ ] No [ ]
CN	Is congestion notification implemented?	O	5.21, Clauses 30, 31, 32, 33, B.11	Yes [ ] No [ ]
PFC	Is Priority-based Flow Control implemented?	O	5.11, Clause 36, B.12	Yes [ ] No [ ]
ETS	Does the implementation support bandwidth management using ETS?	O	Clause 37, B.13	Yes [ ] No [ ]
DCBX	Does the implementation support configuration management via DCBX?	O	Clause 38, B.14	Yes [ ] No [ ]
EVB-S	Does the implementation support EVB Station functionality?	O	5.24, A.39	Yes [ ] No [ ]
SCHED	Does the implementation support scheduled traffic?	O	5.4.1, 5.13.1, 8.6.8, 8.6.9, 12.29, 17.7.22	Yes [ ] No [ ]
PRE	Does the implementation support frame preemption?	O	5.4.1, 5.13.1, 6.7.2, 8.6.8, 12.30, 17.7.23	Yes [ ] No [ ]
PSFP	Does the implementation support PSFP?	O	8.6.5.2.1, 8.6.10, 12.31	Yes [ ] No [ ]
ATS	Does the implementation support Asynchronous Traffic Shaping?	O	8.6.5.2.2, 8.6.8, 8.6.8.5, 8.6.11, 12.31	Yes [ ] No [ ]
CQF	Does the implementation support cyclic queuing and forwarding?	O	5.25, 5.28	Yes [ ] No [ ]
CNC-S	Does the implementation support Centralized Network Configuration (CNC) station functionality?	O	5.29, 46.2, A.17	Yes [ ] No [ ]

B.6 Multiple MAC Registration Protocol (MMRP)

Item	Feature	Status	References	Support
	If MMRP is not supported, mark N/A and continue at B.7.			N/A [ ]
MMRP1	Does the implementation support the exchange of MMRPDUs, using the generic MRPDU format defined in 10.8 to exchange MMRP-specific information, as defined in 10.12?	M	5.4.1.3, 10.8, 10.12	Yes [ ]
MMRP2	Is the MMRP Application supported as defined in 10.12?	M	5.4.1.3, 10.12	Yes [ ]
MMRP5	Is the MAP Context Identifier used to identify a VLAN Context equal to the VID used to identify the corresponding VLAN?	M	10.12.1.1	Yes [ ]
MMRP7	Is the group MAC address used as the destination address for MRPDUs destined for MMRP Participants the group MAC address identified in Table 10-1 as “Customer and Provider Bridge MMRP address”?	M	10.12.1.3	Yes [ ]
MMRP8	Is the EtherType used for MRPDUs destined for MMRP Participants the MMRP EtherType identified in Table 10-2?	M	10.12.1.4, Table 10-2	Yes [ ]
MMRP9	Does the ProtocolVersion used for the implementation of MMRP take the hexadecimal value 0x00?	M	10.12.1.5	Yes [ ]
MMRP10	Are the Attribute Type values used in the implementation as specified in 10.12.1.6?	M	10.12.1.6	Yes [ ]
MMRP11	Does the implementation encode the values in FirstValue fields in accordance with the definition in 10.12.1.7?	M	10.12.1.7	Yes []
MMRP12	Is management of the Restricted_MAC_Address_Registration control parameter supported?	O	10.12.2	Yes [ ] No [ ]
MMRP13	If management of the Restricted_MAC_Address_Registration control parameter is not supported, is the value of this parameter FALSE for all Ports?	¬MMRP12:M	10.12.2	Yes [ ] N/A [ ]
MMRP14	Does the implementations maintain state information for all attribute values that support the Group service requirement registration?	SPRU:M	10.10.2	Yes [ ] N/A [ ]
MMRP15	Is the implementation capable of supporting any attribute value in the range of possible values that can be registered using Group membership and individual MAC address registration?	M	10.12.4	Yes [ ]
MMRP16	State the number of Group membership and individual MAC address state values that can be supported on each Port.	M	10.12.4	Number_____

B.7 Multiple VLAN Registration Protocol (MVRP)

Item	Feature	Status	References	Support
	If MVRP is not supported, mark N/A and continue at B.8.			N/A [ ]
MVRP1	Does the implementation support the exchange of MMRPDUs, using the generic MRPDU format defined in 11.2 to exchange MMRP-specific information, as defined in 10.12?	M	5.4.2, 10.8, 11.2	Yes [ ]
MVRP2	Is the MMRP Application supported as defined in 11.2?	M	5.4.2, 11.2	Yes [ ]
MVRP7	Is the group MAC address used as the destination address for MRPDUs destined for MVRP Participants as defined in 11.2.3.1.3?	M	11.2.3.1.3	Yes [ ]
MVRP8	Is the EtherType used for MRPDUs destined for MVRP Participants the MVRP EtherType identified in Table 10-2?	M	11.2.3.1.4, Table 10-2	Yes [ ]
MVRP9	Does the ProtocolVersion used for the implementation of MVRP take the hexadecimal value 0x00?	M	11.2.3.1.5	Yes [ ]
MVRP10	Are the Attribute Type values used in the implementation as specified in 11.2.3.1.6?	M	11.2.3.1.6	Yes [ ]
MVRP11	Does the implementation encode the values in FirstValue fields in accordance with the definition in 11.2.3.1.7?	M	11.2.3.1.7	Yes [ ]
MVRP12	Is the implementation of MVRP capable of supporting all attribute values in the range of possible values that can be registered using MVRP?	SPRU:M	11.2.7	Yes [ ] N/A [ ]
MVRP13	Is the implementation capable of maintaining current state information for all attributes in the range of possible values?	SPRU:M	11.2.7	Yes [ ] N/A [ ]

B.8 Multiple Registration Protocol (MRP)

Item	Feature	Status	References	Support
MRP5	Does the implementation of MRP meet all of the requirements for interoperability stated in 10.5 that apply to end station operation?	M	10.5	Yes [ ]
MRP6	Does the implementation support the operation of the complete Applicant state machine?	MRP1:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP7	Does the implementation support the operation of the point-to-point subset of the Applicant state machine?	MRP2:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP8	Does the implementation support the operation of the Applicant-Only subset of the Applicant state machine?	MRP3:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP9	Does the implementation support the operation of the Simple-Applicant subset of the Applicant state machine?	MRP4:M	10.7, 10.7.7	Yes [ ] N/A [ ]
MRP10	Does the implementation support the operation of the Registrar state machine?	MRP1:M MRP2:M	10.7, 10.7.8	Yes [ ] N/A [ ]
MRP11	Does the implementation support the operation of the LeaveAll state machine?	MRP1:M MRP2:M	10.7, 10.7.9	Yes [ ] N/A [ ]
MRP12	Does the implementation support the operation of the PeriodicTransmission state machine?	M	10.7, 10.7.10	Yes [ ]

B.9 Forwarding and Queuing Enhancements for time-sensitive streams (FQTSS)

Item	Feature	Status	References	Support
FQTSSE1	Support a minimum of two traffic classes, of which one supports the strict priority algorithm and the other is an SR class?	FQTSSE:M	5.20, 8.6.8.1, 34.6	Yes [ ] N/A [ ]
FQTSSE2	Support the credit-based shaper algorithm as the transmission selection algorithm for frames transmitted for each stream associated with the SR class.	FQTSSE:M	5.20, 8.6.8.2, 34.6	Yes [ ] N/A [ ]
FQTSSE3	Support the operation of the credit-based shaper algorithm on all Ports as the transmission selection algorithm used for the SR class.	FQTSSE:M	5.20, 8.6.8.2, 34.6	Yes [ ] N/A [ ]
FQTSSE4	Use the default priority associated with SR class “B” as shown in Table 6-5 as the priority value carried in transmitted SR class “B” data frames.	FQTSSE:M	5.20, Table 6-5, 34.6	Yes [ ] N/A [ ]
FQTSSE5	Support two or more SR classes (a maximum of seven), and support the operation of the credit-based shaper algorithm on all Ports as the transmission selection algorithm used for those SR classes. The number of SR classes supported shall be stated in the PICS.	FQTSSE:O	5.20, 8.6.8.2, 34.6	Yes [ ] No [ ] Number____
FQTSSE6	Use the default priority associated with SR class “A” as shown in Table 6-5 as the priority value carried in transmitted SR class “A” data frames. If more than two SR classes are supported, the priority value carried in transmitted data frames for the additional SR classes shall be stated in the PICS.	FQTSSE:O	5.20, Table 6-5, 34.6	Yes [ ] No [ ] Priority override values_____

B.10 Stream Reservation Protocol (SRP)

Item	Feature	Status	Reference	Support
	If SRP is not supported, mark N/A and ignore the remainder of this table.			N/A [ ]
SRP-1	Does the implementation support the exchange of Multiple Stream Registration Protocol Data Units (MSRPDUs), using the generic Multiple Registration Protocol Data Unit (MRPDU) format defined in 10.8 to exchange MSRP-specific information, as defined in 35.2.2.8.1, 35.2.2.9.1, and 35.2.2.10.1?	M	5.4.4, 10.8, 35.2.2.8.1, 35.2.2.9.1, 35.2.2.10.1	Yes [ ]
SRP-2	Is the MSRP Application supported as defined in Clause 35?	M	5.4.4, Clause 35	Yes [ ]
SRP-3	Is the group MAC address used as the destination address for MRPDUs destined for MSRP Participants the group MAC address identified in Table 8-1, Table 8-2, Table 8-3 as “Individual LAN Scope group address, Nearest Bridge group address”?	M	35.2.2.1, Table 8-1, Table 8-2, Table 8-3	Yes [ ]
SRP-4	Is the EtherType used for MRPDUs destined for MSRP Participants the MSRP EtherType identified in Table 10-2?	M	35.2.2.2, Table 10-2	Yes [ ]
SRP-5	Does the ProtocolVersion used for the implementation of MSRP take the hexadecimal value 0x01?	M	35.2.2.3	Yes [ ]
SRP-6	Are the Attribute Type values used in the implementation as specified in 35.2.2.4 and Table 35-1?	M	35.2.2.4, Table 35-1	Yes [ ]
SRP-7	Are the Attribute Length values used in the implementation as specified in 35.2.2.5 and Table 35-2?	M	35.2.2.5, Table 35-2	Yes [ ]
SRP-8	Are the MSRP Vector FourPackedEvents values used in the implementation as specified in 35.2.2.7.2 and Table 35-3?	M	35.2.2.7.2, Table 35-3	Yes [ ]
SRP-9	Does the implementation encode the values in FirstValue fields in accordance with the definition in 35.2.2.8, 35.2.2.9, and 35.2.2.10?	M	35.2.2.8, 35.2.2.9, 35.2.2.10	Yes [ ]
SRP-10	Does the Talker implementation populate the Accumulated Latency with a reasonable, nonzero value?	M	35.2.2.8.6, 35.2.2.10.10	Yes [ ]
SRP-11	Does the implementation update the Failure Information end station MAC address and Code when a Talker Failed is declared?	M	35.2.2.8.7, 35.2.2.10.9, 35.2.2.10.12	Yes [ ]

B.10 Stream Reservation Protocol (SRP) *(continued)*

Item	Feature	Status	Reference	Support
SRP-12	Does the implementation create a Talker Failed in the event of insufficient bandwidth or resources?	O	35.1.2.1	Yes [ ] No [ ]
SRP-13	Is talkerPruning and MMRP supported?	O	35.2.4.3.2	Yes [ ] No [ ]
SRP-14	Are MSRPDUs transmitted on all ports?	M	35.2	Yes [ ]
SRP-15	State the number of Talker registration values that can be supported on each Port.	M	35.2.7	Number _____
SRP-16	State the number of Listener registration values that can be supported on each Port.	M	35.2.7	Number _____
SRP-17	Does the Listener issue an appropriate MVRP VLAN membership request before attaching to a Stream?	M	35.1.2.2	Yes [ ]
SRP-18	When MAC_Operational transitions to TRUE does the device declare the default SR class priority value as the SRclassPriority prior to receiving an SRclassPriority declaration from its neighbor?	M	IEEE Std 802.1AC, 35.2.2.9.3, Table 6-5	Yes [ ]
SRP-19	Does the device set SRclassPriority to the value declared by the neighboring device?	M	35.2.2.9.3	Yes [ ]
SRP-20	When MAC_Operational transitions to TRUE does the device declare the default SR_PVID value as the SRclassVID prior to receiving an SRclassVID declaration from its neighbor?	M	IEEE Std 802.1AC, 35.2.2.9.4, Table 9-2	Yes [ ]
SRP-21	Does the device set SRclassVID to the value declared by the neighboring device?	M	35.2.2.9.4	Yes [ ]
SRP-22	Does the implementation support Stream transformation in end station?	O	35.2.2.10.5	Yes [ ] No [ ]
SRP-23	Does the implementation declare the Domain attribute prior to Talker/ Listener attributes?	M	35.2.2.9	Yes [ ]
SRPMDCSN	Does this device support media-dependent CSN functionality on one or more ports?	SRPMDMOCA:M OR: SRPMDDOT11:M	Annex C	Yes [ ] No [ ]
SRPMDMOCA	Does this device support media-dependent MoCA functionality on one or more ports?	O:1	C.2	Yes [ ] No [ ]
SRPMDDOT11	Does this device support media-dependent IEEE 802.11 AP functionality on one or more ports?	O:1	C.3	Yes [ ] No [ ]

B.10 Stream Reservation Protocol (SRP) *(continued)*

Item	Feature	Status	Reference	Support
SRPMDCSN-1	Does this device support a single Designated MSRP Node (DMN)?	SRPMDCSN:M	35.1.1	Yes [ ]
SRPMDMOCA-1	Does this device support DMN Device Attribute Information Element to L2ME message?	SRPMDMOCA:M	C.2.1.2	Yes [ ]
SRPMDMOCA-2	Does this device support DMN selection?	SRPMDMOCA:M	C.2.1.3	Yes [ ]
SRPMDMOCA-3	Does this device support MSRP Attribute Declaration as specified in Table C-1?	SRPMDMOCA:M	C.2.2 Table C-1	Yes [ ]
SRPMDDOT11-1	Does this device support EDCA-AC?	SRPMDDOT11:M	Table C-5	Yes [ ]
SRPMDDOT11-2	Is the DMN and the QAP of the IEEE 802.11 BSS co-located in the same device?	SRPMDDOT11:M	C.3.2	Yes [ ]
SRPMDDOT11-3	Does the device support MLME primitives specified in Table C-4?	SRPMDDOT11:M	C.3.3, Table C-4	Yes [ ]
SRPMDDOT11-4	Does the device support VLAN tag encapsulation/de-encapsulation on the IEEE 802.11 interface?	SRPMDDOT11:M	C.3.3.1	Yes [ ]
SRPMDDOT11-5	Is the reservation process an atomic operation?	SRPMDDOT11:M	C.3.1, Figure C-11, Figure C-12, Figure C-13	Yes [ ]

B.11 Congestion notification

Item	Feature	Status	References	Support
CN-1	Does the system conform to the required provisions of IEEE Std 802.1AB?	CN: M	5.21	Yes [ ]
CN-2	Does the system support the use of the Congestion Notification TLV in LLDP?	CN: M	5.21	Yes [ ]
CN-3	Does the system transmit more than one Congestion Notification TLV in a single LLDPDU?	CN: M		No [ ]
CN-4	Does the system transmit a Congestion Notification TLV with 0 in all of the Per-priority CNPV indicators?	CN: M		No [ ]
CN-5	Does the system implement the Congestion Notification Domain (CND) defense variables, procedures, and state machine?	CN: M	32.4, 32.5, 32.6	Yes [ ]
CN-6	Does the end station support the creation of at least one RP?	CN: M	5.21	Yes [ ]
CN-7	Does the end station allow more than rpppMaxRps RPs to be created on one port and priority?	CN: M	32.10.1	No [ ]
CN-8	Does the end station support at least the cptDisabled and cptInterior defense modes separately on each CNPV?	CN: M	5.21, 32.1.1	Yes [ ]
CN-9	Does the end station add a tag to frames transmitted from CCFs?	CN: O	30.5, 31.2.2.5	Yes [ ] No [ ]
CN-10	Does the end station support both the cptInterior, and cptInteriorReady defense modes separately on each CNPV?	CN: O	5.21, 31.2.2.5 , 32.14.3	Yes [ ] No [ ]
CN-11	Does the end station support the cptEdge defense mode on any CNPV?	CN: O	5.21, 32.4.9	Yes [ ] No [ ]
CN-12	Does the end station accept CN-TAGs in data frames on any CNPV?	CN: O	5.21, 32.4.10	Yes [ ] No [ ]
CN-13	Does the end station support the creation of more than one RP?	CN: O	5.21, 31.2.1	Yes [ ] No [ ]
CN-14	Reserved			
CN-15	Do the end station’s RP(s) limit the output frame rate in response to CNMs received?	CN: M	5.21	Yes [ ]
CN-16	Does the end station distinguish correctly to which RP a given CNM is directed?	CN-13: M	5.21	Yes [ ]
CN-17	Does the end station support the creation of at least one CP?	CN: O	5.21	Yes [ ] No [ ]
CN-18	Does the end station’s have a single flow queue as its default configuration?	CN: M	31.2.1	Yes [ ]
CN-19	Does the end station change its method for assigning frames to Flow queues in a manner that impairs the ability of compliant CPs to throttle its flows?	CN: M	31.2.1	No [ ]

B.11 Congestion notification *(continued)*

Item	Feature	Status	References	Support
CN-20	Does the end station change its method for assigning frames to Flow queues in a manner that significantly increases the likelihood of frame misordering, and thus impacts higher layer functions?	CN: M	31.2.1	No [ ]
CN-21	Does the end station's Rate Limiters always meet the specified formula for L_T?	CN: M	31.2.2.4, Equation (31-1)	Yes [ ]
CN-22	Can the end station's Flow Selection functions drop frames between the Flow queue and the Flow multiplexer?	CN: M	31.2.2.5	No [ ]
CN-23	Does the end station output frames with CN-TAGs on a priority operating in mode cptEdge or cptInterior?	CN: M	32.1.1	No [ ]
CN-24	Do the end station's RPs implement the specified timers, variables. procedures, and state machines?	CN: M	32.7 item b), 32.12, 32.13, 32.14, 32.15	Yes [ ]
CN-25	Does the end station insert the CN-TAG and VLAN-TAG in the correct order (addresses, VLAN-TAG, CN-TAG)?	CN: M	33.2	Yes [ ]
CN-26	Does the end station ignore the CNM's Version field?	CN: M	33.4.1	Yes [ ]
CN-27	Does the end station ignore the CNM's ReservedV field?	CN: M	33.4.2	Yes [ ]
CN-28	Does the end station assign meaning to subfields within a received CNM's Congestion Point Identifier field?	CN: M	33.4.4	No [ ]
CN-29	Does the end station ignore received CNMs that are too short?	CN: M	33.4.11 item a)	Yes [ ]
CN-30	Does the end station ignore received CNMs that have no CN-TAG?	CN: O	33.4.11 item b)	Yes [ ] No [ ]
CN-31	Does the end station ignore received CNMs that have nonzero values in the Version or ReservedV fields?	CN: M	33.4.11 item c)	No [ ]
CN-32	Does the end station support all of the objects required to manage its RP(s)?	CN: M	5.21, 12.21.1, 12.21.6	Yes [ ]
CN-33	Does the end station use the same Reaction Point group managed object to manage RPs serving more than one CNPV?	CN: M	32.11	No [ ]
CN-34	Does the end station support all of the objects in the CN component managed object?	CN-17: M	5.21, 12.21.1	Yes [ ]
CN-35	Does the end station support all of the objects in the CN component priority managed object?	CN-17: M	5.21, 12.21.2	Yes [ ]
CN-36	Does the end station support all of the objects in the CN Port priority managed object?	CN-17: M	5.21, 12.21.3	Yes [ ]
CN-37	Does the end station support all of the objects in the Congestion Point managed object?	CN-17: M	5.21, 12.21.4	Yes [ ]

B.12 Priority-based Flow Control (PFC)

Item	Feature	Status	References	Support
PFC-1	Enabling PFC on at least one priority	PFC: M	36.1.2	Yes [ ]
PFC-2	Processing PFC Requests	PFC: M	36.1.3.1	Yes [ ]
PFC-3	Processing PFC Indications	PFC: M	36.1.3.2	Yes [ ]
PFC-4	PFC delay constraints	PFC: M	36.1.3.3	Yes [ ]
PFC-5	PFC-aware system queue functions	PFC: M	36.2	Yes [ ]
PFC-6	DCBX	PFC: M	5.11	Yes [ ]
PFC-7	Enabling PFC on up to eight priorities	PFC: O	36.1.2	Yes [ ]No [ ]
PFC-8	PFC not enabled for traffic classes using the credit-based shaper algorithm	PFC: M	8.6.8.2	Yes [ ]

B.13 Enhanced Transmission Selection (ETS)

Item	Feature	Status	References	Support
ETS-1	Support at least 3 traffic classes	ETS:M	37.3	Yes [ ]
ETS-2	Support bandwidth configuration with a granularity of 1% or finer	ETS:M	37.3	Yes [ ]
ETS-3	Support bandwidth allocation with a precision of 10%	ETS:M	37.3	Yes [ ]
ETS-4	Support allocation of a portion of available bandwidth to each traffic class	ETS:M	37.3	Yes [ ]
ETS-5	Support DCBX	ETS:M	Clause 38	Yes [ ]

B.14 Data Center Bridging eXchange protocol (DCBX)

Item	Feature	Status	References	Support
DCBX-1	Support LLDP	DCBX:M	IEEE Std 802.1AB	Yes [ ]
DCBX-2	Support the DCBX ETS Configuration TLV	DCBX:M	D.2.8	Yes [ ]
DCBX-3	Support the ETS Recommendation TLV	DCBX:M	D.2.9	Yes [ ]
DCBX-4	Support the Priority-based Flow Control Configuration TLV	DCBX:M	D.2.10	Yes [ ]
DCBX-5	Support the Application Priority TLV	DCBX:M	D.2.11	Yes [ ]
DCBX-6	Support the DCBX asymmetric state machine	DCBX:M	38.4.1	Yes [ ]
DCBX-7	Support the DCBX symmetric state machine	DCBX:M	38.4.2	Yes [ ]
DCBX-8	Support the Application VLAN TLV	DCBX:M	D.2.14	Yes [ ]

B.15 Scheduled traffic

Item	Feature	Status	References	Support
	If neither scheduled traffic (SCHED in B.5) nor cyclic queuing and forwarding (CQF in B.5) are supported, mark N/A and ignore the remainder of this table.		5.25, 5.28, 8.6.8, 8.6.9, 12.29, 17.7.22	N/A [ ]
SCHED1	Does the implementation support the state machines and associated definitions specified in 8.6.9	SCHED OR CQF:M	5.28 item b), 8.6.8, 8.6.9	Yes [ ] N/A [ ]
SCHED2	Does the implementation support the management entities defined in 12.29?	SCHED OR CQF:M	5.28 item c), 12.29	Yes [ ] N/A [ ]
SCHED3	Is the IEEE8021-ST-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND (SCHED OR CQF):O	5.28 item c), 12.29, 17.7.22	Yes [ ] N/A [ ] No [ ]

B.16 Frame Preemption

Item	Feature	Status	References	Support
	If frame preemption (PRE in B.5) is not supported, mark N/A and ignore the remainder of this table.		5.4.1, 5.13.1, 6.7.2, 8.6.8, 12.30, 17.7.23	N/A [ ]
PRE1	Does the implementation support the functionality of frame preemption as specified in 6.7.2 and 8.6.8?	PRE: M	5.4.1, 5.13.1, 6.7.2, 8.6.8	Yes [ ] N/A [ ]
PRE2	Does the implementation support the management entities defined in 12.30?	PRE: M	5.4.1 item ae), 12.30	Yes [ ] N/A [ ]
PRE3	Is the IEEE8021-Preemption-MIB module fully supported (per its MODULE-COMPLIANCE)?	PRE: O	5.4.1 item ae), 12.30, 17.7.23	Yes [ ] N/A [ ]

B.17 Per-Stream Filtering and Policing

Item	Feature	Status	References	Support
	If neither Per-Stream Filtering and Policing (PSFP in B.5) nor cyclic queuing and forwarding (CQF in B.5) are supported, mark N/A and ignore the remainder of this table.		5.28 items d) and e), 8.6.5.2.1, 8.6.10, 12.31, 17.7.24	N/A[ ]
PSFP1	Does the implementation support the state machines and associated definitions as specified in 8.6.10?	PSFP OR CQF:M	5.28 items b) and d), 8.6.5.4, 8.6.10,	Yes [ ] N/A [ ]
PSFP2	Does the implementation support the management entities defined in 12.31 for PSFP?	PSFP OR CQF:M	5.28 item e), 8.6.5.2, 8.6.10, 12.31	Yes [ ] N/A [ ]
PSFP3	Is the IEEE8021-PSFP-MIB module fully supported (per its MODULE-COMPLIANCE)?	MIB AND (PSFP OR CQF):O	12.31, 17.7.24	Yes [ ] N/A [ ] No [ ]

B.18 Asynchronous Traffic Shaping

Item	Feature	Status	References	Support	
	If Asynchronous Traffic Shaping (ATS in Table B.5) is not supported, mark N/A and ignore the remainder of this table.		5.31, 8.6.5.2.2, 8.6.8, 8.6.8.5, 8.6.11, 47.1.2	N/A[ ]	
ATS1	Does the implementation support at least one traffic class that supports the strict priority transmission selection algorithm (8.6.8.1) and another traffic class that supports the ATS transmission selection algorithm (8.6.8.5)?	ATS:M	5.31, 8.6.8, 8.6.8.5,	Yes [ ]	N/A [ ]
ATS2	Does the implementation support ATS schedulers as specified in 8.6.5.6?	ATS:M	5.31, 8.6.5.6, 47.1	Yes [ ]	N/A [ ]
ATS3	Does the implementation support the ATS scheduler state machines as specified in 47.1?	ATS:M	5.31, 47.1	Yes [ ]	N/A [ ]

Annex C

(normative)

Designated MSRP Node (DMN) Implementations

This annex describes the DMN implementation on an IEEE 802.11 Network and Coordinated Shared Networks (CSNs).

C.1 DMNs on CSNs

A CSN is a contention-free, time-division multiplexed-access network, supporting reserved bandwidth based on priority or flow (QoS). One of the nodes of the CSN acts as the Network Coordinator (NC) node, granting transmission opportunities to the other nodes of the network. The NC node also acts as the bandwidth resource manager of the network.

C.1.1 CSN characteristics

CSNs support two types of transmissions: unicast transmission for node-to-node transmission and multicast/broadcast transmission for one-node-to-other/all-nodes transmission. Each node-to-node link has its own bandwidth characteristics that could change over time due to the periodic ranging of the link. The multicast/broadcast transmission characteristics are the lowest common characteristics of multiple/all the links of the network.

A CSN network is physically a shared network, in that a CSN node has a single physical port connected to the half-duplex medium, but is also a logically fully-connected one-hop mesh network, in that every node could transmit to every other node using its own profile over the shared medium.

Figure C-1 illustrates a CSN network acting as a backbone interconnecting AV systems.

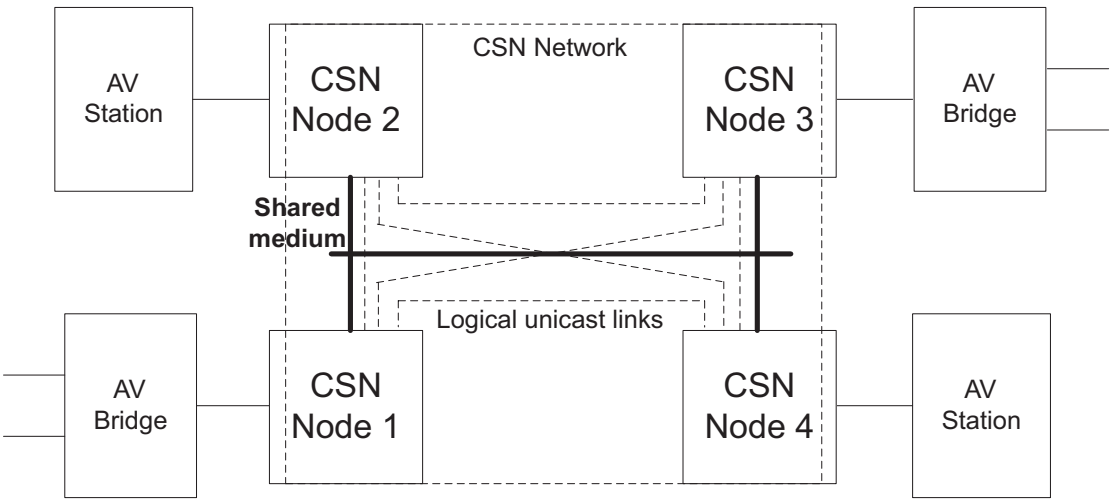


Figure C-1—CSN backbone

Depending on the CSN technology, the Network Coordinator node either may be a fixed node or may be dynamically selected during normal operation.

C.1.2 DMN handling on CSN

From the bandwidth reservation standpoint a CSN network is modeled as a Bridge as illustrated by Figure C-2. Each node-to-node link is equivalent to a Bridge's path from an ingress port to an egress port.

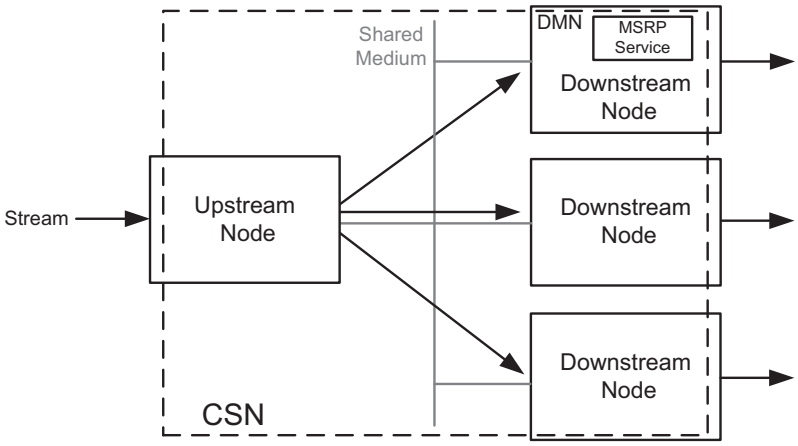


Figure C-2—Bridge's CSN model for bandwidth reservation

A CSN shall provide a single entity called the Designated MSRP Node (DMN) (35.1.1), which communicates with the MSRP Service to manage the CSN bandwidth resources for the MSRP streams.

NOTE 1—The MSRP Service supplies both MSRP Attribute Propagation (MAP) for the CSN and MSRP Attribute Declaration (MAD) for each MSRP-aware CSN node.

NOTE 2—An end station node provides an end station MSRP implementation as outlined in 5.18.3. This MSRP implementation is logically on the upper layer side of this interface. This standard expects that an MSRP-aware CSN node will have a single non-CSN interface. If more interfaces are present, they are expected to be connected through a Bridge function. If this node happens to be the DMN, then this end station MSRP implementation is separate and distinct from the DMN's MSRP Service.

C.1.2.1 DMN selection and migration

Depending on the CSN technology, the DMN might correspond to a static node or dynamically migrate between nodes during normal operation. The DMN selection is network specific and described in C.2.1 and C.3.2.

Over time the DMN constructs its database by handling the MSRP Talker and Listener Declarations generated by the nodes of the CSN. If the DMN migrates, the new DMN broadcasts an MRP LeaveAll message to all the nodes of the CSN, which will force its neighbors to redeclare their attributes. The MSRP Participant nodes answer the MRP LeaveAll message by sending an MRP JoinIn message consumed by the DMN as an MRP Re-Declare! message. These redeclarations permit the new DMN to immediately build its database.

C.1.3 MSRPDU handling on a CSN

Figure C-3 and Figure C-4 illustrate the flow and handling of MSRPDU messages on a CSN.

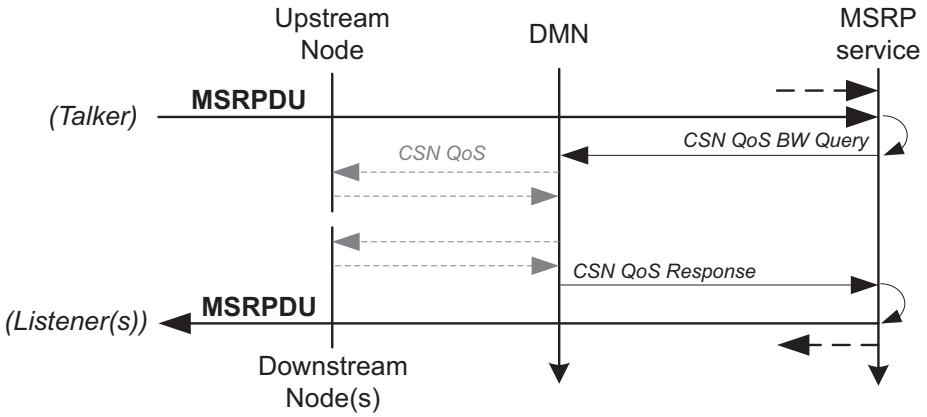


Figure C-3—Talker MSRPDU flow

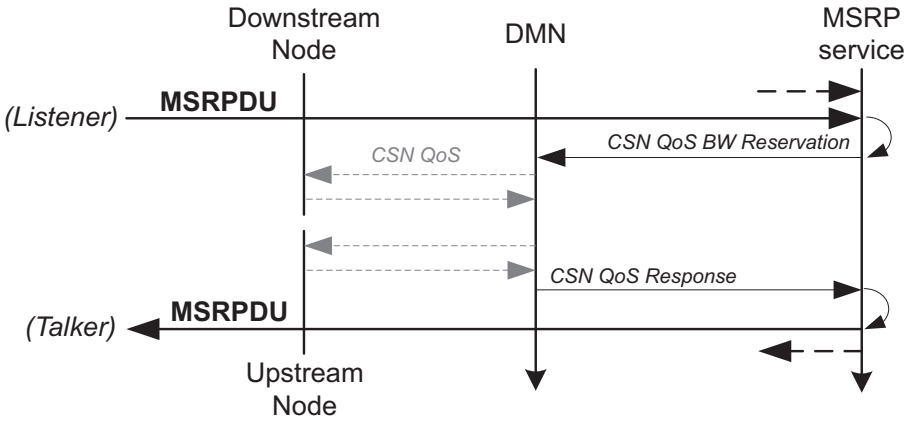


Figure C-4—Listener MSRPDU flow

a) A MSRP-aware CSN node identifies MSRPDUs received on its non-CSN interface (the interface either to another network media or to upper layers of the node) by their destination MAC address (35.2.2.1) and EtherType (35.2.2.2).

b) Non-DMN nodes send MSRPDUs to the DMN over the CSN.

c) The DMN delivers MSRPDUs, along with information about the originating interface, to the MSRP Service.

d) The DMN translates the MSRP TSpec parameters into CSN QoS parameters and invokes the CSN's Protocol Specific QoS transactions with the CSN Network Coordinator (C.2.2, C.3.3) as follows:

   1) When the DMN receives a Talker Advertise message originated from an upstream CSN node, the DMN invokes a bandwidth query transaction with the CSN Network Coordinator to check whether the bandwidth advertised in the message's TSpec is available on each upstream to downstream node link of the CSN network. In addition the DMN associates the MSRP attributes with the CSN's native QoS records via the StreamID (which is included in the CSN frames).

2) When the DMN receives a Listener Ready message originated from a downstream CSN node, the DMN invokes a bandwidth reservation transaction with the CSN QoS manager to reserve the bandwidth associated with the message's StreamID on the downstream to upstream CSN node link.

e) After the DMN completes the CSN QoS transactions, the DMN behaves as an MSRP application on a Bridge and propagates (MAP) and distributes (MAD) MSRP attributes (35.2).

NOTE—When the MAD function of the MSRP Service distributes attributes, it will deliver MSRPDUs to the DMN's non-CSN interface and/or send them to the appropriate MSRP-aware CSN nodes.

C.1.4 CSN bandwidth fluctuations

Bandwidth on a CSN may fluctuate depending on interference experienced by the media. The MSRP Attribute Propagation (35.2.4) supports a *bandwidthAvailabilityChanged* notification when bandwidth increases or decreases across the media. When a bandwidth changed is encountered, MAP will reassess reservation requests to maintain appropriate bandwidth utilization.

C.2 DMN on MoCA

NOTE—The discussion that follows is based on terminology found in the MoCA MAC/PHY Specifications v1.1 and v2.0 [B55] and [B56].

C.2.1 DMN Selection on MoCA Network

C.2.1.1 DMN-capable node discovery

A DMN-capable node shall append the *IEEE DMN Device Attribute Information Element* (C.2.1.2) to the L2ME payload of the Device Discovery Protocol SUBMIT L2ME transaction message specified in the MoCA MAC/PHY Specification v2.0 [B56].

Upon completion of the L2ME Device Discovery transaction, all the DMN-capable nodes of the MoCA network share the same information as follows:

a) Which MoCA nodes are DMN capable
b) Which MoCA node is selected as the DMN

If no DMN is selected, the DMN selection shall be performed (C.2.1.3).

C.2.1.2 IEEE DMN Device Attribute IE

C.2.1.2.1 General

The fields of the IEEE DMN Device Attribute IE are specified in Figure C-5 and C.2.1.2.2 through C.2.1.2.7. The general format of the Device Attribute Information Element is described in the MoCA MAC/PHY Specification v2.0 [B56].

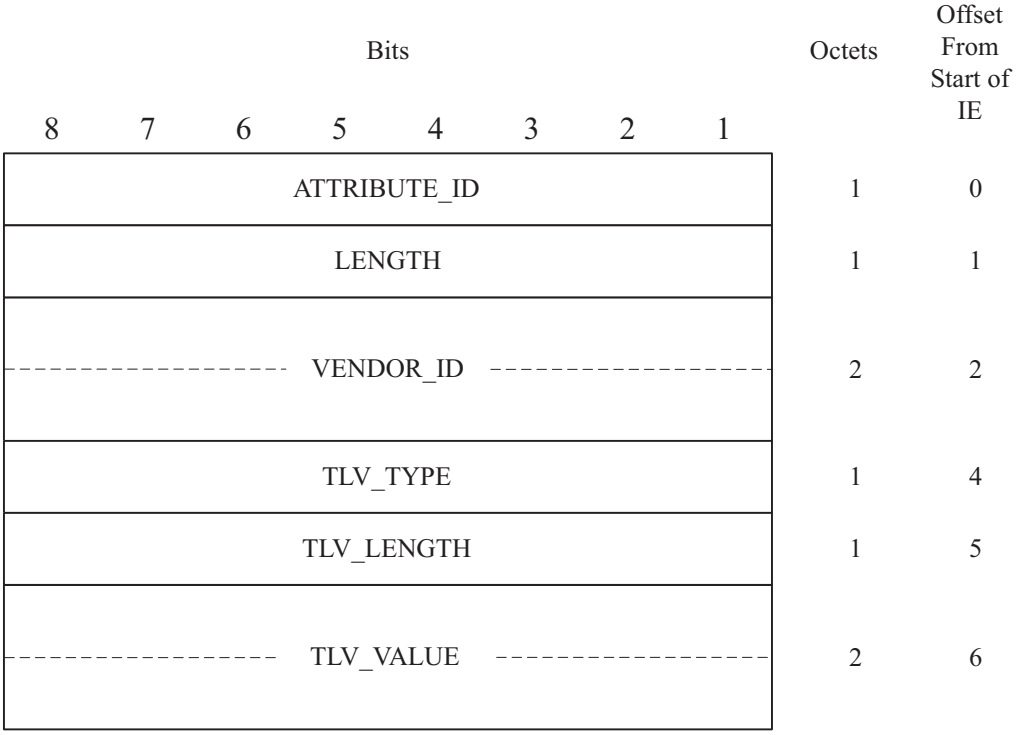


Figure C-5—IEEE DMN Device Attribute IE

C.2.1.2.2 ATTRIBUTE_ID (Enumeration8)

The value of the ATTRIBUTE_ID is 0xFF.

C.2.1.2.3 LENGTH (UInteger8)

The value of the LENGTH is 1.

NOTE—The actual length of the Attribute IE in bits is (LENGTH + 1) × 32.

C.2.1.2.4 VENDOR_ID (Enumeration16)

The value of VENDOR_ID is 0x0090 (IEEE 802.1 AVB).

C.2.1.2.5 TLV_TYPE (Enumeration16)

The value of the TLV_TYPE is 1 (SRP).

C.2.1.2.6 TLV_LENGTH (UInteger8)

The length of the TLV in octets is 4.

C.2.1.2.7 TLV_VALUE (Octet2)

The meaning of the field of the TLV_VALUE are specified as described in C.2.1.2.7.1 through C.2.1.2.7.3.

C.2.1.2.7.1 DMNcapable (Bit 0 - Boolean)

A value of 1 indicates the node is capable of acting as the DMN of the network. A value of 0 indicates the node is not capable to act as a DMN.

C.2.1.2.7.2 DMNselected (Bit 1 - Boolean)

A value of 1 indicates the node has been selected as the DMN of the network. A value of 0 indicates the node is not the selected DMN.

C.2.1.2.7.3 Reserved (Bit 2..15)

These bits are reserved for future use.

C.2.1.3 DMN selection and confirmation

If either 1) the *NODE_BITMASK* field into MAP frames indicates that the selected DMN has been removed from the network (due to failure, power state/down, etc.) or 2) the DMN node discovery (C.2.1.1) does not indicate a DMN selected node, the DMN-capable node with the lowest node ID will start acting as the DMN and confirm the selection to the other DMN-capable nodes by generating a L2ME DMN Confirmation Transaction (C.2.1.3.1).

NOTE—"MAP frame" is defined in the MoCA MAC/PHY Specification v1.1 [B55].

C.2.1.3.1 L2ME DMN Confirmation Transaction

C.2.1.3.1.1 Overview of DMN Confirmation Transaction

Figure C-6 provides an overview of the signals exchanged among the nodes during an L2ME DMN Confirmation Transaction. As shown in the figure, the NC node starts the transaction either when it receives a Submit L2ME Frame from a node (called the DMN Selected Entry Node for that Transaction) or on its own. The transaction includes two L2ME Waves. The details of each message exchanged during the DMN Confirmation Transaction are provided below.

C.2.1.3.1.2 DMN Confirmation Submit

The DMN Confirmation Transaction starts when the DMN Selected Entry Node sends a Submit L2ME Frame to the NC.

The general fields of the Submit L2ME frame are as specified in section 2.2.3.1 of the MoCA MAC/PHY Specification v1.1 [B55]. The parameters in the Submit L2ME Frame are set as follows:

a) VENDOR_ID (see C.2.1.2.4)
b) TRANS_TYPE = 0x1 (SRP)
c) TRANS_SUBTYPE = 0x1 (DMN Confirmation)
d) WAVE0_NODEMASK = (DMN-capable nodes)
e) MSG_PRIORITY = 0xF0
f) TXN_LAST_WAVE_NUM = 0x1
g) L2ME_PAYLOAD = 0 bytes

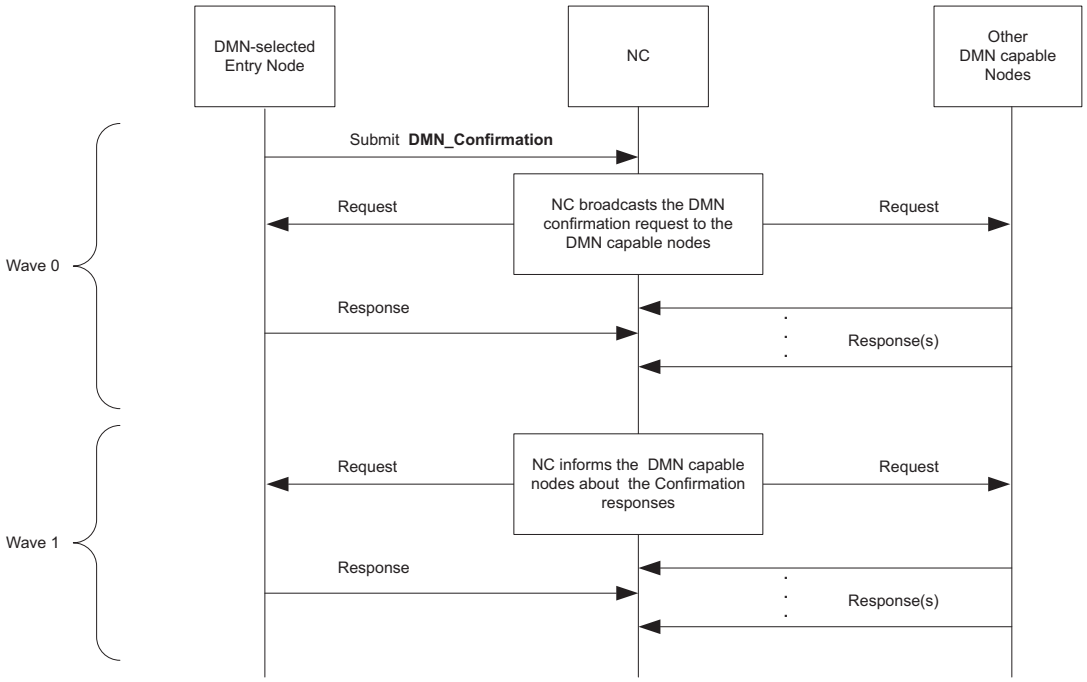


Figure C-6—DMN Confirmation Transaction

C.2.1.3.1.3 Request L2ME Frame of Wave 0 of DMN Confirmation Transaction

In the Wave 0 that follows the DMN Confirmation Submit message, the NC node initiates a Request L2ME Frame based on the Submit L2ME Frame.

The general fields of the Request L2ME frame are as specified in section 2.2.3.2 of the MoCA MAC/PHY Specification v1.1 [B55].

C.2.1.3.1.4 Response L2ME Frame of Wave 0 of DMN Confirmation Transaction

Each of the requested DMN-capable nodes sends a Response L2ME Frame to acknowledge the confirmation request.

The general fields of the Response L2ME frame are as specified in 2.2.3.3 of the MoCA MAC/PHY Specification v1.1 [B55]. The parameters in the Response L2ME Frame are set as follows:

a) RESP_STATUS <INTERPRETED> = ’1’
b) RESP_STATUS <IN_NEXT_WAVE> = ’1’
c) L2ME_PAYLOAD = 0 bytes

C.2.1.3.1.5 Request L2ME Frame of Wave 1 of DMN Confirmation Transaction

In Wave 1, the NC node informs the DMN-capable nodes about the acknowledgment results from Wave 0. The NC node initiates Wave 1 using a Request L2ME Frame with the “concatenated” type of L2ME_PAYLOAD.

The general fields of the Request L2ME frame are as specified in section 2.2.3.1 of the MoCA MAC/PHY Specification v1.1 [B55]. The “concatenated“ L2ME_Payload is as specified in Table 2-4 of the MoCA MAC/PHY Specification v1.1 [B55].

C.2.1.3.1.6 Response L2ME Frame of Wave 1 of DMN Confirmation Transaction

The DMN Confirmation Transaction is completed when the DMN Selected Entry node and the other DMN-capable nodes send their final Response L2ME Frame to the NC node.

The general fields of the Response L2ME frame are as specified in section 2.2.3.3 of the MoCA MAC/PHY Specification v1.1 [B55]. The parameters in the Response L2ME Frame are set as follows:

a) RESP_STATUS <INTERPRETED> = ’1’
b) RESP_STATUS <IN_NEXT_WAVE> = ’0’
c) L2ME_PAYLOAD = 0 bytes

C.2.2 MoCA network bandwidth management

The MSRP service within the MoCA network manages the MoCA bandwidth for the MSRP streams by invoking the MoCA native PQoS transactions. The DMN shall map the MSRP Attribute Declaration and the resultant MAD declarations as described in Table C-1.

Table C-1—SRP to MoCA PQoS Transaction mapping

MSRP Attribute	MAD Primitive	MoCA PQoS Transactions	Description
Talker Advertise	MAD_Join.request(new)	Create PQoS Flow	Query bandwidth without reservation (see NOTE)
Listener Ready or Listener Ready Failed	MAD_Join.request(new)	Create PQoS Flow	Reserve bandwidth for a stream
Listener Ready or Listener Ready Failed	MAD_Join.request()	Update PQoS Flow	Renew the bandwidth reservation (leased time) for a stream
Talker or Listener Leave	MAD_Leave.request()	Delete PQoS Flow	Free bandwidth associated with a stream
NOTE—MoCA PQoS APIs do not include a Bandwidth Query-specific API. Therefore, bandwidth is queried by invoking a CreatePQoSFlow reservation for more bandwidth than the network could provide. The request will fail and CreatePQoSFlow will then return a failure status that includes the bandwidth available for reservations.			

Table C-2 describes the mapping between SRP TSpec components and MoCA PQoS TSPEC parameters.

Table C-2—SRP TSpec to MoCA TSPEC mapping

SRP TSpec	MoCA PQoS TSPEC
MaxFrameSize	Max Packet Size
MaxFrameSize × MaxIntervalFrames	Peak Data Rate
MaxFrameSize × MaxIntervalFrames × Class B class measurement interval (34.4)	(Max) Burst Size

Table C-3 describes the mapping of the SRP StreamID to MoCA PQoS Flow transactions. The MoCA Flow parameters includes a 32-bit field that allows an application, like SRP, to store application-specific information. SRP will use this field (FLOW_TAG) to store the 16-bit unique ID portion of the StreamID.

Table C-3—SRP StreamID to MoCA PQoS Flow transaction mapping

SRP StreamID	MoCA PQoS Flow Transaction		
	Transaction	L2ME Payload	Field
MAC Address	Create PQoS Flow Update PQoS Flow	Submit	PACKET_DA
	Query PQoS Flow	Response	
16-bit Unique ID	Create PQoS Flow Update PQoS Flow	Submit	FLOW_TAG
	Query PQoS Flow	Response	

C.3 DMNs on IEEE 802.11 media

NOTE—Even though IEEE Std 802.11 is not a CSN, it uses the same DMN concepts described below.

From the bandwidth reservation standpoint an IEEE 802.11 BSS network is modeled as a Bridge as illustrated by Figure C-7, Figure C-8, and Figure C-9. Each STA-AP link, STA-AP-STA link and optional STA-STA DLS direct link is equivalent to the path from an input to an output Bridge's port.

An IEEE 802.11 BSS provides a single entity called the Designated MSRP Node (DMN) (35.1.1) to manage the BSS bandwidth resources for the MSRP streams.

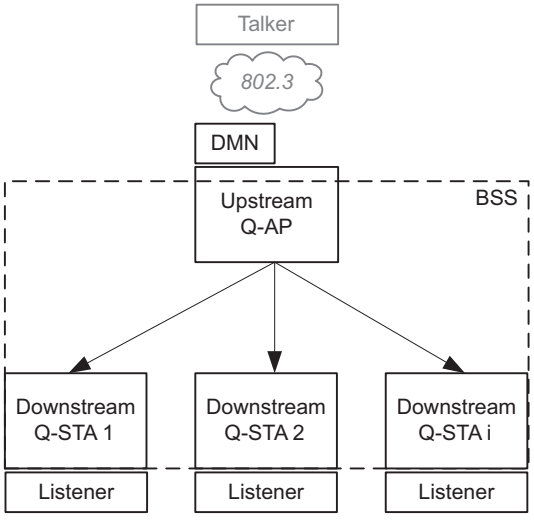


Figure C-7—Bandwidth reservation—bridge model for IEEE 802.11 BSS (STA downstream Port)

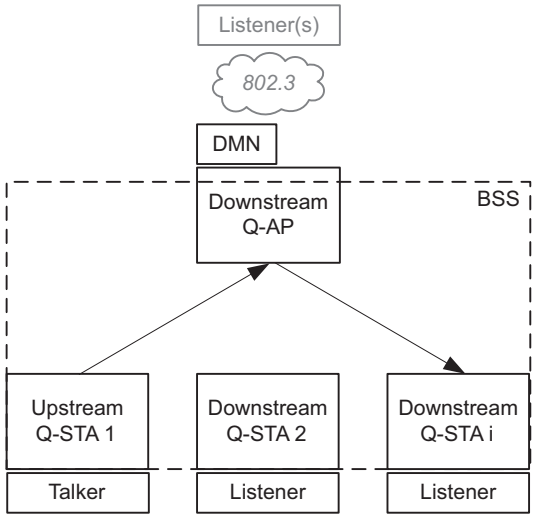


Figure C-8—Bandwidth reservation—bridge model for IEEE 802.11 BSS (STA upstream Port)

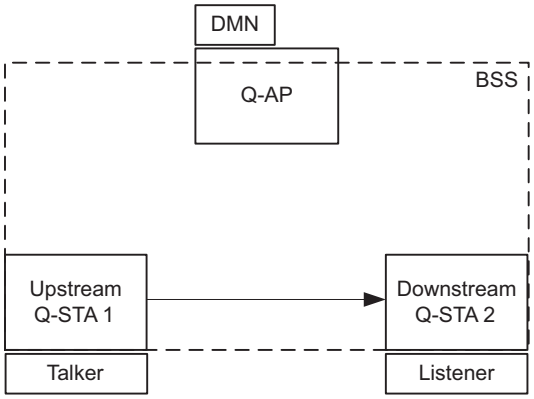


Figure C-9—Bandwidth reservation—bridge model for IEEE 802.11 BSS (direct link setup)

C.3.1 MSRP handling

MSRPDUs are transparently transported by the IEEE 802.11 BSS network and delivered to the DMN.

The DMN maps the MSRP commands into IEEE 802.11 MLME TS commands and interacts with the AP through the AP's MLME SAP.

Figure C-10 through Figure C-13 describe the flow of information between the MSRP and IEEE 802.11 entities, and corresponding over the air IEEE 802.11 frames. Figure C-10 is an example of the IEEE 802.11 bandwidth query process associated with an MSRP Talker Advertise.

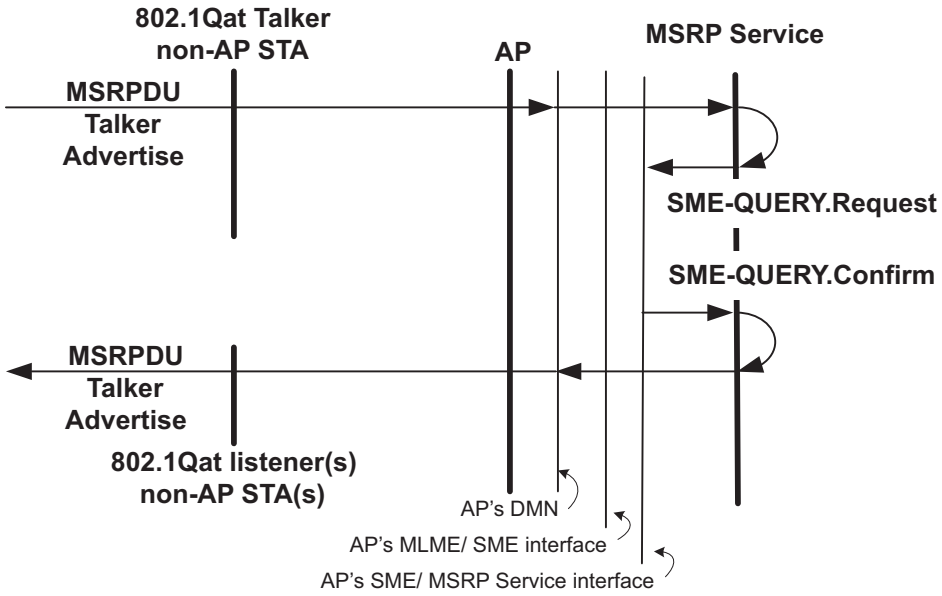


Figure C-10—MSRP/IEEE 802.11 query flows

Figure C-10 is an example of the reservation process associated with a Listener non-AP STA requesting a Stream from the Talker non-AP STA. The diagram at the left of the figure shows the Listener non-AP STA sending a Listener Ready (A) through the AP's MSRP Service, which then propagates that Listener Ready (B) to the Talker non-AP STA. The message flow on the right of the figure shows the corresponding IEEE 802.11 message exchanges associated with the two Listener Readys (A & B).

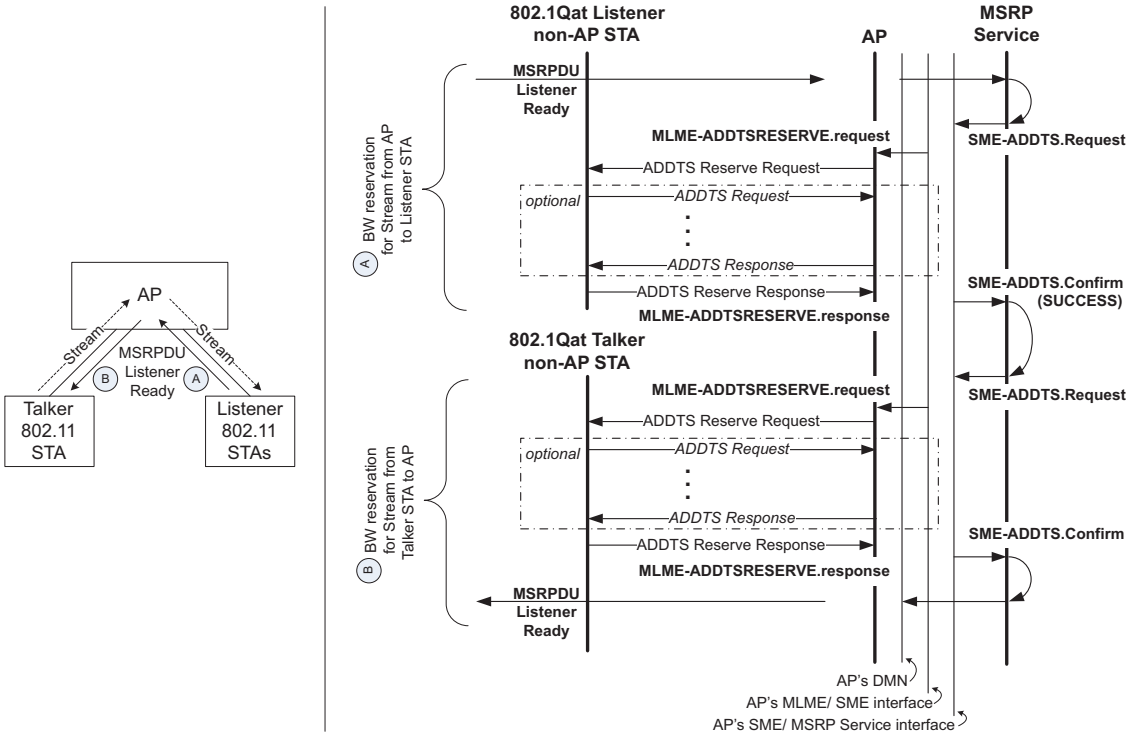


Figure C-11—MSRP/802.11 Talker STA to Listener STA reservation flows

There are two reservations (A & B) required to allow the Stream to flow from Talker to Listener. In Figure C-11, Figure C-12, and Figure C-13, the reservation process must be an atomic operation so, if either reservation fails, then both reservations shall be removed and the MSRP attributes updated accordingly.

Figure C-12 is an example of the reservation process associated with a "Bridged" Listener requesting a Stream from a Talker non-AP STA. The Listener sends a Listener Ready (A) from the "Bridged" side of the network and bandwidth is reserved as explained in SRP (Clause 35). The IEEE 802.11 message exchanges associated with the Listener Ready (B) propagating to the Talker non-AP STA are also shown.

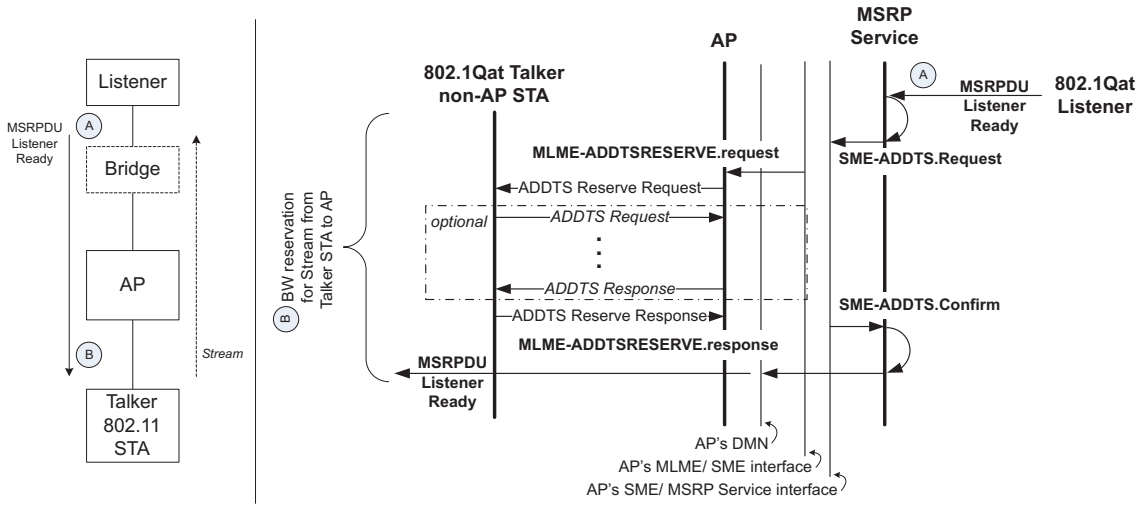


Figure C-12—MSRP/802.11 "Bridged" Listener to Talker STA reservation flows

Figure C-13 is an example of the reservation process associated with a Listener non-AP STA requesting a Stream from a "Bridged" Talker. The Listener non-AP STA sends a Listener Ready (A) through the AP's MSRP Service, resulting in the IEEE 802.11 message exchanges shown. The reservation process associated with the Listener Ready (B) sent to the "Bridged" Talker is explained in SRP (Clause 35).

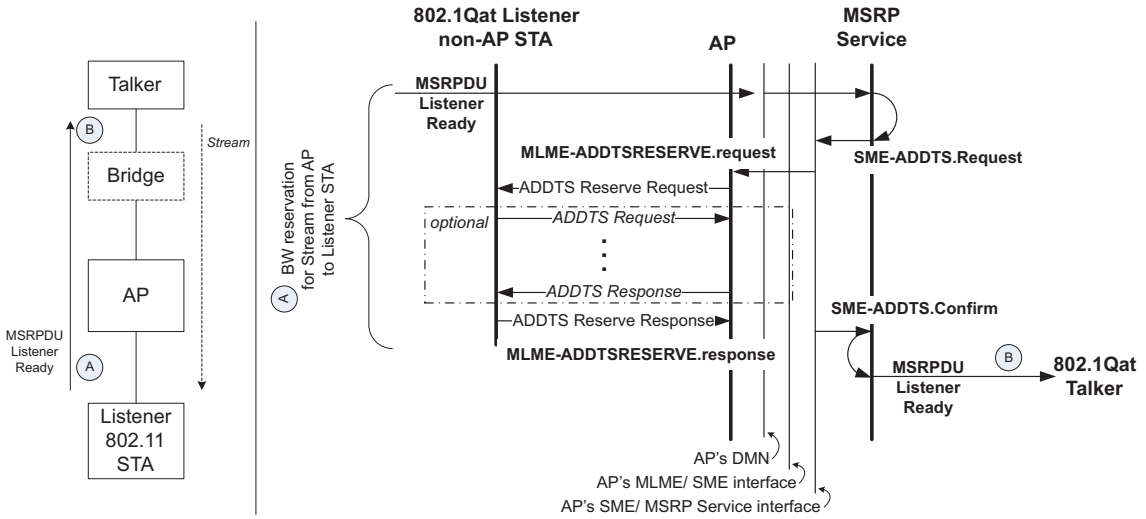


Figure C-13—MSRP/802.11 Listener STA to "Bridged" Talker reservation flows

The IEEE 802.11 message exchanges shown in the preceding three figures are explained in more detail as follows:

a) BBS nodes identify MSRPDUs by their Group Destination Address (35.2.2.1) and EtherType (35.2.2.2) and send these PDUs to the AP.
b) The AP forwards the MSRPDUs to the MSRP service on the DMN.
c) The DMN translates the MSRP TSpec parameters into an equivalent IEEE 802.11 TSPEC and invokes DMN-SME interface primitives with the AP as follows:
    1) When the DMN receives a Talker Advertise message that originated from an upstream BSS node, the DMN invokes QoS Query transactions (SME-QUERY.Request) with the BSS QoS AP (i.e., HC where dot11RobustAVStreamingImplemented is true) to check whether the bandwidth advertised in the message's TSpec is available on each upstream to downstream node link of the BSS. In addition the DMN maps the MSRPDU's TSpec with the message's StreamID.
    2) When the DMN receives a Listener Ready message originated from a downstream BSS node, the DMN invokes a QoS Reservation transaction (SME-ADDTS.Request) with the BSS QoS manager to reserve the bandwidth associated with the message's StreamID on the downstream to upstream BSS node link.

       The IEEE 802.11 BSS QoS AP on receipt of a SME-ADDTS.Request from the DMN shall make a determination about whether to accept the request or deny the request. The algorithm to be used by the BSS QoS AP to make this determination is an implementation detail.

       If the BSS QoS AP decides to accept the request, the AP shall derive a medium time value from the parameters specified in the SME-ADDTS.Request. The BSS QoS AP shall then generate an ADDTS Reserve Request frame in which the medium time value is included and transmit it to the appropriate SRP Talker (BSS upstream) and Listener (BSS downstream) nodes. The appropriate SRP Talker or Listener node replies to this ADDTS Reserve Request frame with an ADDTS Reserve Response frame indicating if the node accepts the reservation request. One or more ADDTS Request and ADDTS Response frames might be exchanged prior to the ADDTS Reserve Response frame.

       If the BSS QoS AP or Listener/Talker node decides to reject the request, it shall respond to the DMN with SME-ADDTS.confirm with a ResultCode of Rejected. The confirm primitive may also include a TSPEC, which the BSS QoS AP can accept, if specified in a subsequent SME-ADDTS.request.

NOTE—The TSPEC included in the SME-ADDTS.confirm is based on the result of the negotiations (labeled optional in Figure C-11 through Figure C-13) with the upstream BSS node. As a result the TSPEC included in the SME-ADDTS.confirm may be different from the one in the SME-ADDTS.request from the DMN.

d) After the DMN completes the BSS QoS transactions (SME-QUERY.Confirm or SME-ADDTS.Confirm as appropriate), the DMN behaves as an MSRP application on a Bridge and propagates MSRP attributes (35.2).

C.3.2 BSS DMN selection

The DMN shall be co-located with the device that supports the QoS AP function in the BSS.

C.3.3 BSS network bandwidth management

The MSRP service within the IEEE 802.11 network manages the BSS bandwidth for the MSRP streams by invoking the MLME QoS services. The DMN shall map the MLME services as described in Table C-4.

Table C-4—SRP to MLME QoS Services mapping

MSRP Attribute	MAD Primitive	SME QoS Services	Description
Talker Advertise	MAD_Join.request(new)	SME-QUERY	Query bandwidth without reservation
Listener Ready or Listener Ready Failed	MAD_Join.request(new)	SME-ADDTS	Reserve bandwidth for a stream
Listener Ready or Listener Ready Failed	MAD_Join.request()	SME-ADDTS[a]	Renew the bandwidth reservation (leased time) for a stream
Talker or Listener Leave	MAD_Leave.request()	SME-DELTS	Free bandwidth associated with a stream

[a] Bandwidth renewal is not required as long as the reservation is already established.

C.3.3.1 MSRPDU Encapsulation/De-encapsulation

In order to preserve the priority of an MSRPDU when traversing through an IEEE 802.11 network not using a Length/Type field in the MSDU, the priority shall be encapsulated while the MSRPDU is in the IEEE 802.11 network and shall be de-encapsulated as it exits. See IEEE Std 802.11 for additional information.

NOTE—For example if the priority of the MSRPDU is 4, DEI=0 and VID = 1893 the equivalent VLAN tag field (32 bits) is 81-00-87-65. When the frame enters the IEEE 802.11 network, the encapsulated 802.11 LLC header is AA-AA-03-00-00-00-81-00-87-65-08-00, where AA-AA-03-00-00-00-81-00-87-65 is the SNAP encoded VLAN header. When the frame exits the IEEE 802.11 network a de-encapsulation operation is performed and the resulting VLAN tag field is 81-00-87-65.

C.3.3.2 QoS Maintenance Report

An SRP DMN may obtain QoS Maintenance Report using IEEE 802.11 Transmit Stream/Category Measurement Requests and processing the corresponding Transmit Stream/Category Measurement Reports. The Transmit Stream/Category Measurement Request is sent to both the SRP Talker (BSS upstream) and the SRP Listener (BSS downstream) nodes. Triggers are set on appropriate conditions such that Transmit Stream/Category Measurement Reports are generated only when predefined thresholds are breached. See 9.4.2.21.11 of IEEE Std 802.11-2016 [B14] for details.

NOTE—This provides an indication to SRP (35.2.4) that bandwidth has changed.

C.3.3.3 SRP TSpec to IEEE 802.11 TSPEC mapping

SR Class B traffic has three parameters associated with it, namely delay budget per IEEE 802.11 hop (20 ms), **MaxFrameSize** (?1500 bytes) and **MaxIntervalFrames** (units of 4000 frames per second). IEEE 802.11 TSPECs include a Minimum PHY rate that is derived from the SR Class B parameters as described below:

a) Overhead = 10-byte VLAN tag + 8 byte Protocol definition = 18 bytes.
b) Mean Data Rate = (SRP TSpec **MaxFrameSize** + overhead) × 4000 × SRP TSpec **MaxIntervalFrames** bytes/second.
c) The Mean Data Rate is also the Max Data Rate (since it is assumed that MSDU size is fixed).
d) Assuming 70% × efficiency between the MAC and the PHY this translates into
(10/7) × (SRP TSpec **MaxFrameSize** + overhead) × 4000 × SRP TSpec **MaxIntervalFrames** bytes/second, or
(10/7) × 8 × (SRP TSpec **MaxFrameSize** + overhead) × 4000 × SRP TSpec **MaxIntervalFrames** bits/second.
e) Minimum PHY Rate is therefore
(10/7) × 8 × (SRP TSpec **MaxFrameSize** + overhead) × 4000 × SRP TSpec **MaxIntervalFrames** bits/second.

NOTE—For example, with 1500 and 1 for **MaxFrameSize** the above turns into 69.394285 Mb/s. Or, with 64 and 1 for **MaxFrameSize** and **MaxIntervalFrames** the above turns into 3.748571 Mb/s.

Table C-5 describes the mapping between SRP TSpec components and IEEE 802.11 QoS TSPEC parameters for the mandatory EDCA-AC mode.

Table C-5—EDCA-AC for AV Streams

TSPEC parameter		SR Class B
TSINFO	TID	5
	Direction	Up, Down
	Access Policy	10 (EDCA)
	ACK Policy	10 (No Ack) / 11 (Block Ack)
	APSD	0
	Aggregation	Yes
	Priority	**5**
Nominal MSDU Size[a]		**SRP TSpec MaxFrameSize+ 18 (also set bit 15 to a 1)**
Maximum MSDU Size		**SRP TSpec MaxFrameSize + 18**
Peak Data Rate		**(SRP TSpec MaxFrameSize + 18) × 4000 × SRP TSpec MaxIntervalFrames**
Minimum PHY Rate[b]		**(10/7) × 8 × (SRP TSpec MaxFrameSize + 18) × 4000 × SRP TSpec MaxIntervalFrames**
Delay Bound		**20 ms**
Surplus Bandwidth Allowance[c]		1.2

[a] bit15 set to indicate that the MSDU size is fixed.
[b] Assuming 70% efficiency between the MAC and the PHY.
[c] 20% surplus allocation.

Table C-6 describes the mapping between SRP **TSpec** components and IEEE 802.11 QoS TSPEC parameters for the optional HCCA mode.

Table C-6—HCCA for AV Streams

TSPEC parameter		SR Class B
TSINFO	TID	5
	Direction	Up, Down
	Access Policy	01 (HCCA)
	ACK Policy	10 (No Ack) / 11 (Block Ack)
	APSD	0
	Aggregation	Yes
	Priority	**5**
Nominal MSDU Size[a]		**0**
Maximum MSDU Size		**SRP TSpec MaxFrameSize+ 18**
Minimum Service Interval		10 ms
Maximum Service Interval		10 ms
Inactivity Interval		0
Minimum Data Rate		0
Mean Data Rate		**0**
Maximum Burst Size		**(SRP TSpec MaxFrameSize + 18) × 4000 × SRP TSpec MaxIntervalFrames × 10^{-2}**
Minimum PHY Rate[b]		**(10/7) × 8 × (SRP TSpec MaxFrameSize+ 18) × 4000 × SRP TSpec MaxIntervalFrames**
Peak Data Rate		**(SRP TSpec MaxFrameSize + 18) × 4000 × SRP TSpec MaxIntervalFrames**
Delay Bound		20 ms
Surplus Bandwidth Allowance[c]		1.2

[a] Bit 15 set to indicate that the MSDU size is fixed.
[b] Assuming 70% efficiency between the MAC and the PHY.
[c] 20% surplus allocation.

Annex D

(normative)

IEEE 802.1 Organizationally Specific TLVs

D.1 Requirements of the IEEE 802.1 Organizationally Specific TLV sets

The IEEE 802.1 Organizationally Specific TLVs may be supported in conjunction with any of the destination MAC addresses identified by IEEE Std 802.1AB for LLDPDU transmission.

If any IEEE 802.1 Organizationally Specific TLV set is supported, all IEEE 802.1 Organizationally Specific TLVs that are identified as members of that TLV set shall be supported. All IEEE 802.1 Organizationally Specific TLVs shall conform to the LLDPDU bit and octet ordering conventions of IEEE Std 802.1AB.

The IEEE 802.1 Organizationally Specific TLVs specified in this standard are listed in Table D-1. Other standards can also define IEEE 802.1 Organizationally Specific TLVs. The “TLV set name” column identifies the TLV set to which each TLV belongs. Any additions or changes to these TLVs will be included in this annex.

Table D-1—IEEE 802.1 Organizationally Specific TLVs

IEEE 802.1 subtype	TLV name	TLV set name	TLV reference	Feature clause reference
01	Port VLAN ID	basicSet	D.2.1	6.9
02	Port And Protocol VLAN ID	basicSet	D.2.2	6.12
03	VLAN Name	basicSet	D.2.3	12.10.2.1.3
04	Protocol Identity	basicSet	D.2.4	D.2.4
05	VID Usage Digest	basicSet	D.2.5	D.2.5
06	Management VID	basicSet	D.2.6	D.2.6
07	Link Aggregation TLV	basicSet	IEEE Std 802.1AX	IEEE Std 802.1AX
08	Congestion Notification	cnSet	D.2.7	Clause 33
09	ETS Configuration TLV	dcbxSet	D.2.8	Clause 38
0A	ETS Recommendation TLV	dcbxSet	D.2.9	Clause 38
0B	Priority-based Flow Control Configuration TLV	dcbxSet	D.2.10	Clause 38
0C	Application Priority TLV	dcbxSet	D.2.11	Clause 38
0D	EVB TLV	evbSet	D.2.12	D.2.12
0E	CDCP TLV	evbSet	D.2.13	D.2.13
10	Application VLAN TLV	dcbxSet	D.2.14	Clause 38

D.2 Organizationally Specific TLV definitions

In the TLV definitions that follow, any fields that are labeled as "Reserved" are transmitted as zero and ignored on receipt.

NOTE—In the case of a Port supported by Link Aggregation (IEEE Std 802.1AX), these TLVs apply to the aggregation, not the individual links. Since sending multiple copies is allowed, an implementation can send these TLVs with the same values on each individual link, but a TLV received on any individual link applies to the aggregation.

D.2.1 Port VLAN ID TLV

The Port VLAN ID TLV is an optional fixed length TLV that allows a VLAN Bridge Port to advertise the port VLAN identifier (PVID) that is associated with untagged or priority tagged frames (see 6.9).

Figure D-1 shows the Port VLAN ID TLV format.

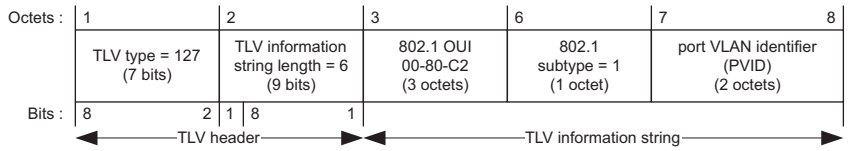


Figure D-1—Port VLAN ID TLV format

D.2.1.1 port VLAN identifier (PVID)

The PVID field shall contain the VID for the Bridge Port as defined in 6.9. A value of zero shall be used if the system either does not know the PVID or does not support Port-based VLAN operation.

D.2.1.2 Port VLAN ID TLV usage rules

An LLDPDU should contain no more than one Port VLAN ID TLV.

D.2.2 Port And Protocol VLAN ID TLV

The Port And Protocol VLAN ID TLV is an optional TLV that allows a Bridge Port to advertise a port and protocol VLAN identifier (PPVID). Figure D-2 shows the Port And Protocol VLAN ID TLV format.

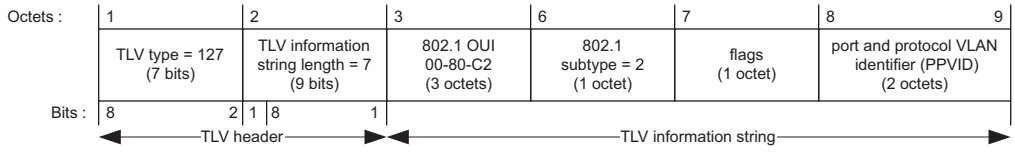


Figure D-2—Port And Protocol VLAN ID TLV format

D.2.2.1 flags

The flags field shall contain a bit map indicating the port and protocol VLAN capability and status as defined in Table D-2.

Table D-2—Port and protocol capability/status

Bit	Function	Value/meaning
0	Reserved for future standardization	—
1	Port and protocol VLAN supported	1 = supported 0 = not supported
2	Port and protocol VLAN enabled	1 = enabled 0 = not enabled
3–7	Reserved for future standardization	(set to zero)

D.2.2.2 port and protocol VLAN identifier (PPVID)

The PPVID field shall contain the PPVID number for this IEEE 802 LAN station. If the port is not capable of supporting port and protocol VLANs and/or the port is not enabled with any port and protocol VLAN, the PPVID number should be zero.

D.2.2.3 Port And Protocol VLAN ID TLV usage rules

Port And Protocol VLAN ID TLVs are subject to the following rules:

a) If more than one Port And Protocol VLAN ID TLV is defined for a port, the PPVID value shall be different from any other PPVID defined for the port.
b) If the support bit (bit 1) of the flag field indicates that the port is not capable of supporting port and protocol VLANs but the enabled bit (bit 2) indicates that the port is enabled with one or more port and protocol VLANs, the Port And Protocol VLAN ID TLV is interpreted as containing an error and will be discarded.
c) If the PPVID reference number is greater than 4094, the Port And Protocol VLAN ID TLV is interpreted as containing an error and is discarded.

D.2.3 VLAN Name TLV

The VLAN Name TLV is an optional TLV that allows an IEEE 802.1Q-compatible IEEE 802 LAN station to advertise the assigned name of any VLAN with which it is configured.

Figure D-3 shows the VLAN Name TLV format.

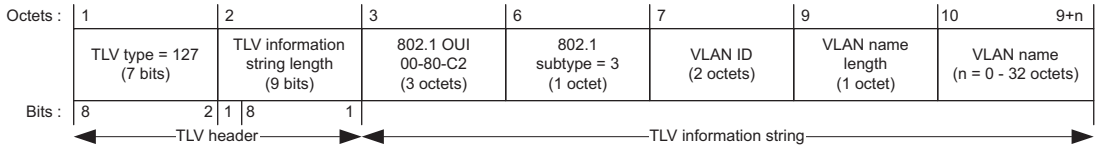


Figure D-3—VLAN Name TLV format

D.2.3.1 TLV information string length

The TLV information string length field shall contain the length, in octets, of the (VLAN name + 7).

D.2.3.2 VLAN ID (VID)

The VLAN ID field shall contain the VID number associated with the VLAN name.

D.2.3.3 VLAN name length

The VLAN name length field shall contain the length, in octets, of the VLAN name. A VLAN name length of zero indicates that there is no VLAN name associated with this VLAN.

D.2.3.4 VLAN name

If present, the VLAN name field shall contain the VLAN's name. If implementations support IETF RFC 4363, the dot1QVLANStaticName object should be used for this field.

D.2.3.5 VLAN Name TLV usage rules

If more than one VLAN Name TLV is defined for a port, the VID and the associated VLAN name combination shall be different from any other VID and VLAN name combination defined for the port.

D.2.4 Protocol Identity TLV

The Protocol Identity TLV is an optional TLV that allows an IEEE 802 LAN station to advertise particular protocols that are accessible through the port. Figure D-4 shows the protocol identity TLV format.

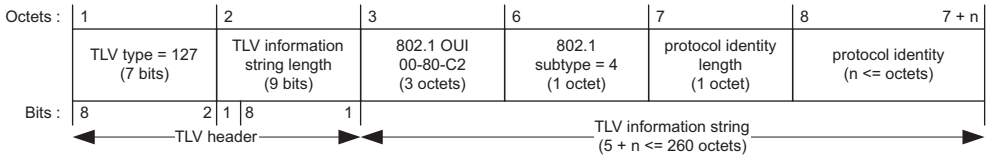


Figure D-4—Protocol Identity TLV format

D.2.4.1 TLV information string length

The TLV information string length field shall contain the length, in octets, of the (protocol identity + 5).

D.2.4.2 protocol identity length

The protocol identity length field shall contain the length, in octets, of the protocol identity.

D.2.4.3 protocol identity

The protocol identity field shall contain the first n octets of the protocol after the layer 2 addresses (i.e., for example, starting with the EtherType field) that the sender would like to advertise. The value of *n* is determined by the need for the protocol to disambiguate itself. The protocol information string shall include enough octets to allow the receiver to correctly identify the protocol and its version. To advertise spanning tree protocols, for example, the protocol identity field would need to include at least eight octets: IEEE 802.3 length (two octets), LLC addresses (two octets), IEEE 802.3 control (one octet), Protocol ID (two octets), and the protocol version (one octet).

D.2.4.4 Protocol Identity TLV usage rules

If more than one Protocol Identity TLV is defined for a port, the protocol identity field value shall be different from any other Protocol Identity TLV defined for the port.

D.2.5 VID Usage Digest TLV

The VID Usage Digest TLV is an optional TLV that allows an IEEE Std 802.1Q-compatible IEEE 802 LAN station to advertise the value of a VID Usage Digest associated with the system. The value of the VID Usage Digest is obtained by applying the CRC32 function (see IEEE Std 802.3) to a VID Usage Table having a fixed length of 512 octets. A bit of the VID Usage Table contains the value PBB-TE-USAGE (binary 1) if the corresponding element of the MST Configuration Table (8.9.1) contains the value PBB-TE MSTID (hex FFE) and otherwise contains the value NON-PBB-TE-USAGE (binary 0).

Figure D-5 shows the VID Usage Digest TLV format.

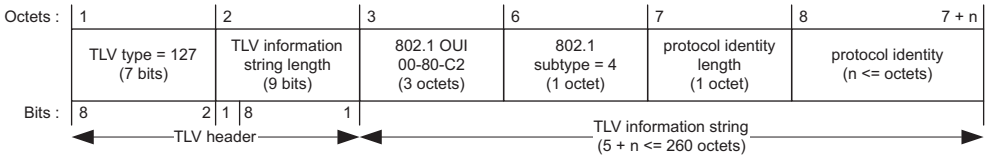


Figure D-5—VID Usage Digest TLV format

D.2.5.1 VID Usage Digest

The VID Usage Digest field shall contain a VID Usage Digest value obtained by applying the CRC32 function to the 512-octet VID Usage Table. A bit of the VID Usage Table contains the value PBB-TE-USAGE (binary 1) if the corresponding element of the MST Configuration Table (8.9.1) contains the value PBB-TE MSTID (hex FFE) and otherwise contains the value NON-PBB-TE-USAGE (binary 0).

D.2.6 Management VID TLV

The Management VID TLV is an optional TLV that allows an IEEE 802.1Q-compatible IEEE 802 LAN station to advertise the value of a Management VID associated with the system.

Figure D-6 shows the Management VID TLV format.

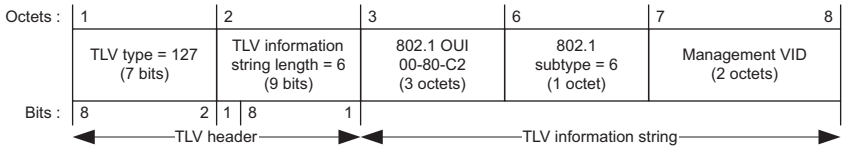


Figure D-6—Management VID TLV format

D.2.6.1 Management VID

The Management VID field shall contain the value configured for the Management VID, or the value 0 if a Management VID has not been provisioned.

D.2.7 Congestion Notification TLV

The TLV illustrated in Figure D-7 is encoded into each LLDP message transmitted by a system that is configured to support congestion notification on one or more priority values.

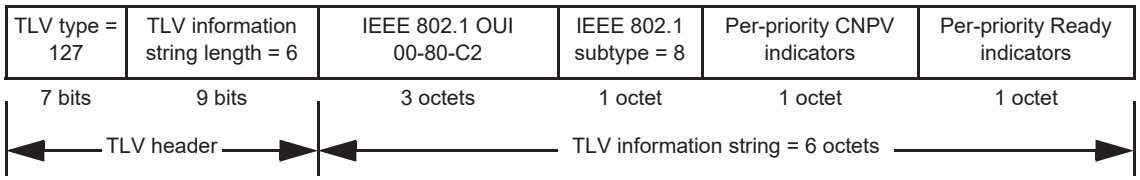


Figure D-7—Congestion Notification TLV format

A system shall transmit no more than one Congestion Notification TLV in a single LLDPDU. If a system receives an LLDPDU with more than one Congestion Notification TLV, the behavior of the receiving system is unspecified. A system shall not transmit a Congestion Notification TLV with all of the Per-priority CNPV indicators (D.2.7.3) clear (0).

D.2.7.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.7.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the Congestion Notification TLV. This does not count the TLV type and TLV information string length fields. It is equal to 6.

D.2.7.3 Per-priority CNPV indicators

A bit vector, one per priority value, containing all eight of the cnpdXmitCnpvCapable variables (32.4.7) for this port. The LSB of the octet carries priority 0's cnpdXmitCnpvCapable variable, and the MSB that of priority 7.

D.2.7.4 Per-priority Ready indicators

A bit vector, one per priority value, containing all eight of the cnpdXmitReady variables (32.4.8) for this port. The LSB of the octet carries priority 0's cnpdXmitReady variable, and the MSB that of priority 7.

D.2.8 ETS Configuration TLV

The TLV illustrated in Figure D-8 is encoded into each LLDP message and may be transmitted by a system in order to indicate the ETS configuration. Shall be sent using Asymmetric attribute passing (38.4.1).

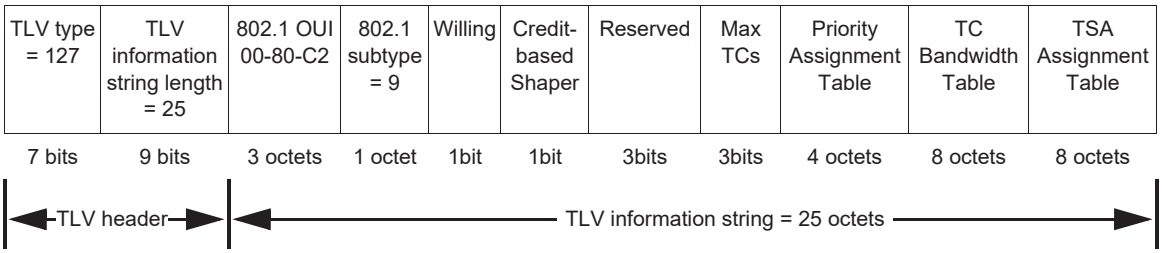


Figure D-8—ETS Configuration TLV format

D.2.8.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.8.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the ETS Configuration TLV. This does not count the TLV type and TLV information string length fields. It is equal to 25.

D.2.8.3 Willing

The Willing bit. A value of one indicates that the station is willing to accept configurations from the remote station.

D.2.8.4 Credit-based Shaper

The Credit-based Shaper bit. A value of one indicates that the station supports the Credit-based Shaper transmission selection algorithm (see Table 8-6 and Clause 34).

D.2.8.5 Max TCs

A 3-bit unsigned integer where the value of the integer is the maximum number of traffic classes that the implementation can support with the value 0 used when a device supports 8.

D.2.8.6 Priority Assignment Table

Table D-3 shows the layout of the priority assignment table.

Table D-3—Priority assignment table

Octets:	1		2		3		4	
	Priority 0	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6	Priority 7
Bits:	7 4	3 0	7 4	3 0	7 4	3 0	7 4	3 0

The table consists of one 4-bit entry per Priority, where:

a) 0–7 indicate the Priority is mapped to the corresponding traffic class; and
b) All other values are Reserved.

D.2.8.7 TC Bandwidth Table

Table D-4 shows the layout of the traffic class bandwidth table.

Table D-4—Traffic class bandwidth assignment table

Octets:	1	2	3	4	5	6	7	8
	TC% 0	TC% 1	TC% 2	TC% 3	TC% 4	TC% 5	TC% 6	TC% 7

The table consists of one 8-bit entry per traffic class, and always contains 8 entries. Each entry:

a) Indicates the current TCBandwidth percentage configured for each traffic class N where N is 0 to 7.
b) Total shall equal 100 (implies valid range is 0–100 for each entry).

NOTE—While it is intended that only TCs configured for ETS will have a bandwidth value associated with them, it is possible, during configuration changes, to have situations where a TC is not configured for ETS but has a nonzero TCBandwidth percentage. In this case, the sum of all the TCBandwidth percentages is still equal to 100, but the TC bandwidth percentages of the non-ETS TCs would be unused bandwidth and reallocated to the ETS TCs.

D.2.8.8 TSA Assignment Table

Table D-5 shows the layout of the Transmission Selection Algorithm (TSA) Assignment Table.

Table D-5—TSA Assignment Table

Octets:	1	2	3	4	5	6	7	8
	Traffic Class 0	Traffic Class 1	Traffic Class 2	Traffic Class 3	Traffic Class 4	Traffic Class 5	Traffic Class 6	Traffic Class 7

The table consists of one 8-bit entry per traffic class. Each entry indicates the Transmission selection algorithm to be used for that traffic class as defined in Table 8-6. A value of 255 indicates a Vendor-specific Transmission selection algorithm.

D.2.9 ETS Recommendation TLV

The TLV illustrated in Figure D-9 is encoded into each LLDP message and may be transmitted by a system in order to indicate a recommendation on how ETS should be configured. A Willing system may receive a recommendation TLV that utilizes more Traffic Classes than the receiving system supports. In this case the receiving system may assign the received recommendations to match its capabilities. Shall be sent using Asymmetric attribute passing (38.4.1).

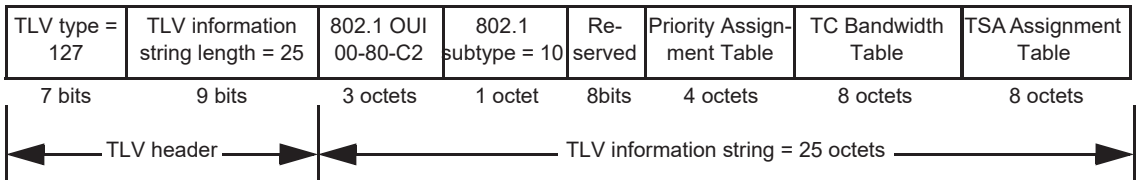


Figure D-9—ETS Recommendation TLV format

D.2.9.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.9.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the ETS Recommendation TLV. This does not count the TLV type and TLV information string length fields. It is equal to 25.

D.2.9.3 Priority Assignment Table

Table D-3 shows the layout of the priority assignment table.

See D.2.8.6 for description of table entries.

D.2.9.4 TC Bandwidth Table

Table D-4 shows the layout of the Traffic Class bandwidth assignment table.

See D.2.8.7 for description of table entries.

D.2.9.5 TSA Assignment Table

Table D-5 shows the layout of the TSA Assignment Table.

See D.2.8.8 for description of table entries.

D.2.10 Priority-based Flow Control Configuration TLV

The TLV illustrated in Figure D-10 is encoded into each LLDP message and may be transmitted by a system in order to indicate how PFC should be configured. Shall be sent using Symmetric attribute passing.

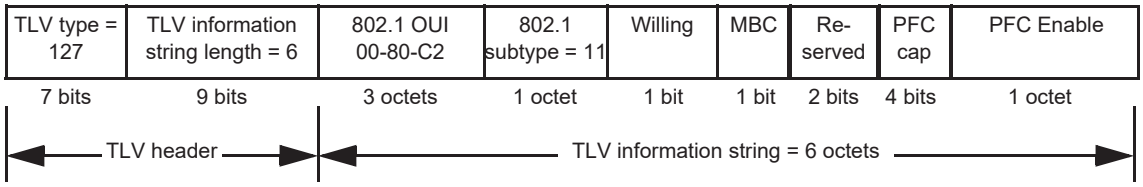


Figure D-10—Priority-based Flow Control Configuration TLV format

D.2.10.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.10.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the Priority-based Flow Control Configuration TLV. This does not count the TLV type and TLV information string length fields. It is equal to 6.

D.2.10.3 Willing

The Willing bit. A value of one indicates that the station is willing to accept configurations from the remote station.

D.2.10.4 MBC

The MACsec Bypass Capability Bit. If set to zero, the sending station is capable of bypassing MACsec processing when MACsec is disabled. If set to one, the sending station is not capable of bypassing MACsec processing when MACsec is disabled (see Clause 36).

D.2.10.5 PFC cap

A 4-bit unsigned integer, PFC cap (PFC capability) indicates the device's limitation of how many traffic classes may simultaneously support PFC.

NOTE 1—PFC may be enabled on up to eight traffic classes allowing each priority to be independently paused.

NOTE 2—In a DCB environment at least one priority would generally have PFC enabled.

D.2.10.6 PFC Enable

Table D-6 shows the layout of the PFC Enable bit vector.

Table D-6—PFC Enable bit vector

Octet:	1							
	Priority 7	Priority 6	Priority 5	Priority 4	Priority 3	Priority 2	Priority 1	Priority 0
Bits:	7	6	5	4	3	2	1	0

A bit vector of 8 bits, one per priority:

a) A one indicates PFC is enabled on the priority.
b) A zero indicates that PFC is disabled on the priority.
c) Local policy in each end of the link decides whether to use the priority if the configuration does not match.

D.2.11 Application Priority TLV

The TLV illustrated in Figure D-11 is encoded into each LLDP message and may be transmitted by a system in order to indicate the application priority table. This TLV is informational and used to indicate to a peer station the local configuration.

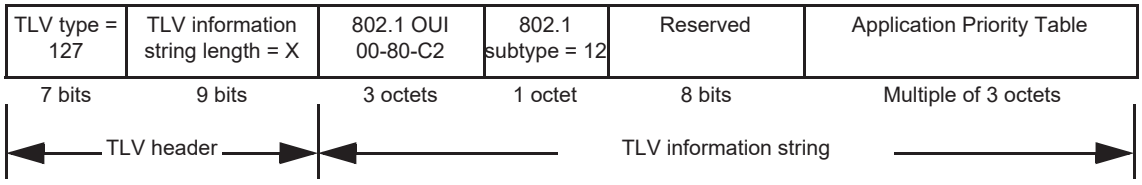


Figure D-11—Application Priority TLV format

D.2.11.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.11.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the Application Priority TLV. This does not count the TLV type and TLV information string length fields. The length for the Application Priority TLV is variable depending on the number of Application Priorities specified. The length shall be 5 plus a multiple of 3 octets.

D.2.11.3 Application Priority Table

Table D-7 shows the layout of a 3-octet entry in the Application Priority Table field.

Table D-7—Application Priority Table Entry format

Octets:	1			2	3
	Priority	Reserved	Sel	Protocol ID	
Bits:	8 6	5 4	3 1	8 1	8 1

The priority field is a 3-bit unsigned integer indicating the priority for which the Protocol ID is being used.

The meaning of the Protocol ID field is determined by the Sel field. Allowed values for the Sel field are shown in Table D-8.

Table D-8—Sel field values

Sel value	Protocol ID value
0	Reserved
1	0: Default application priority. For use when application priority is not otherwise specified. 1–1535: Reserved. 1536–65 535: An EtherType
2	Well Known Port number over TCP, or Stream Control Transmission Protocol (SCTP) [B36].
3	Well Known Port number over UDP, or Datagram Congestion Control Protocol (DCCP).
4	Well Known Port number over TCP, SCTP, UDP, or DCCP.
5	Differentiated Services Code Point (DSCP) value. The 6-bit DSCP value is stored in bits 1–6 of the low order octet of the Protocol ID field (octet 3 of the Application Priority Table Entry). Bits 7 and 8 and the high order octet of the Protocol ID field are set to zero. (See IETF RFC 2474 for the definition of the DSCP value.)
6–7	Reserved

NOTE—The port numbers shown are for identification (i.e., as assigned by IANA) instead of the actual port numbers being used in a particular deployment.

D.2.12 EVB TLV

The EVB TLV is used to:

a) Advertise a station or Bridge’s EVB capabilities.
b) Negotiate and activate common capabilities.

The EVB TLV is exchanged via LLDP and conforms to the LLDP TLV specification. The LLDP database carrying the EVB TLV is addressed using the Nearest Customer Bridge address. One LLDP database is built at the URP of each ER. If the EVB TLV is used for VDP NVO3 support, the LLDP database carrying the EVB TLV can also be accessed using a unicast MAC address.

The EVB TLV allows setting the EVB Bridge's C-VLAN component Port to operate in reflective relay. Reflective relay is implemented by changing the active topology enforcement rules described in 8.6.1 to allow forwarding on the reception Bridge Port. When reflective relay is enabled on a given Bridge Port, that port is a potential transmission port for frames received on that port.

The EVB TLV structure is illustrated in Figure D-12.

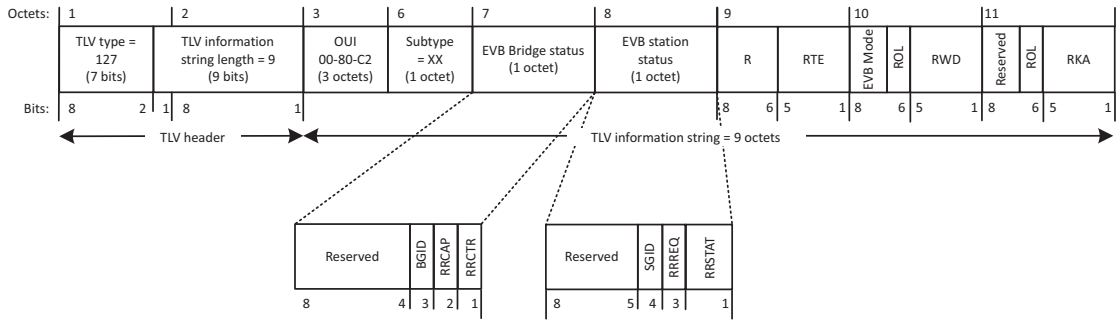


Figure D-12—EVB TLV format

The EVB TLV information string fields are as defined in D.2.12.1 through D.2.12.10.

D.2.12.1 OUI

The OUI used to identify the EVB TLV is the 802.1 OUI 00-80-C2.

D.2.12.2 Subtype

The subtype used to identify the EVB TLV is as shown in Table D-1.

D.2.12.3 EVB Bridge status

The EVB Bridge status field describes EVB capabilities that are supported by the EVB Bridge. If the sender of the TLV is an EVB Bridge (EVB Mode = EVB Bridge—see D.2.12.7), then the field reflects its own capabilities; if the sender of the TLV is an EVB station (EVB Mode = EVB station), then the field reflects the capabilities received from an attached EVB Bridge, or a value of zero if no TLV has been received from an attached EVB Bridge.

If the sender of the TLV is an nNVE (EVB Mode = NVO3 and NVE Role = nNVE—see D.2.12.7 and D.2.12.10), then the field reflects its own capabilities; if the sender of the TLV is a tNVE (EVB Mode = NVO3 and NVE Role = tNVE), then the field reflects the capabilities received from an attached nNVE, or a value of zero if no TLV has been received from an attached nNVE.

Each capability is represented by a single bit flag; a value of TRUE (1) indicates that the capability is supported, a value of FALSE (0) indicates that the capability is not supported.The capabilities are as defined in D.2.12.3.1 through D.2.12.3.5.

D.2.12.3.1 BGID

A value of TRUE indicates that the EVB Bridge wishes to control VID assignments and use the GroupID in VDP exchanges. A value of FALSE indicates that the EVB Bridge does not wish to make use of the Group ID in VDP exchanges.

If the EVB station sets SGID = TRUE, and the EVB Bridge also sets BGID = TRUE, then the EVB Bridge can control VID assignments and use the GroupID in VDP exchanges.

If the EVB station does not set SGID = TRUE, or the EVB Bridge does not set BGID = TRUE, then the EVB Bridge cannot control VID assignments or use the GroupID in VDP exchanges.

In an NVO3 Split-NVE scenario, BGID should always be set to TRUE by nNVE.

D.2.12.3.2 RRCAP

The RRCAP flag indicates the state of the EVB Bridge's reflectiveRelayCapable parameter (40.4.2).

If the EVB Bridge's reflectiveRelayCapable parameter is TRUE, and a TLV has been received by the EVB Bridge from an attached EVB station in which the value of RRREQ (D.2.12.4.2) is also TRUE, then the value of the EVB Bridge's operReflectiveRelayControl parameter (40.4.2) shall be set to TRUE. Otherwise, the value of the EVB Bridge's operReflectiveRelayControl parameter (40.4.2) shall be set to FALSE.

In an NVO3 Split-NVE scenario, RRCAP should be FALSE since reflective relay is not a required capability of nNVE.

D.2.12.3.3 RRCTR

The RRCTR flag indicates the state of the EVB Bridge's operReflectiveRelayControl parameter (40.4.2).

In an NVO3 Split-NVE scenario, RRCTR should be FALSE since RRREQ (D.2.12.4.2) received by nNVE is always FALSE.

D.2.12.3.4 V6CAP

This capability is valid only when NVE Mode is NVO3. A value of TRUE indicates that the nNVE supports the use of IPv6 addresses in the Filter Info field of the VDP association TLV. A value of FALSE indicates that the nNVE does not support the use of IPv6 addresses in that field. When both nNVE and tNVE set V6CAP = TRUE, then IPv6 addresses can be used in the Filter Info field in VDP exchanges; otherwise, IPv6 addresses cannot be used in the Filter Info field in VDP exchanges.

D.2.12.3.5 V4CAP

This capability is valid only when NVE Mode is NVO3. A value of TRUE indicates that the nNVE supports the use of IPv4 addresses in the Filter Info field of the VDP association TLV. A value of FALSE indicates that the nNVE does not support the use of IPv4 addresses in that field. When both nNVE and tNVE set V4CAP = TRUE, then IPv4 addresses can be used in the Filter Info field in VDP exchanges; otherwise, IPv4 addresses cannot be used in the Filter Info field in VDP exchanges.

D.2.12.4 EVB station status

The EVB station status field describes EVB capabilities that are supported by the EVB station. If the sender of the TLV is an EVB station (EVB Mode = EVB station—see D.2.12.7), then the field reflects its own capabilities; if the sender of the TLV is an EVB Bridge (EVB Mode = EVB Bridge), then the field reflects the capabilities received from an attached EVB station, or a value of zero if no TLV has been received from an attached EVB station.

If the sender of the TLV is a tNVE (EVB Mode = NVO3 and NVE Role = tNVE—see D.2.12.7 and D.2.12.10), then the field reflects its own capabilities; if the sender of the TLV is an nNVE (EVB Mode = NVO3 and NVE Role = nNVE), then the field reflects the capabilities received from an attached tNVE, or a value of zero if no TLV has been received from an attached tNVE.

Each capability is represented by a single bit flag; a value of TRUE (1) indicates that the capability is supported, a value of FALSE (0) indicates that the capability is not supported. The capabilities are as defined in D.2.12.4.1 through D.2.12.4.5.

D.2.12.4.1 SGID

A value of TRUE indicates that the EVB station can support the use of the GroupID.

If the EVB station sets SGID = TRUE, and the EVB Bridge also sets BGID = TRUE, then the EVB Bridge can control VID assignments and use the GroupID in VDP exchanges.

If the EVB station does not set SGID = TRUE, or the EVB Bridge does not set BGID = TRUE, then the EVB Bridge cannot control VID assignments or use the GroupID in VDP exchanges.

In an NVO3 Split-NVE scenario, SGID should always be set to TRUE by tNVE.

D.2.12.4.2 RRREQ

The RRREQ flag indicates the state of the EVB station's adminReflectiveRelayRequest parameter (40.4.3).

In an NVO3 Split-NVE scenario, RRREQ should always be set to FALSE in order to make sure reflective relay is not enabled.

D.2.12.4.3 RRSTAT

RRSTAT is a composite flag that indicates the state of the EVB station's operReflectiveRelayStatus parameter (40.4.3) as shown in Table D-9.

Table D-9—RRSAT flag values and meanings

Bit 1	Bit 2	Meaning
TRUE	FALSE	operReflectiveRelayStatus is TRUE
FALSE	FALSE	operReflectiveRelayStatus is FALSE
TRUE	TRUE	operReflectiveRelayStatus is Unknown
FALSE	TRUE	operReflectiveRelayStatus is Unknown

If a TLV has been received by the EVB station from an attached EVB Bridge in which the value of RRCTR (D.2.12.3.3) is TRUE, then the value of the EVB station's operReflectiveRelayStatus parameter (40.4.3) shall be set to TRUE. If a TLV has been received by the EVB station from an attached EVB Bridge in which the value of RRCTR (D.2.12.3.3) is FALSE, then the value of the EVB station's operReflectiveRelayStatus parameter (40.4.3) shall be set to FALSE. If no TLV has been received by the EVB station from an attached EVB Bridge, then the value of the EVB station's operReflectiveRelayStatus parameter (40.4.3) shall be set to Unknown.

In an NVO3 Split-NVE scenario, RRSTAT is always FALSE as RRCTR (D.2.12.3.3) received from nNVE is FALSE.

D.2.12.4.4 V6CAP

This capability is valid only when NVE Mode is NVO3. A value of TRUE indicates that the tNVE supports the use of IPv6 addresses in the Filter Info field of the VDP association TLV. A value of FALSE indicates that the tNVE does not support the use of IPv6 addresses in that field. When both nNVE and tNVE set V6CAP = TRUE, then IPv6 addresses can be used in the Filter Info field in VDP exchanges; otherwise, IPv6 addresses cannot be used in the Filter Info field in VDP exchanges.

D.2.12.4.5 V4CAP

This capability is valid only when NVE Mode is NVO3. A value of TRUE indicates that the tNVE supports the use of IPv4 addresses in the Filter Info field of the VDP association TLV. A value of FALSE indicates that the tNVE does not support the use of IPv4 addresses in that field. When both nNVE and tNVE set V4CAP = TRUE, then IPv4 addresses can be used in the Filter Info field in VDP exchanges; otherwise, IPv4 addresses cannot be used in the Filter Info field in VDP exchanges.

D.2.12.5 R

This field carries the maxRetries value for the ECP state machine (43.3.7.4). Both sides transmit the local value, and use the largest of the two values of R. If no remote value is available, then the local value is used.

D.2.12.6 RTE (retransmission exponent)

RTE is an EVB link or S-channel attribute used to calculate the minimum ECPDU retransmission time, ackTimerInit. The value of ackTimerInit, in ECP timer tics of 10 usec, is calculated as:

2^{RTE} ECP timer tics

Both sides transmit the local value, and use the largest of the two values of RTE for this calculation. If no remote value is available, then the greater of 2 ms and local value is used.

D.2.12.7 EVB Mode

The EVB Mode field represents the value of the EVBMode parameter (40.4) for the sender of the TLV, as shown in Table D-10.

Table D-10—EVB Mode values

EVBMode (40.4)	Field value
Not Supported	0
EVB Bridge	1
EVB station	2
NVO3	3

D.2.12.8 ROL (remote or local) and RWD (resource wait delay)

The RWD value transmitted by the EVB Bridge indicates the exponent value in use by the EVB Bridge for determining the value of the resourceWaitDelay variable (41.5.5.7). The value of resourceWaitDelay, in VDP timer tics of 10 usec, is calculated as:

2^{RWD} VDP timer tics

Both sides transmit the local value, and use the largest of the local and remote values of RWD in calculation of resourceWaitDelay or respWaitDelay variable (41.5.5.9); if there is no remote value available, the local (proposed) value is used. The Remote or Local (ROL) flag indicates whether the remote RWD value is in use (TRUE) or the local value is in use (FALSE) at the sending node.

D.2.12.9 ROL (remote or local) and RKA (reinit keep alive)

The RKA value transmitted by the EVB station indicates the exponent value in use by the EVB station for determining the value of the reinitKeepAlive variable (41.5.5.5). The value of reinitKeepAlive, in VDP timer tics of 10 usec, is calculated as:

2^{RKA} VDP timer tics

Both sides transmit the local value, and use the largest of the local and remote values of RKA in calculation of reinitKeepAlive or toutKeepAlive variable (41.5.5.13); if there is no remote value available, the local (proposed) value is used. The Remote or Local (ROL) flag indicates whether the remote RKA value is in use (TRUE) or the local value is in use (FALSE) at the sending node.

D.2.12.10 NVE Role

NVE Role field represents the value of the NVERole parameter (40.5) for the sender of the TLV, as shown in Table D-11. This field is useful only when EVBMode = NVO3.

Table D-11—NVE Role values

NVERole (40.5)	Field values
nNVE	00
tNVE	01
Reserved	10, 11

D.2.13 CDCP TLV

The EVB station and Bridge both use the same LLDP TLV to configure S-channels (see Figure D-13). This TLV is in LLDP Organizationally Specific TLV format (see IEEE Std 802.1AB). The S-channel's capabilities, requests, and running configuration is encoded in the information string of this TLV as defined in D.2.13.1D.2.13.1 through D.2.13.8.

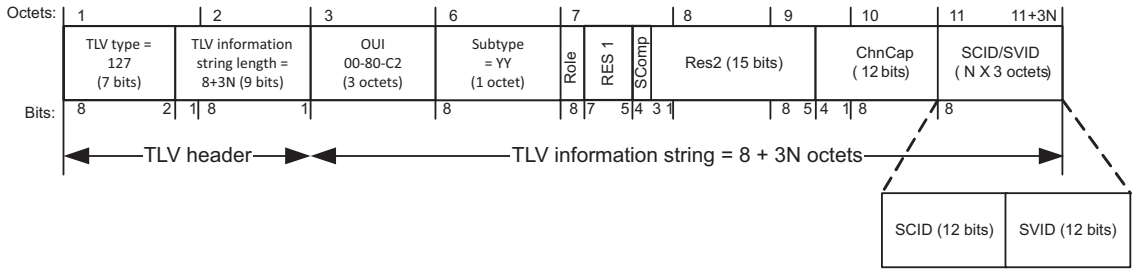


Figure D-13—CDCP TLV structure

D.2.13.1 OUI

The OUI used to identify the CDCP TLV is the 802.1 OUI 00-80-C2.

D.2.13.2 Subtype

The subtype used to identify the CDCP TLV is as shown in Table D-1.

D.2.13.3 Role

Role is a 1-bit field, defined as follows:

a) S(1)—Indicates the sender is operating in the station role, assigns channels numbers and a default SVID for the default channel 1, and requests SVID assignments from the neighboring 'B'.
b) B(0)—Indicates the sender is operating in the Bridge role, accepts S-channel configuration requests from its neighboring 'S' and that the sender will do the best it can to fill the SVID assignment requests from the neighboring 'S'.

D.2.13.4 RES1

RES1 is a 3-bit field, reserved for future standardization. This field is transmitted as zero and ignored on receipt.

D.2.13.5 SComp

SComp is a 1-bit field that indicates the presence or absence of an S-VLAN component for S-channel support. A value of 1 indicates TRUE, zero indicates FALSE.

NOTE—If this bit is zero, then the sender does not have a CDCP state machine, and the other fields in the TLV are not valid.

D.2.13.6 Res2

RES2 is a 15-bit field, reserved for future standardization. This field is transmitted as zero and ignored on receipt.

D.2.13.7 ChnCap

Channel capacity. Identifies the total number of S-channels, both assigned and available to be assigned, that the sender has.

D.2.13.8 SCID/SVID

An SCID/SVID pair exists for each S-channel that is currently supported by the sender. Each SCID/SVID pair consists of two 12-bit values, as follows:

a) SCID—indicates the index number of the S-channel. The station assigns S-channel numbers in the range 0–167. Zero is reserved. The S-channel index should be between 1 and the maximum number of S-channels supported by the port.
b) SVID—The VID assigned to the S-channel. The Bridge assigns SVIDs to channels in the range 1–0xffe. A station uses the 0 SVID to request an SVID assignment from the Bridge.

After the station receives the SVID assignment from the Bridge, it uses the SVID assigned value in all subsequent exchanges for that specific SCID (SCID/SVID pair).

NOTE 1—The first entry in the list of SCID/SVID pairs contains the default S-channel. (i.e., the first channel pair is <1,1>).

NOTE 2—A maximum of 167 S-channels can be supported. Other formats (assuming sequential SVIDs) could be defined to allow support for 4K+ S-channels.

NOTE 3—This listing can be sparse (in order to indicate arrival and removal of S-channels). The S-channel going away is indicated by removing the SCID/SVID pair.

NOTE 4—The order of the list determines the priority of SVID assignments. If the Bridge does not have resources for all channels, it assigns the first channels in the list.

D.2.14 Application VLAN TLV

The TLV illustrated in Figure D-14 is encoded into each LLDP message and may be transmitted by a system in order to indicate the application VLAN table. This TLV is informational and used to indicate to a peer station the local configuration.

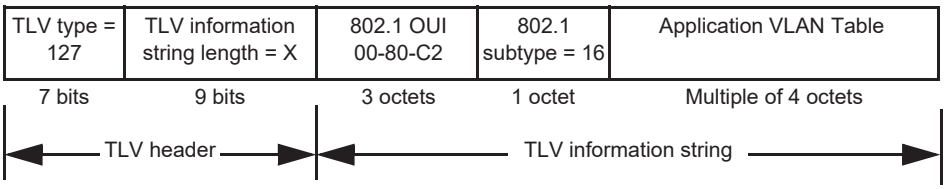


Figure D-14—Application VLAN TLV format

D.2.14.1 TLV type

A 7-bit integer value occupying the most significant bits of the first octet of the TLV. Always contains the value 127.

D.2.14.2 TLV information string length

A 9-bit unsigned integer, occupying the LSB of the first octet of the TLV (the MSB of the TLV information string length) and the entire second octet of the TLV, containing the total number of octets in the TLV information string of the Application VLAN TLV. This does not count the TLV type and TLV information string length fields. The length for the Application VLAN TLV is variable depending on the number of Application VLANs specified. The length shall be 4 plus a multiple of 4 octets.

D.2.14.3 Application VLAN Table

Table D-12 shows the layout of a 4 octet entry in the Application VLAN Table.

Table D-12—Application VLAN Table Entry format

Octets:	1		2			3		4	
Field:	VID			Reserved	Sel	Protocol ID			
Bits:	8	1	8	5	4	3	1	8	1	8	1

The VID field is a 12-bit unsigned integer indicating the VID of the VLAN for which the Protocol ID is being used.

The meaning of the Protocol ID field is determined by the Sel field. Allowed values for the Sel field are shown in Table D-13.

Table D-13—Sel field values

Sel value	Protocol ID value
0	Reserved
1	0: PVID. For use when an application VLAN is not otherwise specified. 1–1535: Reserved 1536–65 535: An EtherType.
2	Well Known Port number over TCP, or SCTP.
3	Well Known Port number over UDP, or DCCP.
4	Well Known Port number over TCP, SCTP, UDP, or DCCP.
5	Differentiated Services Code Point (DSCP) value. The 6-bit DSCP value is stored in bits 1–6 of the low order octet of the Protocol ID field (octet 4 of the Application VLAN Table Entry). Bits 7 and 8 and the high order octet of the Protocol ID field are set to zero. (See IETF RFC 2474 for the definition of the DSCP value.)
6–7	Reserved

The Application VLAN TLV may be exchanged between EVB station ERs (5.24.1) and EVB Bridges (5.23) with LLDP using the Nearest Customer Bridge address. This allows ERs sharing a LAN using S-channels (40.2) to use different VLANs for the same application.

NOTE 1—The Application VLAN TLV allows multiple VLANs to be associated with an application on a port. Issues involved with using multiple VLANs for an application on a port, such as resolving which IP subnetwork corresponds to which VLAN, are beyond the scope of this standard.

NOTE 2—Selection of different IEEE 802.1 paths may use different VLANs, which could be associated with different quality of service levels. This TLV may not apply to deployment cases where the VID is implied by other attributes of the frame, for example, by the IP subnet of the source IP address.

D.3 IEEE 802.1 Organizationally Specific TLV management

D.3.1 IEEE 802.1 Organizationally Specific TLV selection management

TLV selection management consists of providing the network manager with the means to select which specific IEEE 802.1 Organizationally Specific TLVs are enabled for inclusion in an LLDPDU. The following LLDP variables cross reference to LLDP local systems configuration MIB tables indicate which specific TLVs are enabled for the particular port(s) on the system. The specific port(s) through which each TLV is enabled for transmission may be set (or reset) by the network manager:

a) **mibXdot1PortVlanTxEnable:** This variable lists the VID of the port through which the referenced TLV is enabled for transmission.

b) **mibXdot1VlanNameConfigTxEnable:** This variable lists the different VLAN name/PPVID TLVs that are defined for the system, each with a bit map indicating the system ports through which the particular VLAN name TLV is enabled for transmission.

c) **mibXdot1ProtoVlanConfigTxEnable:** This variable lists the Port And Protocol VLAN TLVs that are defined for the system, each with a bit map indicating the system ports through which the particular Port And Protocol VLAN TLV is enabled for transmission.

d) **mibXdot1ProtocolConfigTxEnable:** This variable lists the protocol identity TLVs that are defined for the system, each with a bit map indicating the system ports through which the particular protocol TLV is enabled for transmission.

D.3.2 IEEE 802.1 managed objects—TLV variables

D.3.2.1 Port VLAN ID TLV managed objects

a) **PVID:** The port VLAN identifier (see D.2.1.1).

D.3.2.2 Port And Protocol VLAN ID TLV managed objects

a) **Port and protocol VLAN supported:** A flag indicating whether port and protocol VLANs are supported (see D.2.2.1).
b) **Port and protocol VLAN enabled:** A flag indicating whether port and protocol VLANs are enabled (see D.2.2.1).
c) **PPVID:** The advertised port and protocol VLAN identifier (see D.2.2.2).

D.3.2.3 VLAN Name TLV managed objects

a) **VID:** The VLAN identifier associated with the VLAN name (see D.2.3.2).
b) **VLAN name length:** The length of the VLAN name (see D.2.3.3).
c) **VLAN name:** The VLAN's name (see D.2.3.4).

D.3.2.4 Protocol Identity TLV managed objects

a) **protocol identity length:** The length of the protocol identity (see D.2.4.2).
b) **protocol identity:** The protocol's identity (see D.2.4.3).

D.3.2.5 VID Usage Digest TLV managed objects

a) **VID Usage Digest:** The VID Usage Digest value (see D.2.5.1)

D.3.2.6 Management VID TLV managed objects

a) **Management VID:** The Management VID value (see D.2.6.1)

D.3.2.7 Link Aggregation TLV managed objects

a) **aggregation status:** The capability and current aggregation status of the link (see IEEE Std 802.1AX).
b) **aggregated port ID:** The aggregated port identifier (see IEEE Std 802.1AX).

D.3.2.8 Congestion Notification TLV managed objects

a) **CNPV indicators:** A per-priority CNPV indicator vector (see D.2.7.3).
b) **CN ready indicators:** A per-priority ready indicator vector (see D.2.7.4).

D.3.2.9 EVB TLV managed objects

a) **EVB TLV:** see D.2.12.

D.3.2.10 CDCP TLV managed objects

a) **CDCP TLV:** see D.2.13.

D.4 PICS proforma for IEEE 802.1 Organizationally Specific TLV extensions[57] [58]

D.4.1 Implementation identification

Supplier	
Contact point for queries about the PICS	
Implementation Name(s) and Version(s)	
Other information necessary for full identification—e.g., name(s) and version(s) of machines and/or operating system names	
NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirement for full identification. NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model).	

D.4.2 Protocol summary, IEEE Std 802.1Q

Identification of protocol specification	IEEE Std 802.1Q-2022, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks
Identification of amendments and corrigenda to the PICS proforma that have been completed as part of the PICS	Amd. : Corr. : Amd. : Corr. :
Have any Exception items been required? (See A.3.3: The answer Yes means that the implementation does not conform to IEEE Std 802.1Q.)	No [ ] Yes [ ]

Date of Statement	

[57] Instructions for completing the PICS proforma are given in A.3.

[58] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this annex so that it can be used for its intended purpose and may further publish the completed PICS.

D.4.3 Major capabilities and options

Item	Feature	Status	References	Support
dot1basicSet	Is the IEEE 802.1 Organizationally Specific TLV basicSet implemented?	O.1	D.1, Table D-1	Yes [ ] No [ ]
dot1basictlv	Is each TLV in the IEEE 802.1 Organizationally Specific TLV basicSet implemented?			
	Port VLAN ID TLV	dot1basicSet:M	D.2.1	Yes [ ]
	Port And Protocol VLAN ID TLV	dot1basicSet:M	D.2.2	Yes [ ]
	VLAN Name TLV	dot1basicSet:M	D.2.3	Yes [ ]
	Protocol Identity TLV	dot1basicSet:M	D.2.4	Yes [ ]
	VID Usage Digest TLV	dot1basicSet:M	D.2.5	Yes [ ]
	Management VID TLV	dot1basicSet:M	D.2.6	Yes [ ]
	Link Aggregation TLV	dot1basicSet:M	IEEE Std 802.1AX	Yes [ ]
dot1cnSet	Is the IEEE 802.1 Organizationally Specific TLV cnSet implemented?	O.1	D.1, Table D-1	Yes [ ] No [ ]
dot1cntlv	Is each TLV in the IEEE 802.1 Organizationally Specific TLV lagSet implemented?			
	Link Aggregation TLV	dot1cnSet:M	IEEE Std 802.1AX	Yes [ ]
dot1evbSet	Is the IEEE 802.1 Organizationally Specific TLV evbSet implemented?	O.1	D.2.12, D.2.13, Table D-1	Yes [ ] No [ ]
dot1evbTlv	Is each TLV in the IEEE 802.1 Organizationally Specific TLV evbSet implemented?	dot1evbSet:M	D.2.12, D.2.13, Table D-1	Yes [ ] N/A [ ]
lldpmib	Which type of MIB is implemented (one is mandatory)?			
	SNMP is supported (if yes, answer item **snmpmib** and skip **equivstor**)	O.2	D.5	Yes [ ] No [ ]
	SNMP is not supported (if yes, answer **equivstor** and skip **snmpmib**)	O.2	D.5	Yes [ ] No [ ]
snmpmib	If the SNMP MIB is implemented, is the MIB module in conformance with the MIB groups indicated in Table D-14 for the operating mode being implemented?	M	D.5	Yes [ ]

D.4.3 Major capabilities and options *(continued)*

Item	Feature	Status	References	Support
equivstor	If the SNMP is not supported, is the provided storage and retrieval capability functionally equivalent with the indicated specifications of this clause for the operating mode being implemented?	M	D.2.1. D.2.2, D.2.3, D.2.4, and IEEE Std 802.1AX	Yes [ ]
dcbxSet	Is the IEEE 802.1 DCBX TLV set implemented?	O.1	Annex D	Yes [ ] No [ ]
dcbxtlv	Is each TLV in the IEEE 802.1 DCBX TLV set implemented?			
	ETS Configuration TLV	dcbxSet:M	D.2.8	Yes [ ]
	ETS Recommendation TLV	dcbxSet:M	D.2.9	Yes [ ]
	Priority-based Flow Control Configuration TLV	dcbxSet:M	D.2.10	Yes [ ]
	Application Priority TLV	dcbxSet:M	D.2.11	Yes [ ]
	Application VLAN TLV	dcbxSet:M	D.2.14	Yes [ ]

D.5 IEEE 802.1/LLDP extension MIB

D.5.1 Internet Standard Management Framework

LLDP MIBs are designed to operate in a manner consistent with the principles of the Internet Standard Management Framework, which describes the separation of a data modeling language (for example, SMIv2) from content-specific data models (for example, the LLDP remote systems MIB), and from messages and protocol operations used to manipulate the data (for example, SNMPv3).

For a detailed overview of the documents that describe the current Internet Standard Management Framework, refer to section 7 of IETF RFC 3410 (2002).

Managed objects are accessed via a virtual information store, termed the *Management Information Base* or *MIB*. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This clause specifies a MIB module that is compliant to the SMIv2, which is described in IETF STD 58, IETF RFC 2578, IETF RFC 2579, and IETF RFC 2580.

D.5.2 Structure of the IEEE 802.1/LLDP extension MIB

Table D-14 summarizes the particular object groups that are required for each operating mode. The implemented MIB shall comply with the MIB conformance section for the particular operating mode being supported.

Table D-14—IEEE 802.1 extension MIB object group conformance requirements

MIB group	Rx mode	Tx mode	Tx/Rx mode
lldpV2Xdot1ConfigGroup	M[a]	M	M
lldpV2Xdot1LocSysGroup	M	—	M
lldpV2Xdot1RemSysGroup	—	M	M
ifGeneralInformationGroup	M	M	M
lldpXdot1dcbxETSGroup	DCBX:M	DCBX:M	DCBX:M
lldpXdot1dcbxPFCGroup	DCBX:M	DCBX:M	DCBX:M
lldpXdot1dcbxApplicationPriorityGroup	DCBX:M	DCBX:M	DCBX:M
lldpXdot1dcbxApplicationVlanGroup	DCBX:M	DCBX:M	DCBX:M

[a]M=Mandatory.

Table D-15 shows the structure of the MIB and the relationship of the MIB objects to the LLDP operational status/control variables, LLDP statistics variables, and TLV variables.

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference

MIB table	MIB object	LLDP reference
Configuration group		
lldpV2Xdot1ConfigPortVlanTable		Augments lldpV2Xdot1ConfigPortVlanTable
	lldpV2Xdot1ConfigPortVlanTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpV2Xdot1ConfigVlanNameTable		Augments lldpV2Xdot1LocVlanNameEntry
	lldpV2Xdot1ConfigVlanNameTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpV2Xdot1ConfigProtoVlanTable		Augments lldpV2Xdot1LocProtoVlanEntry
	lldpV2Xdot1ConfigProtoVlanTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpV2Xdot1ConfigProtocolTable		Augments lldpV2Xdot1LocProtocolEntry
	lldpV2Xdot1ConfigProtocolTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpV2Xdot1ConfigVidUsageDigestTable		Augments lldpV2Xdot1LocVidUsageDigestEntry
	lldpV2Xdot1ConfigVidUsageDigestTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpV2Xdot1ConfigManVidTable		Augments lldpV2Xdot1LocManVidEntry
	lldpV2Xdot1ConfigManVidTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpXdot1CnConfigCnTable		Augments lldpV2Xdot1LocManVidEntry
	lldpXdot1CnConfigCnTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpXdot1EvbConfigEvbTable		Augments lldpV2Xdot1LocManVidEntry
	lldpXdot1EvbConfigEvbTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
lldpXdot1EvbConfigCdcpTable		Augments lldpV2Xdot1LocManVidEntry
	lldpXdot1EvbConfigCdcpTxEnable	Normal LLDPDUs, see IEEE Std 802.1AB
Local system information		
lldpV2Xdot1LocTable		D.2.1
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocPortVlanId	PVID, D.2.1.1
lldpV2Xdot1LocProtoVlanTable		D.2.2

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocProtoVlanId	PPVID, D.2.2.2
	lldpV2Xdot1LocProtoVlanSupported	flags, D.2.2.1
	lldpV2Xdot1LocProtoVlanEnabled	flags, D.2.2.1
lldpV2Xdot1LocVlanNameTable		D.2.3
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocVlanId	VID, D.2.3.2 (Table index)
	lldpV2Xdot1LocVlanName	VLAN name, D.2.3.4
lldpV2Xdot1LocProtocolTable		D.2.4
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocProtocolIndex	(Table index)
	lldpV2Xdot1LocProtocolId	protocol identity, D.2.4.3
lldpV2Xdot1LocVidUsageDigestTable		D.2.5
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocVidUsageDigest	VID usage digest, D.2.5.1
lldpV2Xdot1LocManVidTable		D.2.6
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocManVid	Management VID, D.2.6.1
lldpV2Xdot1LocLinkAggTable		IEEE Std 802.1AX
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocLinkAggStatus	aggregation status, IEEE Std 802.1AX
	lldpV2Xdot1LocLinkAggPortId	aggregated port ID, IEEE Std 802.1AX
lldpV2Xdot1LocCnTable		D.2.7
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocCNPVIndicators	CPNV indicators, D.2.7.3
	lldpV2Xdot1LocReadyIndicators	Ready indicators, D.2.7.4
lldpV2Xdot1LocEvbTlvTable		D.2.12
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocEvbTlvString	EVB TLV string, D.2.12
lldpV2Xdot1LocCDCPTlvTable		D.2.13
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1LocCDCPTlvString	CDCP TLV string, D.2.13
Remote system information		
lldpV2Xdot1RemTable		D.2.1

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemPortVlanId	PVID, D.2.1.1
lldpV2Xdot1RemProtoVlanTable		D.2.2
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemProtoVlanId	PPVID, D.2.2.2 (Table index)
	lldpV2Xdot1RemProtoVlanSupported	flags, D.2.2.1
	lldpV2Xdot1RemProtoVlanEnabled	flags, D.2.2.1
lldpV2Xdot1RemVlanNameTable		D.2.3
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemVlanId	VID, D.2.3.2 (Table index)
	lldpV2Xdot1RemVlanName	VLAN name, D.2.3.4
lldpV2Xdot1RemProtocolTable		D.2.4
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemProtocolIndex	(Table index)
	lldpV2Xdot1RemProtocolId	protocol identity, D.2.4.3
lldpV2Xdot1RemVidUsageDigest`V2`Table		D.2.5
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2Xdot1RemIndex	(Table index)
	lldpV2Xdot1RemVidUsageDigest`V2`	VID usage digest, D.2.5.1
lldpV2Xdot1RemManVid`V2`Table		D.2.6

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2Xdot1RemIndex	(Table index)
	lldpV2Xdot1RemManVidV2	Management VID, D.2.6.1
lldpV2Xdot1RemLinkAggTable		IEEE Std 802.1AX
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemLinkAggStatus	aggregation status, IEEE Std 802.1AX
	lldpV2Xdot1RemLinkAggPortId	aggregation port ID, IEEE Std 802.1AX
lldpV2Xdot1RemCnTable		D.2.7
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2LocPortIfIndex	(Table index)
	lldpV2Xdot1RemCNPVIndicators	CPNV indicators, D.2.7.3
	lldpV2Xdot1RemReadyIndicators	Ready indicators, D.2.7.4
lldpV2Xdot1RemEvbTlvTable		D.2.12
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemEvbTlvString	EVB TLV string, D.2.12
lldpV2Xdot1RemCDCPTlvTable		D.2.13
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2Xdot1RemCDCPTlvString	CDCP TLV string, D.2.13
lldpXdot1dcbxConfig extension group[a]		
lldpXdot1dcbxConfigETSConfigurationEntry		
	lldpXdot1dcbxConfigETSConfigurationTxEnable	D.2.8
lldpXdot1dcbxConfigETSRecommendationTable		

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpXdot1dcbxConfigETSRecommendationTxEnable	D.2.9
lldpXdot1dcbxConfigPFCTable		
	lldpXdot1dcbxConfigPFCTxEnable	D.2.10
lldpXdot1dcbxConfigApplicationPriorityTable		
	lldpXdot1dcbxConfigApplicationPriorityTxEnable	D.2.11
lldpXdot1dcbxConfigApplicationVlanTable		
	lldpXdot1dcbxConfigApplicationVlanTxEnable	D.2.14
lldpXdot1dcbxLocalData extension group[a]		
lldpXdot1dcbxLocETSBasicConfigurationTable		
	lldpXdot1dcbxLocETSConCreditBasedShaperSupport	D.2.8.4
	lldpXdot1dcbxLocETSConMaxTC	D.2.8.5
	lldpXdot1dcbxLocETSConWilling	D.2.8.3
	lldpXdot1dcbxLocETSConTrafficClassBandwidthTable	D.2.8.7
	lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmTable	D.2.8.8
lldpXdot1dcbxLocETSConPriorityAssignmentTable		
	lldpXdot1dcbxLocETSConPriority	D.2.8.6
	lldpXdot1dcbxLocETSConTrafficClass	D.2.8.6
lldpXdot1dcbxLocETSRecommendationTable		
	lldpXdot1dcbxLocETSRecoTrafficClassBandwidthTable	D.2.9.4
lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmTable		
	lldpXdot1dcbxLocETSRecoTSAPriority	D.2.9.5
	lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithm	D.2.9.5
lldpXdot1dcbxLocPFCBasicTable		
	lldpXdot1dcbxLocPFCWilling	D.2.10.3
	lldpXdot1dcbxLocPFCMBC	D.2.10.4
	lldpXdot1dcbxLocPFCCap	D.2.10.5
lldpXdot1dcbxLocPFCEnableTable		
	lldpXdot1dcbxLocPFCEnablePriority	D.2.10.6
	lldpXdot1dcbxLocPFCEnableEnabled	D.2.10.6
lldpXdot1dcbxLocApplicationPriorityAppTable		
	lldpXdot1dcbxLocApplicationPriorityAESelector	D.2.11.3
	lldpXdot1dcbxLocApplicationPriorityAEProtocol	D.2.11.3
	lldpXdot1dcbxLocApplicationPriorityAEPriority	D.2.11.3
lldpXdot1dcbxLocApplicationVlanAppTable		
	lldpXdot1dcbxLocApplicationVlanAESelector	D.2.14.3

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpXdot1dcbxLocApplicationVlanAEProtocol	D.2.14.3
	lldpXdot1dcbxLocApplicationVlanAEVlanId	D.2.14.3
lldpXdot1dcbxRemoteData extension group[a]		
lldpXdot1dcbxRemETSBasicConfigurationTable		
	lldpXdot1dcbxRemETSConCreditBasedShaperSupport	D.2.8.4
	lldpXdot1dcbxRemETSConMaxTC	D.2.8.5
	lldpXdot1dcbxRemETSConWilling	D.2.8.3
	lldpXdot1dcbxRemETSConTrafficClassBandwidthTable	D.2.8.7
	lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmTable	D.2.8.8
lldpXdot1dcbxRemETSConPriorityAssignmentTable		
	lldpXdot1dcbxRemETSConPriority	D.2.8.6
	lldpXdot1dcbxRemETSConTrafficClass	D.2.8.6
lldpXdot1dcbxRemETSRecommendationTable		
	lldpXdot1dcbxRemETSRecoTrafficClassBandwidthTable	D.2.9.4
lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmTable		
	lldpXdot1dcbxRemETSRecoTSAPriority	D.2.9.5
	lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithm	D.2.9.5
lldpXdot1dcbxRemPFCBasicTable		
	lldpXdot1dcbxRemPFCWilling	D.2.10.3
	lldpXdot1dcbxRemPFCMBC	D.2.10.4
	lldpXdot1dcbxRemPFCCap	D.2.10.5
lldpXdot1dcbxRemPFCEnableTable		
	lldpXdot1dcbxRemPFCEnablePriority	D.2.10.6
	lldpXdot1dcbxRemPFCEnableEnabled	D.2.10.6
lldpXdot1dcbxRemApplicationPriorityAppTable		
	lldpXdot1dcbxRemApplicationPriorityAESelector	D.2.11.3
	lldpXdot1dcbxRemApplicationPriorityAEProtocol	D.2.11.3
	lldpXdot1dcbxRemApplicationPriorityAEPriority	D.2.11.3
lldpXdot1dcbxRemApplicationVlanAppTable		
	lldpXdot1dcbxRemApplicationVlanAESelector	D.2.14.3
	lldpXdot1dcbxRemApplicationVlanAEProtocol	D.2.14.3
	lldpXdot1dcbxRemApplicationVlanAEVlanId	D.2.14.3
lldpXdot1dcbxAdminData extension group[a]		
lldpXdot1dcbxAdminETSBasicConfigurationTable		

Table D-15—IEEE 802.1/LLDP extension MIB object cross reference *(continued)*

MIB table	MIB object	LLDP reference
	lldpXdot1dcbxAdminETSConCreditBasedShaperSupport	D.2.8.4
	lldpXdot1dcbxAdminETSConMaxTC	D.2.8.5
	lldpXdot1dcbxAdminETSConWilling	D.2.8.3
	lldpXdot1dcbxAdminETSConTrafficClassBandwidthTable	D.2.8.7
	lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmTable	D.2.8.8
lldpXdot1dcbxAdminETSConPriorityAssignmentTable		
	lldpXdot1dcbxAdminETSConPriority	D.2.8.6
	lldpXdot1dcbxAdminETSConTrafficClass	D.2.8.6
lldpXdot1dcbxAdminETSRecommendationTable		
	lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthTable	D.2.9.4
lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmTable		
	lldpXdot1dcbxAdminETSRecoTSAPriority	D.2.9.5
	lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithm	D.2.9.5
lldpXdot1dcbxAdminPFCBasicTable		
	lldpXdot1dcbxAdminPFCWilling	D.2.10.3
	lldpXdot1dcbxAdminPFCMBC	D.2.10.4
	lldpXdot1dcbxAdminPFCCap	D.2.10.5
lldpXdot1dcbxAdminPFCEnableTable		
	lldpXdot1dcbxAdminPFCEnablePriority	D.2.10.6
	lldpXdot1dcbxAdminPFCEnableEnabled	D.2.10.6
lldpXdot1dcbxAdminApplicationPriorityAppTable		
	lldpXdot1dcbxAdminApplicationPriorityAESelector	D.2.11.3
	lldpXdot1dcbxAdminApplicationPriorityAEProtocol	D.2.11.3
	lldpXdot1dcbxAdminApplicationPriorityAEPriority	D.2.11.3
lldpXdot1dcbxAdminApplicationVlanAppTable		
	lldpXdot1dcbxAdminApplicationVlanAESelector	D.2.14.3
	lldpXdot1dcbxAdminApplicationVlanAEProtocol	D.2.14.3
	lldpXdot1dcbxAdminApplicationVlanAEVlanId	D.2.14.3

[a] The term Extension Group is used here to be consistent with LLDP (see IEEE Std 802.1AB).

D.5.3 Relationship to other MIBs

Version 2 of the IEEE 802.1 LLDP extension MIB module appears in D.5.5. Version 1 of the MIB module that was published in IEEE Std 802.1AB-2005 [B6] has been superseded by version 2 of the MIB module, and support of the version 2 module is a requirement for conformance to the required or optional capabilities (Clause 5 of IEEE Std 802.1AB-2009 [B7]) in IEEE Std 802.1AB-2009. The version 2 MIB module reflects

changes in indexation of the MIB objects that support the use of LLDP with multiple destination MAC addresses, as discussed in Clause 6 of IEEE Std 802.1AB-2009 [B7].

The relationship of the IEEE 802.1 LLDP extension MIB module to other MIBs, and coexistence between version 1 and version 2 implementations, is further discussed in 11.3 of IEEE Std 802.1AB-2009 [B7].

D.5.4 Security considerations for IEEE 802.1 LLDP extension MIB module

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write.[59] Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a nonsecure environment without proper protection can have a negative effect on network operations.

Setting the following objects to incorrect values can result in improper operation of LLDP when in the transmit mode:

a) lldpV2Xdot1ConfigPortVlanTxEnableV2
b) lldpV2Xdot1ConfigVlanNameTxEnable
c) lldpV2Xdot1ConfigProtoVlanTxEnable
d) lldpV2Xdot1ConfigProtocolTxEnable
e) lldpV2Xdot1ConfigVidUsageDigestTxEnable
f) lldpV2Xdot1ConfigManVidTxEnable

The following readable objects in this MIB module may be considered to be sensitive or vulnerable in some network environments:

g) MIB objects that are related to the transmit mode:
    1) lldpV2Xdot1LocPortVlanId
    2) lldpV2Xdot1LocProtoVlanSupported
    3) lldpV2Xdot1LocProtoVlanEnabled
    4) lldpV2Xdot1LocVlanName
    5) lldpV2Xdot1LocProtocolId
    6) lldpV2Xdot1LocVidUsageDigest
    7) lldpV2Xdot1LocManVidTxEnable
    8) lldpV2Xdot1LocLinkAggStatus
    9) lldpV2Xdot1LocLinkAggPortId
    10) lldpXdot1dcbxConfigETSConfigurationEntry
    11) lldpXdot1dcbxConfigPFCTable
    12) lldpXdot1dcbxLocETSBasicConfigurationTable
    13) lldpXdot1dcbxLocETSConPriorityAssignmentTable
    14) lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmTable
    15) lldpXdot1dcbxLocPFCBasicTable
    16) lldpXdot1dcbxLocPFCEnableTable
    17) lldpXdot1dcbxAdminETSBasicConfigurationTable
    18) lldpXdot1dcbxAdminETSConPriorityAssignmentTable
    19) lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmTable
    20) lldpXdot1dcbxAdminPFCBasicTable
    21) lldpXdot1dcbxAdminPFCEnableTable
    22) lldpXdot1dcbxLocApplicationPriorityAppTable
    23) lldpXdot1dcbxLocApplicationVlanAppTable
    24) lldpXdot1dcbxAdminApplicationPriorityAppTable

[59] In IETF MIB definitions, the MAX-ACCESS clause defines the type of access that is allowed for particular data elements in the MIB. An explanation of the MAX-ACCESS mappings is given in section 7.3 of IETF RFC 2578 (1999).

25) lldpXdot1dcbxAdminApplicationVlanAppTable

h) MIB objects that are related to the receive mode:
   1) lldpV2Xdot1RemPortVlanId
   2) lldpV2Xdot1RemProtoVlanSupported
   3) lldpV2Xdot1RemProtoVlanEnabled
   4) lldpV2Xdot1RemVlanName
   5) lldpV2Xdot1RemProtocolId
   6) lldpV2Xdot1RemVidUsageDigest
   7) lldpV2Xdot1RemManVidTxEnable
   8) lldpV2Xdot1RemLinkAggStatus
   9) lldpV2Xdot1RemLinkAggPortId
   10) lldpXdot1dcbxConfigETSConfigurationEntry
   11) lldpXdot1dcbxConfigPFCTable
   12) lldpXdot1dcbxRemETSBasicConfigurationTable
   13) lldpXdot1dcbxRemETSConPriorityAssignmentTable
   14) lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmTable
   15) lldpXdot1dcbxRemPFCBasicTable
   16) lldpXdot1dcbxRemPFCEnableTable
   17) lldpXdot1dcbxAdminETSBasicConfigurationTable
   18) lldpXdot1dcbxAdminETSConPriorityAssignmentTable
   19) lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmTable
   20) lldpXdot1dcbxAdminPFCBasicTable
   21) lldpXdot1dcbxAdminPFCEnableTable
   22) lldpXdot1dcbxRemApplicationPriorityAppTable
   23) lldpXdot1dcbxRemApplicationVlanAppTable
   24) lldpXdot1dcbxAdminApplicationPriorityAppTable
   25) lldpXdot1dcbxAdminApplicationVlanAppTable

This concern applies both to objects that describe the configuration of the local host, as well as for objects that describe information from the remote hosts, acquired via LLDP and displayed by the objects in this MIB module. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example, by using IPSec), there is no control about who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

Implementers should consider the security features as provided by the SNMPv3 framework (see IETF RFC 3410 (2002), section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, implementers should not deploy SNMP versions prior to SNMPv3. Instead**,** implementers should deploy SNMPv3 to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

D.5.5 IEEE 802.1 LLDP extension MIB module—version 2[60] [61]

In the following MIB definition, should any discrepancy between the DESCRIPTION text and the corresponding definition in D.2.1 through D.5 occur, the definition in D.2.1 through D.5 shall take precedence.

```
LLDP-EXT-DOT1-V2-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32
        FROM SNMPv2-SMI
    TruthValue,
    TEXTUAL-CONVENTION
        FROM SNMPv2-TC
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ifGeneralInformationGroup
        FROM IF-MIB
    lldpV2Extensions,
    lldpV2LocPortIfIndex,
    lldpV2RemTimeMark,
    lldpV2RemLocalIfIndex,
    lldpV2RemLocalDestMACAddress,
    lldpV2RemIndex,
    lldpV2PortConfigEntry
        FROM LLDP-V2-MIB
    VlanId
        FROM Q-BRIDGE-MIB
    IEEE8021PriorityValue
        FROM IEEE8021-TC-MIB;

lldpV2Xdot1MIB MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
            "The LLDP Management Information Base extension module for
            IEEE 802.1 organizationally defined discovery information.

            In order to ensure the uniqueness of the LLDP-V2-MIB,
            lldpV2Xdot1MIB is branched from lldpV2Extensions using an
            Organizationally Unique Identifier (OUI) value as the node.
            An OUI is a 24 bit globally unique number assigned by the
            IEEE Registration Authority - see:

            http://standards.ieee.org/develop/regauth/oui/index.html

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.
```

[60] *Copyright release for MIBs:* Users of this standard may freely reproduce the MIB modules in this standard so that they can be used for their intended purpose.

[61] An ASCII version of this MIB module is attached to the PDF version of this standard, and can be obtained by Web browser from the IEEE 802.1 Website at https://1.ieee802.org/mib-modules/.

```
        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected.
            Changes introduced by IEEE Std 802.1Qcd-2015 and
            IEEE Std 802.1Q-2014 Cor 1-2015 merged. "

    REVISION "201502160000Z" -- February 16, 2015
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 Cor-1.
            Updated as a result of maintenance items #0132 and #0152"

    REVISION "201502160000Z" -- February 16, 2015
    DESCRIPTION
            "Published as part of IEEE Std 802.1Qcd.
            Adds Application VLAN TLV objects to the DCBX groups of
            the MIB module."

    REVISION "201412150000Z" -- December 15, 2014
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected.
            New tables lldpV2Xdot1RemVidUsageDigestV2Table
            and lldpV2Xdot1RemManVidV2Table inserted; old
            versions deprecated. New versions add an index for
            lldpV2RemIndex. "

    REVISION "201103250000Z" -- March 25, 2011
    DESCRIPTION
            "Published as part of IEEE Std 802.1Qaz-2011. Adds the DCBX
            objects to the MIB module"

    REVISION "201103230000Z" -- March 23, 2011
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2011 revision.
            This revision contains changes associated with
            relocating the extension MIB from IEEE Std 802.1AB to
            IEEE Std 802.1Q, minor tweaks to the text of the
            DESCRIPTION statement above to fix references to
            IEEE Std 802.1Q, updating of references to refer to
            Annex D, and addition of object definitions for
            Congestion Notification TLVs and corresponding
            compliance statements."

    REVISION "200906080000Z" -- June 08, 2009
    DESCRIPTION
            "Published as part of IEEE Std 802.1AB-2009 revision.
            This revision incorporated changes to the MIB to
            support the use of LLDP with multiple destination MAC
            addresses, and to import the Link Aggregation TLV
            from the IEEE 802.3 extension MIB"

-- OUI for IEEE 802.1 is 32962 (00-80-C2)
   ::= { lldpV2Extensions 32962 }

--------------------------------------------------------------------------
--------------------------------------------------------------------------
--
-- Organizationally Defined Information Extension - IEEE 802.1
-- Definitions to support the basicSet TLV set (Table D-1)
--
--------------------------------------------------------------------------
```

```
-- ----------------------------------------------------------------------

lldpV2Xdot1Objects    OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 1 }

-- LLDP IEEE 802.1 extension MIB groups
lldpV2Xdot1Config     OBJECT IDENTIFIER ::= { lldpV2Xdot1Objects 1 }
lldpV2Xdot1LocalData  OBJECT IDENTIFIER ::= { lldpV2Xdot1Objects 2 }
lldpV2Xdot1RemoteData OBJECT IDENTIFIER ::= { lldpV2Xdot1Objects 3 }

-- ----------------------------------------------------------------------
-- Textual Convention definitions
-- ----------------------------------------------------------------------

LldpV2XLinkAggStatusMap ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
            "This TC describes the link aggregation status.

            The bit 'aggCapable(0)' indicates the link is capable of being
            aggregated if 1, not capable if 0.

            The bit 'aggEnabled(1)' indicates the link is currently in
            an aggregation if 1, not in an aggregation if 0.

            The bits 'portTypeLS(1)' and portTypeMS(2)' form the LS
            and MS bits of a Port Type value respectively:
            00 = no port type specified
            01 = transmitted from Aggregation Port
            10 = transmitted from Aggregator
            11 = transmitted from an Aggregator with a single
                 Aggregation Port.

            The remaining bits are reserved for future standardization."
    SYNTAX  BITS {
            aggCapable(0),
            aggEnabled(1),
            portTypeLS(2),
            portTypeMS(3)
    }

-- ----------------------------------------------------------------------
-- IEEE 802.1 - Configuration for the basicSet TLV set
-- ----------------------------------------------------------------------

--
-- lldpV2Xdot1ConfigPortVlanTable : configure the transmission of the
--                                  Port VLAN-ID TLVs on set of ports.
--

lldpV2Xdot1ConfigPortVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1ConfigPortVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "A table that controls selection of LLDP Port VLAN-ID TLVs
            to be transmitted on individual ports."
    ::= { lldpV2Xdot1Config 1 }

lldpV2Xdot1ConfigPortVlanEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1ConfigPortVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "LLDP configuration information that controls the
            transmission of IEEE 802.1 organizationally defined Port
            VLAN-ID TLV on LLDP transmission-capable ports.

            This configuration object augments the
            lldpV2PortConfigEntry of the LLDP-MIB, therefore it is only
            present along with the port configuration defined by the
            associated lldpV2PortConfigEntry entry.
```

```
            Each active lldpConfigEntry is restored from non-volatile
            storage (along with the corresponding
            lldpV2PortConfigEntry) after a re-initialization of the
            management system."
    AUGMENTS { lldpV2PortConfigEntry }
    ::= { lldpV2Xdot1ConfigPortVlanTable 1 }

LldpV2Xdot1ConfigPortVlanEntry ::= SEQUENCE {
      lldpV2Xdot1ConfigPortVlanTxEnable  TruthValue
}

lldpV2Xdot1ConfigPortVlanTxEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-write
    STATUS      current
    DESCRIPTION
            "The lldpV2Xdot1ConfigPortVlanTxEnable, which is defined
            as a truth value and configured by the network management,
            determines whether the IEEE 802.1 organizationally defined
            port VLAN TLV transmission is allowed on a given LLDP
            transmission-capable port.

            The value of this object is restored from non-volatile
            storage after a re-initialization of the management system."
    REFERENCE
            "9.1.2.1 of IEEE Std 802.1AB"
    DEFVAL  { false }
    ::= { lldpV2Xdot1ConfigPortVlanEntry 1 }


--
-- lldpV2Xdot1ConfigVlanNameTable : configure the transmission of the
--                                  VLAN name instances on set of ports.
--

lldpV2Xdot1ConfigVlanNameTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1ConfigVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The table that controls selection of LLDP VLAN name TLV
            instances to be transmitted on individual ports."
    ::= { lldpV2Xdot1Config 2 }

lldpV2Xdot1ConfigVlanNameEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1ConfigVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "LLDP configuration information that specifies the set of
            ports (represented as a PortList) on which the Local System
            VLAN name instance is transmitted.

            This configuration object augments the lldpV2LocVlanEntry,
            therefore it is only present along with the VLAN Name
            instance contained in the associated lldpV2LocVlanNameEntry
            entry.

            Each active lldpV2Xdot1ConfigVlanNameEntry is restored
            from non-volatile storage (along with the corresponding
            lldpV2Xdot1LocVlanNameEntry) after a re-initialization of
            the management system."
    AUGMENTS { lldpV2Xdot1LocVlanNameEntry }
    ::= { lldpV2Xdot1ConfigVlanNameTable 1 }



LldpV2Xdot1ConfigVlanNameEntry ::= SEQUENCE {
      lldpV2Xdot1ConfigVlanNameTxEnable  TruthValue
}

lldpV2Xdot1ConfigVlanNameTxEnable  OBJECT-TYPE
```

```
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
            "The boolean value that indicates whether the corresponding
            Local System VLAN name instance is transmitted on the
            port defined by the given lldpV2Xdot1LocVlanNameEntry.

            The value of this object is restored from non-volatile
            storage after a re-initialization of the management
            system."
    REFERENCE
            "9.1.2.1 of IEEE Std 802.1AB"
    DEFVAL  { false }
    ::= { lldpV2Xdot1ConfigVlanNameEntry 1 }


--
-- lldpV2Xdot1ConfigProtoVlanTable : configure the transmission of the
--                                   protocol VLAN instances on set
--                                   of ports.
--

lldpV2Xdot1ConfigProtoVlanTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1ConfigProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The table that controls selection of LLDP Port And
            Protocol VLAN ID TLV instances to be transmitted on
            individual ports."
    ::= { lldpV2Xdot1Config 3 }

lldpV2Xdot1ConfigProtoVlanEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1ConfigProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "LLDP configuration information that specifies the set of
            ports (represented as a PortList) on which the Local System
            Protocol VLAN instance is transmitted.

            This configuration object augments the
            lldpV2Xdot1LocVlanEntry, therefore it is only present along
            with the Port and Protocol VLAN ID instance contained in
            the associated lldpV2Xdot1LocVlanEntry entry.

            Each active lldpV2Xdot1ConfigProtoVlanEntry is restored
            from non-volatile storage (along with the corresponding
            lldpV2Xdot1LocProtoVlanEntry) after a re-initialization of
            the management system."

    AUGMENTS { lldpV2Xdot1LocProtoVlanEntry }
    ::= { lldpV2Xdot1ConfigProtoVlanTable 1 }


LldpV2Xdot1ConfigProtoVlanEntry ::= SEQUENCE {
      lldpV2Xdot1ConfigProtoVlanTxEnable   TruthValue
}

lldpV2Xdot1ConfigProtoVlanTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
            "The boolean value that indicates whether the corresponding
            Local System Port and Protocol VLAN instance is
            transmitted on the port defined by the given
            lldpV2Xdot1LocProtoVlanEntry.

            The value of this object is restored from non-volatile
            storage after a re-initialization of the management system."
```

```
    REFERENCE
            "9.1.2.1 of IEEE Std 802.1AB"
    DEFVAL  { false }
    ::= { lldpV2Xdot1ConfigProtoVlanEntry 1 }


--
-- lldpV2Xdot1ConfigProtocolTable : configure the transmission of the
--                                  protocol instances on set
--                                  of ports.
--

lldpV2Xdot1ConfigProtocolTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1ConfigProtocolEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The table that controls selection of LLDP Protocol
            TLV instances to be transmitted on individual ports."
    ::= { lldpV2Xdot1Config 4 }

lldpV2Xdot1ConfigProtocolEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1ConfigProtocolEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "LLDP configuration information that specifies the set of
            ports (represented as a PortList) on which the Local System
            Protocol instance is transmitted.

            This configuration object augments the
            lldpV2Xdot1LocProtoEntry, therefore it is only present
            along with the Protocol instance contained in the
            associated lldpV2Xdot1LocProtoEntry entry.

            Each active lldpV2Xdot1ConfigProtocolEntry is restored
            from non-volatile storage (along with the corresponding
            lldpV2Xdot1LocProtocolEntry) after a re-initialization of
            the management system."
    AUGMENTS { lldpV2Xdot1LocProtocolEntry }
    ::= { lldpV2Xdot1ConfigProtocolTable 1 }


LldpV2Xdot1ConfigProtocolEntry ::= SEQUENCE {
      lldpV2Xdot1ConfigProtocolTxEnable   TruthValue
}

lldpV2Xdot1ConfigProtocolTxEnable  OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
            "The boolean value that indicates whether the corresponding
            Local System Protocol Identity instance is transmitted
            on the port defined by the given
            lldpV2Xdot1LocProtocolEntry.

            The value of this object is restored from non-volatile
            storage after a re-initialization of the management
            system."
    REFERENCE
            "9.1.2.1 of IEEE Std 802.1AB"
    DEFVAL  { false }
    ::= { lldpV2Xdot1ConfigProtocolEntry 1 }

--
-- lldpV2Xdot1ConfigVidUsageDigestTable: configure the transmission
-- of the VID Usage Digest TLVs on set of ports.
--
lldpV2Xdot1ConfigVidUsageDigestTable OBJECT-TYPE
     SYNTAX SEQUENCE OF LldpV2Xdot1ConfigVidUsageDigestEntry
     MAX-ACCESS not-accessible
```

```
     STATUS current
     DESCRIPTION
          "A table that controls selection of LLDP VID Usage Digest
          TLVs to be transmitted on individual ports."
::= { lldpV2Xdot1Config 5 }

lldpV2Xdot1ConfigVidUsageDigestEntry OBJECT-TYPE
     SYNTAX LldpV2Xdot1ConfigVidUsageDigestEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "LLDP configuration information that specifies the set of
          ports (represented as a PortList) on which the local
          system VID Usage Digest instance will be transmitted.
          This configuration object augments the
          lldpLocVidUsageDigestEntry, therefore it is only present
          along with the VID Usage Digest instance
          contained in the associated lldpV2Xdot1LocVidUsageDigestEntry
          entry. Each active lldpConfigVidUsageDigestEntry must be
          restored from non-volatile storage and re-created (along with
          the corresponding lldpV2Xdot1LocVidUsageDigestEntry) after
          a re-initialization of the management system."
     AUGMENTS { lldpV2Xdot1LocVidUsageDigestEntry }
::= { lldpV2Xdot1ConfigVidUsageDigestTable 1 }

LldpV2Xdot1ConfigVidUsageDigestEntry ::= SEQUENCE {
     lldpV2Xdot1ConfigVidUsageDigestTxEnable TruthValue
     }

lldpV2Xdot1ConfigVidUsageDigestTxEnable OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-write
     STATUS current
     DESCRIPTION
          "The boolean value that indicates whether the corresponding
          Local System VID Usage Digest instance will be transmitted
          on the port defined by the given
          lldpV2Xdot1LocVidUsageDigestEntry. The value of this object
          must be restored from non-volatile storage after a
          reinitialization of the management system."
     REFERENCE
          "9.1.2.1 of IEEE Std 802.1AB"
     DEFVAL { false }
::= { lldpV2Xdot1ConfigVidUsageDigestEntry 1 }


--
-- lldpV2Xdot1ConfigManVidTable : configure the transmission of the
-- Management VID TLVs on set of ports.
--
lldpV2Xdot1ConfigManVidTable OBJECT-TYPE
     SYNTAX SEQUENCE OF LldpV2Xdot1ConfigManVidEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "A table that controls selection of LLDP Management VID
          TLVs to be transmitted on individual ports."
::= { lldpV2Xdot1Config 6 }

lldpV2Xdot1ConfigManVidEntry OBJECT-TYPE
     SYNTAX LldpV2Xdot1ConfigManVidEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "LLDP configuration information that specifies the set of
          port/destination address pairs on which the Local
          System Management VID will be transmitted.
          This configuration object augments the
          lldpV2Xdot1LocManVidEntry, therefore it is
          only present along with the Management VID contained
          in the associated lldpV2Xdot1LocManVidEntry entry.
          Each active lldpV2Xdot1ConfigManVidEntry must be
```

```
          restored from non-volatile storage (along with the
          corresponding lldpV2Xdot1LocManVidEntry) after a
          re-initialization of the management system."
     AUGMENTS { lldpV2Xdot1LocManVidEntry }
::= { lldpV2Xdot1ConfigManVidTable 1 }

LldpV2Xdot1ConfigManVidEntry ::= SEQUENCE {
     lldpV2Xdot1ConfigManVidTxEnable TruthValue
     }

lldpV2Xdot1ConfigManVidTxEnable OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-write
     STATUS current
     DESCRIPTION
          "The lldpV2Xdot1ConfigManVidTxEnable, which is defined as a
          truth value and configured by the network management,
          determines whether the IEEE 802.1 organizationally
          defined Management VID TLV transmission is allowed on a given
          LLDP transmission-capable port.
          The value of this object must be restored from
          non-volatile storage after a re-initialization of the
          management system."
     REFERENCE
          "9.1.2.1 of IEEE Std 802.1AB"
     DEFVAL { false }
::= { lldpV2Xdot1ConfigManVidEntry 1 }


-----------------------------------------------------------------------
-- IEEE 802.1 - Local System Information
-----------------------------------------------------------------------

--
-- lldpV2Xdot1LocTable - indexed by ifIndex.
--

lldpV2Xdot1LocTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port for IEEE 802.1
            organizationally defined LLDP extension on the local system
            known to this agent."
    ::= { lldpV2Xdot1LocalData 1 }

lldpV2Xdot1LocEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Information about IEEE 802.1 organizationally defined
            LLDP extension."
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocTable 1 }

LldpV2Xdot1LocEntry ::= SEQUENCE {
         lldpV2Xdot1LocPortVlanId       Unsigned32
}

lldpV2Xdot1LocPortVlanId OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..4094)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the port's VLAN
            identifier associated with the local system.   A value
            of zero shall be used if the system either does not know
            the PVID or does
            not support Port-based VLAN operation."
    REFERENCE
```

```
            "D.2.1.1"
    ::= { lldpV2Xdot1LocEntry 1 }



--
-- lldpV2Xdot1LocProtoVlanTable: Port and Protocol VLAN information
-- re-indexed by ifIndex.
--

lldpV2Xdot1LocProtoVlanTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per Port and Protocol
            VLAN information about the local system."
    ::= { lldpV2Xdot1LocalData 2 }

lldpV2Xdot1LocProtoVlanEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Port and protocol VLAN ID Information about a particular
            port component.  There may be multiple port and protocol
            VLANs, identified by a particular
            lldpV2Xdot1LocProtoVlanId, configured on the given port."
    INDEX   { lldpV2LocPortIfIndex,
              lldpV2Xdot1LocProtoVlanId }
    ::= { lldpV2Xdot1LocProtoVlanTable 1 }

LldpV2Xdot1LocProtoVlanEntry ::= SEQUENCE {
      lldpV2Xdot1LocProtoVlanId        Unsigned32,
      lldpV2Xdot1LocProtoVlanSupported TruthValue,
      lldpV2Xdot1LocProtoVlanEnabled   TruthValue
}

lldpV2Xdot1LocProtoVlanId  OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..4094)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the port and protocol
            VLANs associated with the given port associated with the
            local system.  A value of zero shall be used if the system
            either does not know the protocol VLAN ID (PPVID) or does
            not support port and protocol VLAN operation."
    REFERENCE
            "D.2.2.2"
    ::= { lldpV2Xdot1LocProtoVlanEntry 1 }

lldpV2Xdot1LocProtoVlanSupported  OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The truth value used to indicate whether the given port
            (associated with the local system) supports port and
            protocol VLANs."
    REFERENCE
            "D.2.2.1"
    ::= { lldpV2Xdot1LocProtoVlanEntry 2 }

lldpV2Xdot1LocProtoVlanEnabled  OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The truth value used to indicate whether the port and
            protocol VLANs are enabled on the given port associated
            with the local system."
```

```
    REFERENCE
            "D.2.2.1"
    ::= { lldpV2Xdot1LocProtoVlanEntry 3 }



--
-- lldpV2Xdot1LocVlanNameTable : VLAN name information about the local
-- system indexed by ifIndex.
--

lldpV2Xdot1LocVlanNameTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per IEEE 802.1Q VLAN
            name information on the local system known to this agent."
    ::= { lldpV2Xdot1LocalData 3 }

lldpV2Xdot1LocVlanNameEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "VLAN name Information about a particular port component.
            There may be multiple VLANs, identified by a particular
            lldpV2Xdot1LocVlanId, configured on the given port."
    INDEX   { lldpV2LocPortIfIndex,
              lldpV2Xdot1LocVlanId }
    ::= { lldpV2Xdot1LocVlanNameTable 1 }

LldpV2Xdot1LocVlanNameEntry ::= SEQUENCE {
      lldpV2Xdot1LocVlanId             VlanId,
      lldpV2Xdot1LocVlanName           SnmpAdminString
}

lldpV2Xdot1LocVlanId  OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the IEEE 802.1Q
            VLAN IDs with which the given port is compatible."
    REFERENCE
            "D.2.3.2"
    ::= { lldpV2Xdot1LocVlanNameEntry 1 }

lldpV2Xdot1LocVlanName  OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(1..32))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The string value used to identify VLAN name identified
            by the Vlan Id associated with the given port on the
            local system.

            This object should contain the value of the
            dot1QVLANStaticName object (defined in IETF RFC 4363)
            identified with the given lldpV2Xdot1LocVlanId."
    REFERENCE
            "D.2.3.4"
    ::= { lldpV2Xdot1LocVlanNameEntry 2 }



--
-- lldpV2Xdot1LocProtocolTable : Protocol Identity information
-- re-indexed by ifIndex and destination address
--

lldpV2Xdot1LocProtocolTable  OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocProtocolEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per protocol identity
            information on the local system known to this agent."
    REFERENCE
            "D.2.4"
    ::= { lldpV2Xdot1LocalData 4 }

lldpV2Xdot1LocProtocolEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocProtocolEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Information about particular protocols that are accessible
            through the given port component.

            There may be multiple protocols, identified by particular
            lldpV2Xdot1ProtocolIndex, lldpV2LocPortIfIndex"
    REFERENCE
            "D.2.4"
    INDEX   { lldpV2LocPortIfIndex,
              lldpV2Xdot1LocProtocolIndex }
    ::= { lldpV2Xdot1LocProtocolTable 1 }

LldpV2Xdot1LocProtocolEntry ::= SEQUENCE {
      lldpV2Xdot1LocProtocolIndex Unsigned32,
      lldpV2Xdot1LocProtocolId    OCTET STRING
}


lldpV2Xdot1LocProtocolIndex  OBJECT-TYPE
    SYNTAX      Unsigned32(1..2147483647)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This object represents an arbitrary local integer value
            used by this agent to identify a particular protocol
            identity."
    ::= { lldpV2Xdot1LocProtocolEntry 1 }

lldpV2Xdot1LocProtocolId  OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (1..255))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The octet string value used to identify the protocols
            associated with the given port of the local system."
    REFERENCE
            "D.2.4.3"
    ::= { lldpV2Xdot1LocProtocolEntry 2 }

--
-- lldpV2Xdot1LocVidUsageDigestTable: Table of hash values of
-- system VID Usage Table transmitted
-- via VID Usage Digest TLV.
--


lldpV2Xdot1LocVidUsageDigestTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocVidUsageDigestEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for usage digest
            information on the local system known to this agent."
    REFERENCE
            "D.2.5"
    ::= { lldpV2Xdot1LocalData 5 }
```

```
lldpV2Xdot1LocVidUsageDigestEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocVidUsageDigestEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Usage digest information to be transmitted
            through the given port."
    REFERENCE
            "D.2.5"
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocVidUsageDigestTable 1 }

LldpV2Xdot1LocVidUsageDigestEntry ::= SEQUENCE {
      lldpV2Xdot1LocVidUsageDigest Unsigned32
}


lldpV2Xdot1LocVidUsageDigest OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The integer value obtained by applying the CRC32 function
        to the 128-octet VID Usage Table. A bit of the VID Usage
        Table contains the value PBB-TE-USAGE (binary 1) if the
        corresponding element of the MST Configuration Table
        (IEEE Std 802.1Q 8.9.1) contains the value PBB-TE MSTID
        (hex FFE) and otherwise contains the value NON-PBB-TE-USAGE
        (binary 0)."
    REFERENCE
        "D.2.5.1"
::= { lldpV2Xdot1LocVidUsageDigestEntry 1 }

--
-- lldpV2Xdot1LocManVidTable: Table of values configured on the Local
-- system for the Management VID, or the value 0 if a Management VID
-- has not been provisioned.
--

lldpV2Xdot1LocManVidTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocManVidEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for usage digest
            information on the local system known to this agent."
    REFERENCE
            "D.2.6"
    ::= { lldpV2Xdot1LocalData 6 }

lldpV2Xdot1LocManVidEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocManVidEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Usage digest information to be transmitted
            through the given port."
    REFERENCE
            "D.2.6"
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocManVidTable 1 }

LldpV2Xdot1LocManVidEntry ::= SEQUENCE {
      lldpV2Xdot1LocManVid Unsigned32
}

lldpV2Xdot1LocManVid OBJECT-TYPE
    SYNTAX Unsigned32 (0|1..4094)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
```

```
        "The integer value configured on the Local system for
        the Management VID, or
        the value 0 if a Management VID has not been provisioned."
    REFERENCE
        "D.2.6.1"
::= { lldpV2Xdot1LocManVidEntry 1 }


--------------------------------------------------------------------
-- IEEE 802.1 - Local System Information - Link Aggregation
--------------------------------------------------------------------

---
---
--- lldpV2Xdot1LocLinkAggTable: Link Aggregation Information Table
---
---
lldpV2Xdot1LocLinkAggTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocLinkAggEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port of link aggregation
            information (as a part of the LLDP 802.1 organizational
            extension) on the local system known to this agent."
    ::= { lldpV2Xdot1LocalData 7 }

lldpV2Xdot1LocLinkAggEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocLinkAggEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Link Aggregation information about a particular port
            component."
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocLinkAggTable 1 }

LldpV2Xdot1LocLinkAggEntry ::= SEQUENCE {
      lldpV2Xdot1LocLinkAggStatus       LldpV2XLinkAggStatusMap,
      lldpV2Xdot1LocLinkAggPortId       Unsigned32
}

lldpV2Xdot1LocLinkAggStatus OBJECT-TYPE
    SYNTAX      LldpV2XLinkAggStatusMap
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The bitmap value contains the link aggregation
            capabilities and the current aggregation status of the
            link."
    REFERENCE
            "IEEE Std 802.1AX"
    ::= { lldpV2Xdot1LocLinkAggEntry 1 }

lldpV2Xdot1LocLinkAggPortId OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..2147483647)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the IEEE 802.1 aggregated port
            identifier, aAggPortID (IEEE Std 802.1AX, 6.3.2.1.1),
            derived from the ifNumber of the  ifIndex for the port
            component in link aggregation.

            If the port is not in link aggregation state and/or it
            does not support link aggregation, this value should be set
            to zero."
    REFERENCE
            "IEEE Std 802.1AX"
    ::= { lldpV2Xdot1LocLinkAggEntry 2 }
```

```
-- ----------------------------------------------------------------------
-- IEEE 802.1 - Remote System Information
-- ----------------------------------------------------------------------

--
-- lldpV2Xdot1RemTable - re-indexed for ifIndex and destination MAC
-- address

lldpV2Xdot1RemTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per physical network
            connection known to this agent.  The agent may wish to
            ensure that only one lldpV2Xdot1RemEntry is present for
            each local port, or it may choose to maintain multiple
            lldpV2Xdot1RemEntries for the same local port."
    ::= { lldpV2Xdot1RemoteData 1 }

lldpV2Xdot1RemEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Information about a particular port component."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemTable 1 }

LldpV2Xdot1RemEntry ::= SEQUENCE {
            lldpV2Xdot1RemPortVlanId           Unsigned32
}

lldpV2Xdot1RemPortVlanId OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..4094)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the port's VLAN
            identifier associated with the remote system.  if the
            remote system either does not know the PVID or does not
            support Port-based VLAN operation, the value of
            lldpV2Xdot1RemPortVlanId should be zero."
    REFERENCE
            "D.2.1.1"
    ::= { lldpV2Xdot1RemEntry 1 }



--
-- lldpV2Xdot1RemProtoVlanTable - re-indexed by ifIndex and
-- destination MAC address
--

lldpV2Xdot1RemProtoVlanTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per Port and Protocol
            VLAN information about the remote system, received on the
            given port."
    ::= { lldpV2Xdot1RemoteData 2 }

lldpV2Xdot1RemProtoVlanEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemProtoVlanEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
            "Port and protocol VLAN name Information about a particular
            port component.  There may be multiple protocol VLANs,
            identified by a particular lldpV2Xdot1RemProtoVlanId,
            configured on the remote system."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex,
              lldpV2Xdot1RemProtoVlanId }
    ::= { lldpV2Xdot1RemProtoVlanTable 1 }

LldpV2Xdot1RemProtoVlanEntry ::= SEQUENCE {
            lldpV2Xdot1RemProtoVlanId          Unsigned32,
            lldpV2Xdot1RemProtoVlanSupported   TruthValue,
            lldpV2Xdot1RemProtoVlanEnabled     TruthValue
}

lldpV2Xdot1RemProtoVlanId  OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..4094)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the port and protocol
            VLANs associated with the given port associated with the
            remote system.

            If port and protocol VLANs are not supported on the given
            port associated with the remote system, or if the port is
            not enabled with any port and protocol VLAN, the value of
            lldpV2Xdot1RemProtoVlanId should be zero."
    REFERENCE
            "D.2.2.2"
    ::= { lldpV2Xdot1RemProtoVlanEntry 1 }

lldpV2Xdot1RemProtoVlanSupported  OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The truth value used to indicate whether the given port
            (associated with the remote system) is capable of
            supporting port and protocol VLANs."
    REFERENCE
            "D.2.2.1"
    ::= { lldpV2Xdot1RemProtoVlanEntry 2 }

lldpV2Xdot1RemProtoVlanEnabled  OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The truth value used to indicate whether the port and
            protocol VLANs are enabled on the given port associated
            with
            the remote system."
    REFERENCE
            "D.2.2.1"
    ::= { lldpV2Xdot1RemProtoVlanEntry 3 }



--
-- lldpV2Xdot1RemVlanNameTable : VLAN name information of the remote
--                               systems
-- Re-indexed by ifIndex and destination MAC address
--

lldpV2Xdot1RemVlanNameTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
```

```
    DESCRIPTION
            "This table contains one or more rows per IEEE 802.1Q VLAN
            name information about the remote system, received on the
            given port."
    REFERENCE
            "D.2.3"
    ::= { lldpV2Xdot1RemoteData 3 }

lldpV2Xdot1RemVlanNameEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemVlanNameEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "VLAN name Information about a particular port component.
            There may be multiple VLANs, identified by a particular
            lldpV2Xdot1RemVlanId, received on the given port."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex,
              lldpV2Xdot1RemVlanId }
    ::= { lldpV2Xdot1RemVlanNameTable 1 }

LldpV2Xdot1RemVlanNameEntry ::= SEQUENCE {
            lldpV2Xdot1RemVlanId       VlanId,
            lldpV2Xdot1RemVlanName     SnmpAdminString
}


lldpV2Xdot1RemVlanId  OBJECT-TYPE
    SYNTAX      VlanId
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "The integer value used to identify the IEEE 802.1Q
            VLAN IDs with which the given port of the remote system
            is compatible."
    REFERENCE
            "D.2.3.2"
    ::= { lldpV2Xdot1RemVlanNameEntry 1 }

lldpV2Xdot1RemVlanName  OBJECT-TYPE
    SYNTAX      SnmpAdminString (SIZE(1..32))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The string value used to identify VLAN name identified
            by the VLAN Id associated with the remote system."
    REFERENCE
            "D.2.3.4"
    ::= { lldpV2Xdot1RemVlanNameEntry 2 }



--
-- lldpV2Xdot1RemProtocolTable : Protocol information of the remote
-- systems Re-indexed by ifIndex and destination MAC address
--

lldpV2Xdot1RemProtocolTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemProtocolEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one or more rows per protocol
            information about the remote system, received on
            the given port."
    ::= { lldpV2Xdot1RemoteData 4 }

lldpV2Xdot1RemProtocolEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemProtocolEntry
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
    DESCRIPTION
            "Protocol information about a particular port component.
            There may be multiple protocols, identified by a particular
            lldpV2Xdot1ProtocolIndex, received on the given port."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex,
              lldpV2Xdot1RemProtocolIndex }
    ::= { lldpV2Xdot1RemProtocolTable 1 }

LldpV2Xdot1RemProtocolEntry ::= SEQUENCE {
            lldpV2Xdot1RemProtocolIndex     Unsigned32,
            lldpV2Xdot1RemProtocolId        OCTET STRING
}

lldpV2Xdot1RemProtocolIndex  OBJECT-TYPE
    SYNTAX      Unsigned32(1..2147483647)
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This object represents an arbitrary local integer value
            used by this agent to identify a particular protocol
            identity."
    ::= { lldpV2Xdot1RemProtocolEntry 1 }

lldpV2Xdot1RemProtocolId  OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (1..255))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The octet string value used to identify the protocols
            associated with the given port of remote system."
    REFERENCE
            "D.2.4.3"
    ::= { lldpV2Xdot1RemProtocolEntry 2 }



--
-- lldpV2Xdot1RemVidUsageDigestTable: Table of hash values of
-- system VID Usage Table received
-- via VID Usage Digest TLV.
-- This version replaced by a reindexed version (V2).
--


lldpV2Xdot1RemVidUsageDigestTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemVidUsageDigestEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for usage digest
            information received by the local system."
    REFERENCE
            "D.2.5"
    ::= { lldpV2Xdot1RemoteData 5 }

lldpV2Xdot1RemVidUsageDigestEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemVidUsageDigestEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
            "Usage digest information received on
            the given port/destination address pair."
    REFERENCE
            "D.2.5"
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress }
```

```
    ::= { lldpV2Xdot1RemVidUsageDigestTable 1 }

LldpV2Xdot1RemVidUsageDigestEntry ::= SEQUENCE {
      lldpV2Xdot1RemVidUsageDigest  Unsigned32
}


lldpV2Xdot1RemVidUsageDigest OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS deprecated
    DESCRIPTION
        "The integer value obtained by applying the CRC32 function
        to the 128-octet VID Usage Table. A bit of the VID Usage
        Table contains the value PBB-TE-USAGE (binary 1) if the
        corresponding element of the MST Configuration Table
        (IEEE Std 802.1Q 8.9.1) contains the value PBB-TE MSTID
        (hex FFE) and otherwise contains the value NON-PBB-TE-USAGE
        (binary 0)."
    REFERENCE
        "D.2.5.1"
::= { lldpV2Xdot1RemVidUsageDigestEntry 1 }

--
-- lldpV2Xdot1RemManVidTable: Table of values configured on remote
-- systems for the Management VID, or the value 0 if a Management
-- VID has not been provisioned.
-- This version replaced by a reindexed version (V2).
--


lldpV2Xdot1RemManVidTable  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemManVidEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for management VID
            information received from remote systems."
    REFERENCE
            "D.2.6"
    ::= { lldpV2Xdot1RemoteData 6 }

lldpV2Xdot1RemManVidEntry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemManVidEntry
    MAX-ACCESS  not-accessible
    STATUS      deprecated
    DESCRIPTION
            "Management VID information received
            through the given port/destination address pair."
    REFERENCE
            "D.2.6"
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress }
    ::= { lldpV2Xdot1RemManVidTable 1 }

LldpV2Xdot1RemManVidEntry ::= SEQUENCE {
      lldpV2Xdot1RemManVid            Unsigned32
}

lldpV2Xdot1RemManVid OBJECT-TYPE
    SYNTAX Unsigned32 (0|1..4094)
    MAX-ACCESS read-only
    STATUS deprecated
    DESCRIPTION
        "The integer value configured on a system for
        the Management VID, or
        the value 0 if a Management VID has not been provisioned."
    REFERENCE
        "D.2.6.1"
::= { lldpV2Xdot1RemManVidEntry 1 }
```

```
--
-- lldpV2Xdot1RemVidUsageDigestV2Table: Table of hash values of
-- system VID Usage Table received
-- via VID Usage Digest TLV.
--


lldpV2Xdot1RemVidUsageDigestV2Table  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemVidUsageDigestV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for usage digest
            information received by the local system."
    REFERENCE
            "D.2.5"
    ::= { lldpV2Xdot1RemoteData 8 }

lldpV2Xdot1RemVidUsageDigestV2Entry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemVidUsageDigestV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Usage digest information received on
            the given port/destination address pair."
    REFERENCE
            "D.2.5"
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemVidUsageDigestV2Table 1 }

LldpV2Xdot1RemVidUsageDigestV2Entry ::= SEQUENCE {
      lldpV2Xdot1RemVidUsageDigestV2  Unsigned32
}


lldpV2Xdot1RemVidUsageDigestV2 OBJECT-TYPE
    SYNTAX Unsigned32
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The integer value obtained by applying the CRC32 function
        to the 128-octet VID Usage Table. A bit of the VID Usage
        Table contains the value PBB-TE-USAGE (binary 1) if the
        corresponding element of the MST Configuration Table
        (IEEE Std 802.1Q 8.9.1) contains the value PBB-TE MSTID
        (hex FFE) and otherwise contains the value NON-PBB-TE-USAGE
        (binary 0)."
    REFERENCE
        "D.2.5.1"
::= { lldpV2Xdot1RemVidUsageDigestV2Entry 1 }


--
-- lldpV2Xdot1RemManVidV2Table: Table of values configured on remote
-- systems for the Management VID, or the value 0 if a Management
-- VID has not been provisioned.
--

lldpV2Xdot1RemManVidV2Table  OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemManVidV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per ifIndex/
            destination MAC address pair for management VID
```

```
            information received from remote systems."
    REFERENCE
            "D.2.6"
    ::= { lldpV2Xdot1RemoteData 9 }

lldpV2Xdot1RemManVidV2Entry  OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemManVidV2Entry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Management VID information received
            through the given port/destination address pair."
    REFERENCE
            "D.2.6"
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemManVidV2Table 1 }

LldpV2Xdot1RemManVidV2Entry ::= SEQUENCE {
      lldpV2Xdot1RemManVidV2            Unsigned32
}

lldpV2Xdot1RemManVidV2 OBJECT-TYPE
    SYNTAX Unsigned32 (0|1..4094)
    MAX-ACCESS read-only
    STATUS current
    DESCRIPTION
        "The integer value configured on a system for
        the Management VID, or
        the value 0 if a Management VID has not been provisioned."
    REFERENCE
        "D.2.6.1"
::= { lldpV2Xdot1RemManVidV2Entry 1 }



--------------------------------------------------------------------------
-- Remote System Information - Link Aggregation
--------------------------------------------------------------------------

---
---
--- lldpV2Xdot1RemLinkAggTable: Link Aggregation Information Table
---
---
lldpV2Xdot1RemLinkAggTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemLinkAggEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains port link aggregation information
            (as a part of the LLDP IEEE 802.1 organizational extension)
            of the remote system."
    ::= { lldpV2Xdot1RemoteData 7 }

lldpV2Xdot1RemLinkAggEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemLinkAggEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Link Aggregation information about remote system's port
            component."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemLinkAggTable 1 }

LldpV2Xdot1RemLinkAggEntry ::= SEQUENCE {
            lldpV2Xdot1RemLinkAggStatus        LldpV2XLinkAggStatusMap,
```

```
            lldpV2Xdot1RemLinkAggPortId        Unsigned32
}

lldpV2Xdot1RemLinkAggStatus OBJECT-TYPE
    SYNTAX      LldpV2XLinkAggStatusMap
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "The bitmap value contains the link aggregation capabilities
            and the current aggregation status of the link."
    REFERENCE
            "IEEE Std 802.1AX"
    ::= { lldpV2Xdot1RemLinkAggEntry 1 }

lldpV2Xdot1RemLinkAggPortId OBJECT-TYPE
    SYNTAX      Unsigned32(0|1..2147483647)
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the IEEE 802.1 aggregated port
            identifier, aAggPortID (IEEE Std 802.1AX, 6.3.2.1.1),
            derived from the ifNumber of the  ifIndex for the port
            component associated with the remote system.

            If the remote port is not in link aggregation state and/or
            it does not support link aggregation, this value should be
            zero."
    REFERENCE
            "IEEE Std 802.1AX"
    ::= { lldpV2Xdot1RemLinkAggEntry 2 }


--------------------------------------------------------------------------
-- Conformance Information for the basicSet TLV set
--------------------------------------------------------------------------

lldpV2Xdot1Conformance
    OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 2 }
lldpV2Xdot1Compliances
    OBJECT IDENTIFIER ::= { lldpV2Xdot1Conformance 1 }
lldpV2Xdot1Groups
    OBJECT IDENTIFIER ::= { lldpV2Xdot1Conformance 2 }

-- compliance statements


lldpV2Xdot1TxRxCompliance MODULE-COMPLIANCE
    STATUS  current
    DESCRIPTION
            "A compliance statement for SNMP entities that implement
            the IEEE 802.1 organizationally defined LLDP extension MIB.

            This group is mandatory for all agents that implement the
            LLDP 802.1 organizational extension in TX and/or RX mode
            for the basicSet TLV set.

            This version defines compliance requirements for
            V2 of the LLDP MIB."
    MODULE  -- this module
        MANDATORY-GROUPS { lldpV2Xdot1ConfigGroup,
                           ifGeneralInformationGroup
        }
    ::= { lldpV2Xdot1Compliances 1 }


lldpV2Xdot1TxCompliance MODULE-COMPLIANCE
    STATUS  current
    DESCRIPTION
            "A compliance statement for SNMP entities that implement
            the IEEE 802.1 organizationally defined LLDP extension MIB.

            This group is mandatory for agents that implement the
```

```
            LLDP 802.1 organizational extension in the RX mode
            for the basicSet TLV set.

            This version defines compliance requirements for
            V2 of the LLDP MIB."
    MODULE  -- this module
        MANDATORY-GROUPS { lldpV2Xdot1LocSysGroup }

    ::= { lldpV2Xdot1Compliances 2 }

lldpV2Xdot1RxCompliance MODULE-COMPLIANCE
    STATUS  deprecated
    DESCRIPTION
            "A compliance statement for SNMP entities that implement
            the IEEE 802.1 organizationally defined LLDP extension MIB.

            This group is mandatory for agents that implement the
            LLDP 802.1 organizational extension in the RX mode
            for the basicSet TLV set.

            This version defines compliance requirements for
            V2 of the LLDP MIB."
    MODULE  -- this module
        MANDATORY-GROUPS { lldpV2Xdot1RemSysGroup }

    ::= { lldpV2Xdot1Compliances 3 }

lldpV2Xdot1RxComplianceV2 MODULE-COMPLIANCE
    STATUS    current
    DESCRIPTION
            "A compliance statement for SNMP entities that implement
            the IEEE 802.1 organizationally defined LLDP extension MIB.

            This group is mandatory for agents that implement the
            LLDP 802.1 organizational extension in the RX mode
            for the basicSet TLV set.

            This version defines compliance requirements for
            V2 of the LLDP MIB."
    MODULE  -- this module
        MANDATORY-GROUPS { lldpV2Xdot1RemSysV2Group }

    ::= { lldpV2Xdot1Compliances 4 }


-- MIB groupings for the basicSet TLV set

lldpV2Xdot1ConfigGroup    OBJECT-GROUP
    OBJECTS {
        lldpV2Xdot1ConfigPortVlanTxEnable,
        lldpV2Xdot1ConfigVlanNameTxEnable,
        lldpV2Xdot1ConfigProtoVlanTxEnable,
        lldpV2Xdot1ConfigProtocolTxEnable,
        lldpV2Xdot1ConfigVidUsageDigestTxEnable,
        lldpV2Xdot1ConfigManVidTxEnable
    }
    STATUS  current
    DESCRIPTION
            "The collection of objects that are used to configure the
            IEEE 802.1 organizationally defined LLDP extension
            implementation behavior for the basicSet TLV set."
    ::= { lldpV2Xdot1Groups 1 }

lldpV2Xdot1LocSysGroup  OBJECT-GROUP
    OBJECTS {
        lldpV2Xdot1LocPortVlanId,
        lldpV2Xdot1LocProtoVlanSupported,
        lldpV2Xdot1LocProtoVlanEnabled,
        lldpV2Xdot1LocVlanName,
        lldpV2Xdot1LocProtocolId,
        lldpV2Xdot1LocVidUsageDigest,
        lldpV2Xdot1LocManVid,
```

```
        lldpV2Xdot1LocLinkAggStatus,
        lldpV2Xdot1LocLinkAggPortId
    }
    STATUS  current
    DESCRIPTION
            "The collection of objects that are used to represent
            IEEE 802.1 organizationally defined LLDP extension
            associated with the Local Device Information for the
            basicSet TLV set."
    ::= { lldpV2Xdot1Groups 2 }

lldpV2Xdot1RemSysGroup  OBJECT-GROUP
    OBJECTS {
        lldpV2Xdot1RemPortVlanId,
        lldpV2Xdot1RemProtoVlanSupported,
        lldpV2Xdot1RemProtoVlanEnabled,
        lldpV2Xdot1RemVlanName,
        lldpV2Xdot1RemProtocolId,
        lldpV2Xdot1RemVidUsageDigest,
        lldpV2Xdot1RemManVid,
        lldpV2Xdot1RemLinkAggStatus,
        lldpV2Xdot1RemLinkAggPortId
    }
    STATUS  deprecated
    DESCRIPTION
            "The collection of objects that are used to represent LLDP
            802.1 organizational extension Remote Device Information
            for the basicSet TLV set."
    ::= { lldpV2Xdot1Groups 3 }

lldpV2Xdot1RemSysV2Group  OBJECT-GROUP
    OBJECTS {
        lldpV2Xdot1RemPortVlanId,
        lldpV2Xdot1RemProtoVlanSupported,
        lldpV2Xdot1RemProtoVlanEnabled,
        lldpV2Xdot1RemVlanName,
        lldpV2Xdot1RemProtocolId,
        lldpV2Xdot1RemVidUsageDigestV2,
        lldpV2Xdot1RemManVidV2,
        lldpV2Xdot1RemLinkAggStatus,
        lldpV2Xdot1RemLinkAggPortId
    }
    STATUS  current
    DESCRIPTION
            "The collection of objects that are used to represent LLDP
            802.1 organizational extension Remote Device Information
            for the basicSet TLV set."
    ::= { lldpV2Xdot1Groups 4 }

-- ------------------------------------------------------------------------
-- ------------------------------------------------------------------------
--
-- Organizationally Defined Information Extension - IEEE 802.1
-- Definitions to support the cnSet TLV set (Table D-1)
-- for Congestion Notification
--
-- ------------------------------------------------------------------------
-- ------------------------------------------------------------------------

lldpXdot1CnMIB OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 3 }
lldpXdot1CnObjects OBJECT IDENTIFIER ::= { lldpXdot1CnMIB 1 }

-- CN 802.1 MIB Extension groups

lldpXdot1CnConfig OBJECT IDENTIFIER ::= { lldpXdot1CnObjects 1 }
lldpXdot1CnLocalData OBJECT IDENTIFIER ::= { lldpXdot1CnObjects 2 }
lldpXdot1CnRemoteData OBJECT IDENTIFIER ::= { lldpXdot1CnObjects 3 }

-- ------------------------------------------------------------------
-- Textual conventions for Congestion Notification
-- ------------------------------------------------------------------
```

```
LldpV2CnBitVector ::= TEXTUAL-CONVENTION
    STATUS      current
    DESCRIPTION
            "This TC describes a bit vector used in the Congestion
            Notification objects. Each bit represents a Boolean status
            associated with a priority code point. A bit value of 0
            represents FALSE, 1 represents TRUE.

            The bit 'pri0status(0)' indicates the status for priority 0
            The bit 'pri1status(1)' indicates the status for priority 1
            The bit 'pri2status(2)' indicates the status for priority 2
            The bit 'pri3status(3)' indicates the status for priority 3
            The bit 'pri4status(4)' indicates the status for priority 4
            The bit 'pri5status(5)' indicates the status for priority 5
            The bit 'pri6status(6)' indicates the status for priority 6
            The bit 'pri7status(7)' indicates the status for priority 7"

    SYNTAX  BITS {
            pri0status(0),
            pri1status(1),
            pri2status(2),
            pri3status(3),
            pri4status(4),
            pri5status(5),
            pri6status(6),
            pri7status(7)
    }

-----------------------------------------------------------------------
-- IEEE 802.1 - Congestion Notification Configuration
-----------------------------------------------------------------------

--
--  lldpXdot1CnConfigCnTable : configure the
--  transmission of the Congestion Notification TLV on a set of ports
--

lldpXdot1CnConfigCnTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1CnConfigCnEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of Congestion Notification
         TLVs to be transmitted on individual ports."
    ::= { lldpXdot1CnConfig 1 }

lldpXdot1CnConfigCnEntry OBJECT-TYPE
    SYNTAX        LldpXdot1CnConfigCnEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        Congestion Notification TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS      { lldpV2PortConfigEntry }
    ::= { lldpXdot1CnConfigCnTable 1 }

LldpXdot1CnConfigCnEntry ::= SEQUENCE {
    lldpXdot1CnConfigCnTxEnable TruthValue
}

lldpXdot1CnConfigCnTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
```

```
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1CnConfigCnTxEnable, which is
        defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined Congestion Notification TLV transmission is allowed
        on a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.7"
    DEFVAL         { false }
    ::= { lldpXdot1CnConfigCnEntry 1 }

--------------------------------------------------------------------------
-- IEEE 802.1 - Congestion Notification Local System Information
--------------------------------------------------------------------------

---
---
--- lldpV2Xdot1LocCnTable: Port Extension Information Table
---
---
lldpV2Xdot1LocCnTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocCnEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port of Congestion
            Notification information (as a part of the LLDP
            802.1 organizational extension) on the local system
            known to this agent."
    ::= { lldpXdot1CnLocalData 1 }

lldpV2Xdot1LocCnEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocCnEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Congestion Notification information about a
            particular port component."
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocCnTable 1 }

LldpV2Xdot1LocCnEntry ::= SEQUENCE {
      lldpV2Xdot1LocCNPVIndicators    LldpV2CnBitVector,
      lldpV2Xdot1LocReadyIndicators   LldpV2CnBitVector
}

lldpV2Xdot1LocCNPVIndicators OBJECT-TYPE
    SYNTAX      LldpV2CnBitVector
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the CNPV indicators
            for the Port."
    REFERENCE
            "D.2.7.3"
    ::= { lldpV2Xdot1LocCnEntry 1 }

lldpV2Xdot1LocReadyIndicators OBJECT-TYPE
    SYNTAX      LldpV2CnBitVector
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the Ready indicators
            for the Port."
    REFERENCE
            "D.2.7.4"
    ::= { lldpV2Xdot1LocCnEntry 2 }
```

```
-- ------------------------------------------------------------------------
-- IEEE 802.1 - Congestion Notification Remote System Information
-- ------------------------------------------------------------------------

---
---
--- lldpV2Xdot1RemCnTable: Port Extension Information Table
---
---
lldpV2Xdot1RemCnTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemCnEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains Congestion Notification information
            (as a part of the LLDP IEEE 802.1 organizational extension)
            of the remote system."
    ::= { lldpXdot1CnRemoteData 1 }

lldpV2Xdot1RemCnEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemCnEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "Port Extension information about remote systems port
            component."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemCnTable 1 }

LldpV2Xdot1RemCnEntry ::= SEQUENCE {
      lldpV2Xdot1RemCNPVIndicators    LldpV2CnBitVector,
      lldpV2Xdot1RemReadyIndicators   LldpV2CnBitVector
}

lldpV2Xdot1RemCNPVIndicators OBJECT-TYPE
    SYNTAX      LldpV2CnBitVector
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the CNPV indicators
            for the Port."
    REFERENCE
            "D.2.7.3"
    ::= { lldpV2Xdot1RemCnEntry 1 }

lldpV2Xdot1RemReadyIndicators OBJECT-TYPE
    SYNTAX      LldpV2CnBitVector
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the Ready indicators
            for the Port."
    REFERENCE
            "D.2.7.4"
    ::= { lldpV2Xdot1RemCnEntry 2 }

-- ------------------------------------------------------------------------
-- IEEE 802.1 - Congestion Notification Conformance Information
-- ------------------------------------------------------------------------

lldpXdot1CnConformance OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 4 }

lldpXdot1CnCompliances
    OBJECT IDENTIFIER ::= { lldpXdot1CnConformance 1 }
lldpXdot1CnGroups OBJECT IDENTIFIER ::= { lldpXdot1CnConformance 2 }

--
-- Congestion Notification - Compliance Statements
```

```
--

lldpXdot1CnCompliance MODULE-COMPLIANCE
    STATUS        current
    DESCRIPTION
         "A compliance statement for SNMP entities that implement
         the IEEE 802.1 organizationally defined Congestion
         Notification LLDP extension MIB.

         This group is mandatory for agents that implement the
         Congestion Notification cnSet TLV set."
    MODULE        -- this module
        MANDATORY-GROUPS  { lldpXdot1CnGroup,
                            ifGeneralInformationGroup }
    ::= { lldpXdot1CnCompliances 1 }


--
-- Congestion Notification - MIB groupings
--

lldpXdot1CnGroup  OBJECT-GROUP
    OBJECTS {
        lldpXdot1CnConfigCnTxEnable,
        lldpV2Xdot1LocCNPVIndicators,
        lldpV2Xdot1LocReadyIndicators,
        lldpV2Xdot1RemCNPVIndicators,
        lldpV2Xdot1RemReadyIndicators
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects that support the
        Congestion Notification cnSet TLV set."
    ::= { lldpXdot1CnGroups 1 }

-----------------------------------------------------------------------
-----------------------------------------------------------------------
--
-- Organizationally Defined Information Extension - IEEE 802.1
-- Definitions to support the Data Center eXchange Protocol
-- (DCBX) TLV set (Table D-1)
--
-----------------------------------------------------------------------
-----------------------------------------------------------------------
lldpXdot1dcbxMIB OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 5 }
lldpXdot1dcbxObjects       OBJECT IDENTIFIER ::= { lldpXdot1dcbxMIB 1 }

-- DCBX 802.1 MIB Extension groups

lldpXdot1dcbxConfig     OBJECT IDENTIFIER ::= { lldpXdot1dcbxObjects 1 }
lldpXdot1dcbxLocalData  OBJECT IDENTIFIER ::= { lldpXdot1dcbxObjects 2 }
lldpXdot1dcbxRemoteData OBJECT IDENTIFIER ::= { lldpXdot1dcbxObjects 3 }
lldpXdot1dcbxAdminData  OBJECT IDENTIFIER ::= { lldpXdot1dcbxObjects 4 }

-----------------------------------------------------------------
-- IEEE 802.1 - DCBX Textual Conventions
-----------------------------------------------------------------

LldpXdot1dcbxTrafficClassValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS    current
    DESCRIPTION
        "Indicates a traffic class.  Values 0-7 correspond to
        traffic classes."
    SYNTAX    Unsigned32 (0..7)

LldpXdot1dcbxTrafficClassBandwidthValue ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS    current
    DESCRIPTION
        "Indicates the bandwidth in percent assigned to a
        traffic class."
```

```
    SYNTAX    Unsigned32 (0..100)

LldpXdot1dcbxAppSelector ::= TEXTUAL-CONVENTION
    STATUS    current
    DESCRIPTION
        "Indicates the contents of a protocol object
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    SYNTAX INTEGER {
        asEtherType(1),
        asTCPPortNumber(2),
        asUDPPortNumber(3),
        asTCPUDPPortNumber(4),
        asDSCPValue(5)
    }

 LldpXdot1dcbxAppProtocol ::= TEXTUAL-CONVENTION
     DISPLAY-HINT "d"
     STATUS        current
     DESCRIPTION
         "Contains the application protocol indicator the
         type of which is specified by an object with
         the syntax of
         LldpXdot1dcbxAppSelector"
     SYNTAX Unsigned32 (0..65535)

LldpXdot1dcbxSupportedCapacity ::= TEXTUAL-CONVENTION
    DISPLAY-HINT "d"
    STATUS    current
    DESCRIPTION
        "Indicates the supported capacity of a given feature,
        for example, the number of traffic classes supported.
        This TC is used for features that have a maximum
        capacity of eight and a minimum of one."
    SYNTAX Unsigned32 (1..8)

LldpXdot1dcbxTrafficSelectionAlgorithm ::= TEXTUAL-CONVENTION
    STATUS    current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm
        0: Strict Priority
        1: Credit-based shaper
        2: Enhanced transmission selection
        3-254: Reserved for future standardization
        255: Vendor specific"
    SYNTAX INTEGER {
        tsaStrictPriority(0),
        tsaCreditBasedShaper(1),
        tsaEnhancedTransmission(2),
        tsaVendorSpecific(255)
    }

-- ------------------------------------------------------------------
-- IEEE 802.1 - DCBX Configuration
-- ------------------------------------------------------------------

--
--  lldpXdot1dcbxConfigETSConfigurationTable : configure the
--  transmission of the ETS Configuration TLV on a set of ports
--

lldpXdot1dcbxConfigETSConfigurationTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxConfigETSConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
```

```
        "A table that controls selection of ETS Configuration
         TLVs to be transmitted on individual ports."
    ::= { lldpXdot1dcbxConfig 1 }

lldpXdot1dcbxConfigETSConfigurationEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxConfigETSConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        ETS Configuration TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS      { lldpV2PortConfigEntry }
    ::= { lldpXdot1dcbxConfigETSConfigurationTable 1 }

LldpXdot1dcbxConfigETSConfigurationEntry ::= SEQUENCE {
    lldpXdot1dcbxConfigETSConfigurationTxEnable TruthValue
}

lldpXdot1dcbxConfigETSConfigurationTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1dcbxConfigETSConfigurationTxEnable, which is
        defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined ETS Configuration TLV transmission is allowed on a
        given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.8"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxConfigETSConfigurationEntry 1 }

--
--  lldpXdot1dcbxConfigETSRecommendationTable : configure the
--  transmission of the ETS Recommendation TLV on a set of ports
--

lldpXdot1dcbxConfigETSRecommendationTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxConfigETSRecommendationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of ETS Recommendation
        TLVs to be transmitted on individual ports."
    ::= { lldpXdot1dcbxConfig 2 }

lldpXdot1dcbxConfigETSRecommendationEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxConfigETSRecommendationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        ETS Recommendation TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
```

```
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS     { lldpV2PortConfigEntry }
    ::= { lldpXdot1dcbxConfigETSRecommendationTable 1 }

LldpXdot1dcbxConfigETSRecommendationEntry ::= SEQUENCE {
    lldpXdot1dcbxConfigETSRecommendationTxEnable TruthValue
}

lldpXdot1dcbxConfigETSRecommendationTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1dcbxConfigETSRecommendationTxEnable, which is
        defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined ETS Recommendation TLV transmission is allowed on a
        given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.9"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxConfigETSRecommendationEntry 1 }
--
--  lldpXdot1dcbxConfigPFCTable : configure the transmission of the
--  Priority-based Flow Control Configuration TLV on a set of ports
--

lldpXdot1dcbxConfigPFCTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxConfigPFCEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of Priority-based
        Flow Control Configuration TLVs to be transmitted on individual ports."
    ::= { lldpXdot1dcbxConfig 3 }

lldpXdot1dcbxConfigPFCEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxConfigPFCEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        Priority-based Flow Control Configuration TLV on LLDP
        transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS     { lldpV2PortConfigEntry }
    ::= { lldpXdot1dcbxConfigPFCTable 1 }

LldpXdot1dcbxConfigPFCEntry ::= SEQUENCE {
    lldpXdot1dcbxConfigPFCTxEnable TruthValue
}

lldpXdot1dcbxConfigPFCTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
```

```
    DESCRIPTION
        "The lldpXdot1dcbxConfigPFCTxEnable, which is defined
        as a truth value and configured by the network management,
        determines whether the IEEE 802.1 organizationally defined
        Priority-based Flow Control Configuration TLV transmission is allowed on
        a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.10"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxConfigPFCEntry 1 }

--
--  lldpXdot1dcbxConfigApplicationPriorityTable : configure the
--  transmission of the Application Priority TLV on a set of ports
--

lldpXdot1dcbxConfigApplicationPriorityTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxConfigApplicationPriorityEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of Priority-based
        Flow Control Configuration TLVs to be transmitted on individual ports."
    ::= { lldpXdot1dcbxConfig 4 }

lldpXdot1dcbxConfigApplicationPriorityEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxConfigApplicationPriorityEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        Application Priority TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS     { lldpV2PortConfigEntry }
    ::= { lldpXdot1dcbxConfigApplicationPriorityTable 1 }

LldpXdot1dcbxConfigApplicationPriorityEntry ::= SEQUENCE {
    lldpXdot1dcbxConfigApplicationPriorityTxEnable TruthValue
}

lldpXdot1dcbxConfigApplicationPriorityTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1dcbxConfigApplicationPriorityTxEnable, which
        is defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined Application Priority TLV transmission is allowed on
        a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.11"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxConfigApplicationPriorityEntry 1 }

--
```

```
--  lldpXdot1dcbxConfigApplicationVlanTable : configure the
--  transmission of the Application VLAN TLV on a set of ports
--

lldpXdot1dcbxConfigApplicationVlanTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxConfigApplicationVlanEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of Application VLAN
        TLVs to be transmitted on individual ports."
    ::= { lldpXdot1dcbxConfig 5 }

lldpXdot1dcbxConfigApplicationVlanEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxConfigApplicationVlanEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        Application VLAN TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS     { lldpV2PortConfigEntry }
    ::= { lldpXdot1dcbxConfigApplicationVlanTable 1 }

LldpXdot1dcbxConfigApplicationVlanEntry ::= SEQUENCE {
    lldpXdot1dcbxConfigApplicationVlanTxEnable TruthValue
}

lldpXdot1dcbxConfigApplicationVlanTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1dcbxConfigApplicationVlanTxEnable, which
        is defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined Application VLAN TLV transmission is allowed on
        a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.14"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxConfigApplicationVlanEntry 1 }

-- ------------------------------------------------------------------------
-- IEEE 802.1 - DCBX Local System Information
-- ------------------------------------------------------------------------

--
-- lldpXdot1dcbxLocETSConfigurationTable - Contains the information
-- for the ETS Configuration TLV.
--
lldpXdot1dcbxLocETSConfiguration OBJECT IDENTIFIER
    ::= { lldpXdot1dcbxLocalData 1 }

lldpXdot1dcbxLocETSBasicConfigurationTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxLocETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
```

```
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP ETS Configuration TLV on
        the local system known to this agent"
    ::= { lldpXdot1dcbxLocETSConfiguration 1 }

lldpXdot1dcbxLocETSBasicConfigurationEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        ETS Configuration TLV LLDP extension."
    INDEX         { lldpV2LocPortIfIndex }
    ::= { lldpXdot1dcbxLocETSBasicConfigurationTable 1 }

LldpXdot1dcbxLocETSBasicConfigurationEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSConCreditBasedShaperSupport TruthValue,
    lldpXdot1dcbxLocETSConTrafficClassesSupported
        LldpXdot1dcbxSupportedCapacity,
    lldpXdot1dcbxLocETSConWilling    TruthValue
}

lldpXdot1dcbxLocETSConCreditBasedShaperSupport OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the credit-based shaper Traffic Selection
        Algorithm is supported on the local system."
    REFERENCE
        "D.2.8.4"
    ::= { lldpXdot1dcbxLocETSBasicConfigurationEntry 1 }

lldpXdot1dcbxLocETSConTrafficClassesSupported OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the number of traffic classes supported."
    REFERENCE
        "D.2.8.5"
    ::= { lldpXdot1dcbxLocETSBasicConfigurationEntry 2 }

lldpXdot1dcbxLocETSConWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is willing to accept the
        ETS configuration recommended by the remote system."
    REFERENCE
        "D.2.8.3"
    ::= { lldpXdot1dcbxLocETSBasicConfigurationEntry 3 }

lldpXdot1dcbxLocETSConPriorityAssignmentTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per priority.  The entry in each
        row indicates the traffic class to which the priority is
        assigned."
    ::= { lldpXdot1dcbxLocETSConfiguration 2 }

lldpXdot1dcbxLocETSConPriorityAssignmentEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a priority to traffic class assignment."
    INDEX        {
```

```
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxLocETSConPriority
    }
    ::= { lldpXdot1dcbxLocETSConPriorityAssignmentTable 1 }

LldpXdot1dcbxLocETSConPriorityAssignmentEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSConPriority      IEEE8021PriorityValue,
    lldpXdot1dcbxLocETSConPriTrafficClass
        LldpXdot1dcbxTrafficClassValue
}

lldpXdot1dcbxLocETSConPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the priority that is assigned to a traffic
        class."
    REFERENCE
        "D.2.8.6"
    ::= { lldpXdot1dcbxLocETSConPriorityAssignmentEntry 1 }

lldpXdot1dcbxLocETSConPriTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to which this priority is
        to be assigned."
    REFERENCE
        "D.2.8.6"
    ::= { lldpXdot1dcbxLocETSConPriorityAssignmentEntry 2 }

lldpXdot1dcbxLocETSConTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxLocETSConfiguration 3 }

lldpXdot1dcbxLocETSConTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxLocETSConTrafficClass
    }
    ::= { lldpXdot1dcbxLocETSConTrafficClassBandwidthTable 1 }

LldpXdot1dcbxLocETSConTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSConTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxLocETSConTrafficClassBandwidth
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxLocETSConTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.8.7"
```

```
    ::= { lldpXdot1dcbxLocETSConTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxLocETSConTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class."
    REFERENCE
        "D.2.8.7"
    ::= { lldpXdot1dcbxLocETSConTrafficClassBandwidthEntry 2 }


lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The entry
        in each row indicates the traffic selection algorithm to be
        used by the traffic class."
    ::= { lldpXdot1dcbxLocETSConfiguration 4 }

lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to traffic selection algorithm
         assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxLocETSConTSATrafficClass
    }
    ::= { lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSConTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxLocETSConTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxLocETSConTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class that is assigned to a traffic
        selection algorithm."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxLocETSConTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxLocETSConTrafficSelectionAlgorithmEntry 2 }

--
-- lldpXdot1dcbxLocETSRecommendationTable - Contains the information for
-- the ETS Recommendation TLV.
--
lldpXdot1dcbxLocETSReco OBJECT IDENTIFIER ::=
  { lldpXdot1dcbxLocalData 2 }
```

```
lldpXdot1dcbxLocETSRecoTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxLocETSReco 1 }

lldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxLocETSRecoTrafficClass
    }
    ::= { lldpXdot1dcbxLocETSRecoTrafficClassBandwidthTable 1 }

LldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSRecoTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxLocETSRecoTrafficClassBandwidth
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxLocETSRecoTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.9.3"
    ::= { lldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxLocETSRecoTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class."
    REFERENCE
        "D.2.9.4"
    ::= { lldpXdot1dcbxLocETSRecoTrafficClassBandwidthEntry 2 }

lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per priority.  The entry in each
        row indicates the traffic selection algorithm to be used
        by the traffic class."
    ::= { lldpXdot1dcbxLocETSReco 2 }

lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a priority to traffic selection algorithm
         assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
```

```
                lldpXdot1dcbxLocETSRecoTSATrafficClass
    }
    ::= { lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxLocETSRecoTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxLocETSRecoTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class that is assigned to a traffic
        selection algorithm."
    REFERENCE
        "D.2.9.5"
    ::= { lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.9.5"
    ::= { lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithmEntry 2 }

--
-- lldpXdot1dcbxLocPFCTable - Contains the information for the PFC
-- Configuration TLV.
--
lldpXdot1dcbxLocPFC OBJECT IDENTIFIER ::= { lldpXdot1dcbxLocalData 3 }

lldpXdot1dcbxLocPFCBasicTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxLocPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP PFC TLV on the local
        system known to this agent"
    ::= { lldpXdot1dcbxLocPFC 1 }

lldpXdot1dcbxLocPFCBasicEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        PFC TLV LLDP extension."
    INDEX         { lldpV2LocPortIfIndex }
    ::= { lldpXdot1dcbxLocPFCBasicTable 1 }

LldpXdot1dcbxLocPFCBasicEntry ::= SEQUENCE {
    lldpXdot1dcbxLocPFCWilling    TruthValue,
    lldpXdot1dcbxLocPFCMBC           TruthValue,
    lldpXdot1dcbxLocPFCCap        LldpXdot1dcbxSupportedCapacity
}

lldpXdot1dcbxLocPFCWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is willing to accept the
        PFC configuration of the remote system."
```

```
    REFERENCE
        "D.2.10.3"
    ::= { lldpXdot1dcbxLocPFCBasicEntry 1}

lldpXdot1dcbxLocPFCMBC OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is capable of bypassing
        MACsec processing when MACsec is disabled."
    REFERENCE
        "D.2.10.4"
    ::= { lldpXdot1dcbxLocPFCBasicEntry 2}

lldpXdot1dcbxLocPFCCap OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the number of traffic classes on the local device
        that may simultaneously have PFC enabled."
    REFERENCE
        "D.2.10.5"
    ::= { lldpXdot1dcbxLocPFCBasicEntry 3}

lldpXdot1dcbxLocPFCEnableTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxLocPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains eight entries, one entry per priority,
        indicating if PFC is enabled on the corresponding priority."
    ::= { lldpXdot1dcbxLocPFC 2 }

lldpXdot1dcbxLocPFCEnableEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Each entry indicates if PFC is enabled on the
        correponding priority"
    INDEX {
        lldpV2LocPortIfIndex,
        lldpXdot1dcbxLocPFCEnablePriority
    }
    ::= { lldpXdot1dcbxLocPFCEnableTable 1 }

LldpXdot1dcbxLocPFCEnableEntry ::= SEQUENCE {
    lldpXdot1dcbxLocPFCEnablePriority   IEEE8021PriorityValue,
    lldpXdot1dcbxLocPFCEnableEnabled    TruthValue
}

lldpXdot1dcbxLocPFCEnablePriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Prioity for which PFC is enabled / disabled"
    ::= { lldpXdot1dcbxLocPFCEnableEntry 1 }

lldpXdot1dcbxLocPFCEnableEnabled OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if PFC is enabled on the corresponding priority"
    REFERENCE
        "D.2.10.6"
    ::= { lldpXdot1dcbxLocPFCEnableEntry 2 }
--
-- lldpXdot1dcbxLocApplicationPriorityTable - Contains the information
```

```
-- for the Application Priority TLV.
--

lldpXdot1dcbxLocApplicationPriorityAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocApplicationPriorityAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the priority to be used
        for a given application"
    ::= { lldpXdot1dcbxLocalData 4 }

lldpXdot1dcbxLocApplicationPriorityAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocApplicationPriorityAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the priority to be used for a
        given application."
    INDEX         {
                  lldpV2LocPortIfIndex,
                  lldpXdot1dcbxLocApplicationPriorityAESelector,
                  lldpXdot1dcbxLocApplicationPriorityAEProtocol
    }
    ::= { lldpXdot1dcbxLocApplicationPriorityAppTable 1 }

LldpXdot1dcbxLocApplicationPriorityAppEntry ::= SEQUENCE {
    lldpXdot1dcbxLocApplicationPriorityAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxLocApplicationPriorityAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxLocApplicationPriorityAEPriority
        IEEE8021PriorityValue
}

lldpXdot1dcbxLocApplicationPriorityAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxLocApplicationPriorityAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxLocApplicationPriorityAppEntry 1 }

lldpXdot1dcbxLocApplicationPriorityAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxLocApplicationPriorityAESelector."
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxLocApplicationPriorityAppEntry 2 }

lldpXdot1dcbxLocApplicationPriorityAEPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "The priority code point that should be used in
```

```
        frames transporting the protocol indicated by
        lldpXdot1dcbxLocApplicationPriorityAESelector and
        lldpXdot1dcbxLocApplicationPriorityAEProtocol"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxLocApplicationPriorityAppEntry 3 }

--
-- lldpXdot1dcbxLocApplicationVlanAppTable - Contains the information
-- for the Application VLAN TLV.
--

lldpXdot1dcbxLocApplicationVlanAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxLocApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the VLAN to be used
        for a given application"
    ::= { lldpXdot1dcbxLocalData 5 }

lldpXdot1dcbxLocApplicationVlanAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxLocApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the VLAN to be used for a
        given application."
    INDEX         {
                  lldpV2LocPortIfIndex,
                  lldpXdot1dcbxLocApplicationVlanAESelector,
                  lldpXdot1dcbxLocApplicationVlanAEProtocol
    }
    ::= { lldpXdot1dcbxLocApplicationVlanAppTable 1 }

LldpXdot1dcbxLocApplicationVlanAppEntry ::= SEQUENCE {
    lldpXdot1dcbxLocApplicationVlanAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxLocApplicationVlanAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxLocApplicationVlanAEVlanId
        VlanId
}

lldpXdot1dcbxLocApplicationVlanAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxLocApplicationVlanAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxLocApplicationVlanAppEntry 1 }

lldpXdot1dcbxLocApplicationVlanAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxLocApplicationVlanAESelector."
    REFERENCE
```

```
        "D.2.11.3"
    ::= { lldpXdot1dcbxLocApplicationVlanAppEntry 2 }

lldpXdot1dcbxLocApplicationVlanAEVlanId OBJECT-TYPE
    SYNTAX        VlanId
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "The VLAN Identifier that should be used in
        frames transporting the protocol indicated by
        lldpXdot1dcbxLocApplicationVlanAESelector and
        lldpXdot1dcbxLocApplicationVlanAEProtocol"
    REFERENCE
        "D.2.14.3"
    ::= { lldpXdot1dcbxLocApplicationVlanAppEntry 3 }


--------------------------------------------------------------------------
-- IEEE 802.1 - DCBX Remote System Information
--------------------------------------------------------------------------

--
-- lldpXdot1dcbxRemETSConfigurationTable - Contains the information
-- for the remote system ETS Configuration TLV.
--
lldpXdot1dcbxRemETSConfiguration OBJECT IDENTIFIER
    ::= { lldpXdot1dcbxRemoteData 1 }

lldpXdot1dcbxRemETSBasicConfigurationTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxRemETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP ETS Configuration TLV on
        the local system known to this agent"
    ::= { lldpXdot1dcbxRemETSConfiguration 1 }

lldpXdot1dcbxRemETSBasicConfigurationEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        ETS Configuration TLV LLDP extension."
    INDEX         {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex
    }
    ::= { lldpXdot1dcbxRemETSBasicConfigurationTable 1 }

LldpXdot1dcbxRemETSBasicConfigurationEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSConCreditBasedShaperSupport     TruthValue,
    lldpXdot1dcbxRemETSConTrafficClassesSupported
        LldpXdot1dcbxSupportedCapacity,
    lldpXdot1dcbxRemETSConWilling    TruthValue
}

lldpXdot1dcbxRemETSConCreditBasedShaperSupport OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the credit-based shaper Traffic Selection
        algorithm is supported on the remote system."
    REFERENCE
        "D.2.8.4"
    ::= { lldpXdot1dcbxRemETSBasicConfigurationEntry 1 }

lldpXdot1dcbxRemETSConTrafficClassesSupported OBJECT-TYPE
```

```
    SYNTAX        LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the number of traffic classes supported."
    REFERENCE
        "D.2.8.5"
    ::= { lldpXdot1dcbxRemETSBasicConfigurationEntry 2 }

lldpXdot1dcbxRemETSConWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the remote system is willing to accept the
        ETS configuration recommended by the remote system."
    REFERENCE
        "D.2.8.3"
    ::= { lldpXdot1dcbxRemETSBasicConfigurationEntry 3 }

lldpXdot1dcbxRemETSConPriorityAssignmentTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per priority.  The entry in
        each row indicates the traffic class to which the
        priority is assigned."
    ::= { lldpXdot1dcbxRemETSConfiguration 2 }

lldpXdot1dcbxRemETSConPriorityAssignmentEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a priority to traffic class assignment."
    INDEX        {
                 lldpV2RemTimeMark,
                 lldpV2RemLocalIfIndex,
                 lldpV2RemLocalDestMACAddress,
                 lldpV2RemIndex,
                 lldpXdot1dcbxRemETSConPriority
    }
    ::= { lldpXdot1dcbxRemETSConPriorityAssignmentTable 1 }

LldpXdot1dcbxRemETSConPriorityAssignmentEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSConPriority      IEEE8021PriorityValue,
    lldpXdot1dcbxRemETSConPriTrafficClass
        LldpXdot1dcbxTrafficClassValue
}

lldpXdot1dcbxRemETSConPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the priority that is assigned to a traffic
        class."
    REFERENCE
        "D.2.8.6"
    ::= { lldpXdot1dcbxRemETSConPriorityAssignmentEntry 1 }

lldpXdot1dcbxRemETSConPriTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to which this priority is
        to be assigned."
    REFERENCE
        "D.2.8.6"
```

```
    ::= { lldpXdot1dcbxRemETSConPriorityAssignmentEntry 2 }

lldpXdot1dcbxRemETSConTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxRemETSConfiguration 3 }

lldpXdot1dcbxRemETSConTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2RemTimeMark,
                lldpV2RemLocalIfIndex,
                lldpV2RemLocalDestMACAddress,
                lldpV2RemIndex,
                lldpXdot1dcbxRemETSConTrafficClass
    }
    ::= { lldpXdot1dcbxRemETSConTrafficClassBandwidthTable 1 }

LldpXdot1dcbxRemETSConTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSConTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxRemETSConTrafficClassBandwidth
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxRemETSConTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.8.7"
    ::= { lldpXdot1dcbxRemETSConTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxRemETSConTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class."
    REFERENCE
        "D.2.8.7"
    ::= { lldpXdot1dcbxRemETSConTrafficClassBandwidthEntry 2 }


lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic selection
        algorithm to be used by the traffic class."
    ::= { lldpXdot1dcbxRemETSConfiguration 4 }

lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
```

```
    DESCRIPTION
        "Indicates a traffic class to traffic selection
        algorithm assignment."
    INDEX       {
                lldpV2RemTimeMark,
                lldpV2RemLocalIfIndex,
                lldpV2RemLocalDestMACAddress,
                lldpV2RemIndex,
                lldpXdot1dcbxRemETSConTSATrafficClass
    }
    ::= { lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSConTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxRemETSConTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxRemETSConTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class that is assigned to a traffic
        selection algorithm."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxRemETSConTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxRemETSConTrafficSelectionAlgorithmEntry 2 }

--
-- lldpXdot1dcbxRemETSRecommendationTable - Contains the information for
-- the remote system ETS Recommendation TLV.
--
lldpXdot1dcbxRemETSReco OBJECT IDENTIFIER ::=
  { lldpXdot1dcbxRemoteData 2 }

lldpXdot1dcbxRemETSRecoTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxRemETSReco 1 }

lldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2RemTimeMark,
                lldpV2RemLocalIfIndex,
                lldpV2RemLocalDestMACAddress,
                lldpV2RemIndex,
                lldpXdot1dcbxRemETSRecoTrafficClass
    }
```

```
    ::= { lldpXdot1dcbxRemETSRecoTrafficClassBandwidthTable 1 }

LldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSRecoTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxRemETSRecoTrafficClassBandwidth
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxRemETSRecoTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.9.4"
    ::= { lldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxRemETSRecoTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class."
    REFERENCE
        "D.2.9.4"
    ::= { lldpXdot1dcbxRemETSRecoTrafficClassBandwidthEntry 2 }

lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic selection
        algorithm to be used by the priority."
    ::= { lldpXdot1dcbxRemETSReco 2 }

lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a priority to traffic selection algorithm
         assignment."
    INDEX        {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex,
                  lldpXdot1dcbxRemETSRecoTSATrafficClass
    }
    ::= { lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxRemETSRecoTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxRemETSRecoTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class that is assigned to a traffic
        selection algorithm."
    REFERENCE
```

```
        "D.2.9.5"
    ::= { lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.9.5"
    ::= { lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithmEntry 2 }

--
-- lldpXdot1dcbxRemPFCTable - Contains the information for the remote
-- system PFC TLV.
--
lldpXdot1dcbxRemPFC OBJECT IDENTIFIER ::= { lldpXdot1dcbxRemoteData 3 }

lldpXdot1dcbxRemPFCBasicTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxRemPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP PFC TLV on the local
        system known to this agent"
    ::= { lldpXdot1dcbxRemPFC 1 }

lldpXdot1dcbxRemPFCBasicEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        PFC TLV LLDP extension."
    INDEX         {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex
    }
    ::= { lldpXdot1dcbxRemPFCBasicTable 1 }

LldpXdot1dcbxRemPFCBasicEntry ::= SEQUENCE {
    lldpXdot1dcbxRemPFCWilling    TruthValue,
    lldpXdot1dcbxRemPFCMBC        TruthValue,
    lldpXdot1dcbxRemPFCCap        LldpXdot1dcbxSupportedCapacity
}

lldpXdot1dcbxRemPFCWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the remote system is willing to accept the
        PFC configuration of the local system."
    REFERENCE
        "D.2.10.3"
    ::= { lldpXdot1dcbxRemPFCBasicEntry 1}

lldpXdot1dcbxRemPFCMBC OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the remote system is capable of bypassing
        MACsec processing when MACsec is disabled."
    REFERENCE
        "D.2.10.4"
    ::= { lldpXdot1dcbxRemPFCBasicEntry 2}
```

```
lldpXdot1dcbxRemPFCCap OBJECT-TYPE
    SYNTAX         LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS     read-only
    STATUS         current
    DESCRIPTION
        "Indicates the number of traffic classes on the remote device
        that may simultaneously have PFC enabled."
    REFERENCE
        "D.2.10.5"
    ::= { lldpXdot1dcbxRemPFCBasicEntry 3}

lldpXdot1dcbxRemPFCEnableTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxRemPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains eight entries, one entry per priority,
        indicating if PFC is enabled on the corresponding priority."
    ::= { lldpXdot1dcbxRemPFC 2 }

lldpXdot1dcbxRemPFCEnableEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Each entry indicates if PFC is enabled on the
        corresponding priority"
    INDEX         {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex,
                  lldpXdot1dcbxRemPFCEnablePriority
    }
    ::= { lldpXdot1dcbxRemPFCEnableTable 1 }

LldpXdot1dcbxRemPFCEnableEntry ::= SEQUENCE {
    lldpXdot1dcbxRemPFCEnablePriority   IEEE8021PriorityValue,
    lldpXdot1dcbxRemPFCEnableEnabled    TruthValue
}

lldpXdot1dcbxRemPFCEnablePriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Prioity for which PFC is enabled / disabled"
    ::= { lldpXdot1dcbxRemPFCEnableEntry 1 }

lldpXdot1dcbxRemPFCEnableEnabled OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if PFC is enabled on the corresponding priority"
    REFERENCE
        "D.2.10.6"
    ::= { lldpXdot1dcbxRemPFCEnableEntry 2 }

--
-- lldpXdot1dcbxRemApplicationPriorityTable - Contains the information
-- for the remote system Application Priority TLV.
--

lldpXdot1dcbxRemApplicationPriorityAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemApplicationPriorityAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the priority to be used
```

```
        for a given application"
    ::= { lldpXdot1dcbxRemoteData 4 }

lldpXdot1dcbxRemApplicationPriorityAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemApplicationPriorityAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the priority to be used for a
        given application."
    INDEX         {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex,
                  lldpXdot1dcbxRemApplicationPriorityAESelector,
                  lldpXdot1dcbxRemApplicationPriorityAEProtocol
    }
    ::= { lldpXdot1dcbxRemApplicationPriorityAppTable 1 }

LldpXdot1dcbxRemApplicationPriorityAppEntry ::= SEQUENCE {
    lldpXdot1dcbxRemApplicationPriorityAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxRemApplicationPriorityAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxRemApplicationPriorityAEPriority
        IEEE8021PriorityValue
}

lldpXdot1dcbxRemApplicationPriorityAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxRemApplicationPriorityAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxRemApplicationPriorityAppEntry 1 }

lldpXdot1dcbxRemApplicationPriorityAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxRemApplicationPriorityAESelector."
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxRemApplicationPriorityAppEntry 2 }

lldpXdot1dcbxRemApplicationPriorityAEPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "The priority code point that should be used in
        frames transporting the protocol indicated by
        lldpXdot1dcbxRemApplicationPriorityAESelector and
        lldpXdot1dcbxRemApplicationPriorityAEProtocol"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxRemApplicationPriorityAppEntry 3 }
```

```
--
-- lldpXdot1dcbxRemApplicationVlanAppTable - Contains the information
-- for the remote system Application VLAN TLV.
--

lldpXdot1dcbxRemApplicationVlanAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxRemApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the VLAN to be used
        for a given application"
    ::= { lldpXdot1dcbxRemoteData 5 }

lldpXdot1dcbxRemApplicationVlanAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxRemApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the VLAN to be used for a
        given application."
    INDEX         {
                  lldpV2RemTimeMark,
                  lldpV2RemLocalIfIndex,
                  lldpV2RemLocalDestMACAddress,
                  lldpV2RemIndex,
                  lldpXdot1dcbxRemApplicationVlanAESelector,
                  lldpXdot1dcbxRemApplicationVlanAEProtocol
    }
    ::= { lldpXdot1dcbxRemApplicationVlanAppTable 1 }

LldpXdot1dcbxRemApplicationVlanAppEntry ::= SEQUENCE {
    lldpXdot1dcbxRemApplicationVlanAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxRemApplicationVlanAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxRemApplicationVlanAEVlanId
        VlanId
}

lldpXdot1dcbxRemApplicationVlanAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxRemApplicationVlanAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxRemApplicationVlanAppEntry 1 }

lldpXdot1dcbxRemApplicationVlanAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxRemApplicationVlanAESelector."
    REFERENCE
        "D.2.11.3"
    ::= { lldpXdot1dcbxRemApplicationVlanAppEntry 2 }

lldpXdot1dcbxRemApplicationVlanAEVlanId OBJECT-TYPE
```

```
    SYNTAX        VlanId
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "The VLAN Identifier that should be used in
        frames transporting the protocol indicated by
        lldpXdot1dcbxRemApplicationVlanAESelector and
        lldpXdot1dcbxRemApplicationVlanAEProtocol"
    REFERENCE
        "D.2.14.3"
    ::= { lldpXdot1dcbxRemApplicationVlanAppEntry 3 }


-------------------------------------------------------------------------
-- IEEE 802.1 - DCBX Administrative Information
-------------------------------------------------------------------------

--
-- lldpXdot1dcbxAdminETSConfigurationTable - Contains the information
-- for the ETS Configuration TLV.
--
lldpXdot1dcbxAdminETSConfiguration OBJECT IDENTIFIER
    ::= { lldpXdot1dcbxAdminData 1 }

lldpXdot1dcbxAdminETSBasicConfigurationTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP ETS Configuration TLV
        on the local system known to this agent"
    ::= { lldpXdot1dcbxAdminETSConfiguration 1 }

lldpXdot1dcbxAdminETSBasicConfigurationEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminETSBasicConfigurationEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        ETS Configuration TLV LLDP extension."
    INDEX         { lldpV2LocPortIfIndex }
    ::= { lldpXdot1dcbxAdminETSBasicConfigurationTable 1 }

LldpXdot1dcbxAdminETSBasicConfigurationEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSConCreditBasedShaperSupport      TruthValue,
    lldpXdot1dcbxAdminETSConTrafficClassesSupported
        LldpXdot1dcbxSupportedCapacity,
    lldpXdot1dcbxAdminETSConWilling    TruthValue
}

lldpXdot1dcbxAdminETSConCreditBasedShaperSupport OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates support for the credit-based shaper Traffic
        Selection Algorithm."
    REFERENCE
        "D.2.8.4"
    ::= { lldpXdot1dcbxAdminETSBasicConfigurationEntry 1 }

lldpXdot1dcbxAdminETSConTrafficClassesSupported OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates the number of traffic classes supported."
    REFERENCE
        "D.2.8.5"
    ::= { lldpXdot1dcbxAdminETSBasicConfigurationEntry 2 }
```

```
lldpXdot1dcbxAdminETSConWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is willing to accept the
        ETS configuration recommended by the remote system."
    REFERENCE
        "D.2.8.3"
    DEFVAL         { false }
    ::= { lldpXdot1dcbxAdminETSBasicConfigurationEntry 3 }

lldpXdot1dcbxAdminETSConPriorityAssignmentTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per priority.  The entry in each
        row indicates the traffic class to which the priority is
        assigned."
    ::= { lldpXdot1dcbxAdminETSConfiguration 2 }

lldpXdot1dcbxAdminETSConPriorityAssignmentEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminETSConPriorityAssignmentEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a priority to traffic class assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxAdminETSConPriority
    }
    ::= { lldpXdot1dcbxAdminETSConPriorityAssignmentTable 1 }

LldpXdot1dcbxAdminETSConPriorityAssignmentEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSConPriority        IEEE8021PriorityValue,
    lldpXdot1dcbxAdminETSConPriTrafficClass
        LldpXdot1dcbxTrafficClassValue
}

lldpXdot1dcbxAdminETSConPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the priority that is assigned to a traffic
        class."
    REFERENCE
        "D.2.8.6"
    ::= { lldpXdot1dcbxAdminETSConPriorityAssignmentEntry 1 }

lldpXdot1dcbxAdminETSConPriTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to which this priority is
        to be assigned."
    REFERENCE
        "D.2.8.6"
    DEFVAL      { 0 }
    ::= { lldpXdot1dcbxAdminETSConPriorityAssignmentEntry 2 }

lldpXdot1dcbxAdminETSConTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
```

```
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxAdminETSConfiguration 3 }

lldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX      LldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxAdminETSConTrafficClass
    }
    ::= { lldpXdot1dcbxAdminETSConTrafficClassBandwidthTable 1 }

LldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSConTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxAdminETSConTrafficClassBandwidth
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxAdminETSConTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.8.7"
    ::= { lldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxAdminETSConTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class.
        The sum of the bandwidths assigned to a given port is
        required at all times to equal 100.  An operation that
        attempts to change this table such that the bandwidth
        entires do not total 100 shall be rejected. An implication
        of this is that modification of this table requires that
        multiple set operations be included in a single SNMP PDU,
        commonly referred to as an MSET operation, to perform
        simultaneous set operations to keep the sum at 100.  Any
        attempt to change a single entry in this table will result
        in the operation being rejected since entries in the
        table referring to the given port will no longer
        sum to 100."
    REFERENCE
        "D.2.8.7"
    ::= { lldpXdot1dcbxAdminETSConTrafficClassBandwidthEntry 2 }

lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The entry
        in each row indicates the traffic selection algorithm to
        be used by the priority."
    ::= { lldpXdot1dcbxAdminETSConfiguration 4 }

lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
```

```
        "Indicates a traffic class to traffic selection
        algorithm assignment."
    INDEX       {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxAdminETSConTSATrafficClass
    }
    ::= { lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSConTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxAdminETSConTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class that is assigned
        to a traffic selection algorithm."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.8.8"
    ::= { lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithmEntry 2 }


--
-- lldpXdot1dcbxAdminETSRecommendationTable - Contains the information
-- for the ETS Recommendation TLV.
--
lldpXdot1dcbxAdminETSReco OBJECT IDENTIFIER ::=
  { lldpXdot1dcbxAdminData 2 }

lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The
        entry in each row indicates the traffic class to
        which the bandwidth is assigned."
    ::= { lldpXdot1dcbxAdminETSReco 1 }

lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry OBJECT-TYPE
    SYNTAX      LldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to Bandwidth assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxAdminETSRecoTrafficClass
    }
    ::= { lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthTable 1 }

LldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSRecoTrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxAdminETSRecoTrafficClassBandwidth
```

```
        LldpXdot1dcbxTrafficClassBandwidthValue
}

lldpXdot1dcbxAdminETSRecoTrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the traffic class to
        which this bandwidth applies"
    REFERENCE
        "D.2.9.4"
    ::= { lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry 1 }

lldpXdot1dcbxAdminETSRecoTrafficClassBandwidth OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassBandwidthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates the bandwidth assigned to this traffic class.
        The sum of the bandwidths assigned to a given port is
        required at all times to equal 100.  An operation that
        attempts to change this table such that the bandwidth
        entires do not total 100 shall be rejected. An implication
        of this is that modification of this table requires that
        multiple set operations be included in a single SNMP PDU,
        commonly referred to as an MSET operation, to perform
        simultaneous set operations to keep the sum at 100.  Any
        attempt to change a single entry in this table will result
        in the operation being rejected since entries in the
        table referring to the given port will no longer
        sum to 100."

    REFERENCE
        "D.2.9.4"
    ::= { lldpXdot1dcbxAdminETSRecoTrafficClassBandwidthEntry 2 }

lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per traffic class.  The entry
        in each row indicates the traffic selection algorithm to
        be used by the traffic class."
    ::= { lldpXdot1dcbxAdminETSReco 2 }

lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry OBJECT-TYPE
    SYNTAX    LldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates a traffic class to traffic selection
        algorithm assignment."
    INDEX        {
                lldpV2LocPortIfIndex,
                lldpXdot1dcbxAdminETSRecoTSATrafficClass
    }
    ::= { lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmTable 1 }

LldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminETSRecoTSATrafficClass
        LldpXdot1dcbxTrafficClassValue,
    lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithm
        LldpXdot1dcbxTrafficSelectionAlgorithm
}

lldpXdot1dcbxAdminETSRecoTSATrafficClass OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficClassValue
    MAX-ACCESS    not-accessible
    STATUS        current
```

```
    DESCRIPTION
        "Indicates the traffic class that is assigned to a traffic
        selection algorithm."
    REFERENCE
        "D.2.9.5"
    ::= { lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry 1 }

lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithm OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxTrafficSelectionAlgorithm
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates the Traffic Selection Algorithm to which this
        traffic class is to be assigned."
    REFERENCE
        "D.2.9.5"
    ::= { lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithmEntry 2 }

--
-- lldpXdot1dcbxAdminPFCTable - Contains the information for the PFC
-- Configuration TLV.
--
lldpXdot1dcbxAdminPFC OBJECT IDENTIFIER ::= { lldpXdot1dcbxAdminData 3 }

lldpXdot1dcbxAdminPFCBasicTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxAdminPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains one row per port for the IEEE 802.1
        organizationally defined LLDP PFC TLV on the local
        system known to this agent"
    ::= { lldpXdot1dcbxAdminPFC 1 }

lldpXdot1dcbxAdminPFCBasicEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminPFCBasicEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Information about the IEEE 802.1 organizational defined
        PFC TLV LLDP extension."
    INDEX         { lldpV2LocPortIfIndex }
    ::= { lldpXdot1dcbxAdminPFCBasicTable 1 }

LldpXdot1dcbxAdminPFCBasicEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminPFCWilling    TruthValue,
    lldpXdot1dcbxAdminPFCMBC        TruthValue,
    lldpXdot1dcbxAdminPFCCap        LldpXdot1dcbxSupportedCapacity
}

lldpXdot1dcbxAdminPFCWilling OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is willing to accept the
        PFC configuration of the remote system."
    REFERENCE
        "D.2.10.3"
    DEFVAL      { false }
    ::= { lldpXdot1dcbxAdminPFCBasicEntry 1}

lldpXdot1dcbxAdminPFCMBC OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
        "Indicates if the local system is capable of bypassing
        MACsec processing when MACsec is disabled."
    REFERENCE
        "D.2.10.4"
    ::= { lldpXdot1dcbxAdminPFCBasicEntry 2}
```

```
lldpXdot1dcbxAdminPFCCap OBJECT-TYPE
    SYNTAX         LldpXdot1dcbxSupportedCapacity
    MAX-ACCESS    read-only
    STATUS    current
    DESCRIPTION
        "Indicates the number of traffic classes on the local device
        that may simultaneously have PFC enabled.

        Note that this typically indicates a physical limitation of the
        device.  However, some devices may allow this parameter to be
        administratively configured, in which case the MAX-ACCESS
        should be changed to read-write with and an appropriate
        DEFVAL added."
    REFERENCE
        "D.2.10.5"
    ::= { lldpXdot1dcbxAdminPFCBasicEntry 3}

lldpXdot1dcbxAdminPFCEnableTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1dcbxAdminPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "This table contains eight entries, one entry per priority,
        indicating if PFC is enabled on the corresponding priority."
    ::= { lldpXdot1dcbxAdminPFC 2 }

lldpXdot1dcbxAdminPFCEnableEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminPFCEnableEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Each entry indicates if PFC is enabled on the
        corresponding priority"
    INDEX {
        lldpV2LocPortIfIndex,
        lldpXdot1dcbxAdminPFCEnablePriority
    }
    ::= { lldpXdot1dcbxAdminPFCEnableTable 1 }

LldpXdot1dcbxAdminPFCEnableEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminPFCEnablePriority    IEEE8021PriorityValue,
    lldpXdot1dcbxAdminPFCEnableEnabled    TruthValue
    }

lldpXdot1dcbxAdminPFCEnablePriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Prioity for which PFC is enabled / disabled"
    ::= { lldpXdot1dcbxAdminPFCEnableEntry 1 }

lldpXdot1dcbxAdminPFCEnableEnabled OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "Indicates if PFC is enabled on the corresponding priority"
    REFERENCE
        "D.2.10.6"
    DEFVAL      { false }
    ::= { lldpXdot1dcbxAdminPFCEnableEntry 2 }

--
-- lldpXdot1dcbxAdminApplicationPriorityTable - Contains the
-- information for the Application Priority TLV.
--

lldpXdot1dcbxAdminApplicationPriorityAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminApplicationPriorityAppEntry
```

```
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the priorty to be used
        for a given application"
    ::= { lldpXdot1dcbxAdminData 4 }

lldpXdot1dcbxAdminApplicationPriorityAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminApplicationPriorityAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the priority to be used for a
        given application."
    INDEX         {
                  lldpV2LocPortIfIndex,
                  lldpXdot1dcbxAdminApplicationPriorityAESelector,
                  lldpXdot1dcbxAdminApplicationPriorityAEProtocol
    }
    ::= { lldpXdot1dcbxAdminApplicationPriorityAppTable 1 }

LldpXdot1dcbxAdminApplicationPriorityAppEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminApplicationPriorityAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxAdminApplicationPriorityAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxAdminApplicationPriorityAEPriority
        IEEE8021PriorityValue
}

lldpXdot1dcbxAdminApplicationPriorityAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxAdminApplicationPriorityAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.10.6"
    ::= { lldpXdot1dcbxAdminApplicationPriorityAppEntry 1 }

lldpXdot1dcbxAdminApplicationPriorityAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxAdminApplicationPriorityAESelector."
    REFERENCE
        "D.2.10.6"
    ::= { lldpXdot1dcbxAdminApplicationPriorityAppEntry 2 }

lldpXdot1dcbxAdminApplicationPriorityAEPriority OBJECT-TYPE
    SYNTAX        IEEE8021PriorityValue
    MAX-ACCESS    read-create
    STATUS        current
    DESCRIPTION
        "The priority code point that should be used in
        frames transporting the protocol indicated by
        lldpXdot1dcbxAdminApplicationPriorityAESelector and
        lldpXdot1dcbxAdminApplicationPriorityAEProtocol"
    REFERENCE
        "D.2.10.6"
    ::= { lldpXdot1dcbxAdminApplicationPriorityAppEntry 3 }
```

```
--
-- lldpXdot1dcbxAdminApplicationVlanAppTable - Contains the
-- information for the Application VLAN TLV.
--

lldpXdot1dcbxAdminApplicationVlanAppTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF
        LldpXdot1dcbxAdminApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Table containing entries indicating the VLAN to be used
        for a given application"
    ::= { lldpXdot1dcbxAdminData 5 }

lldpXdot1dcbxAdminApplicationVlanAppEntry OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAdminApplicationVlanAppEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Entry that indicates the VLAN to be used for a
        given application."
    INDEX         {
                  lldpV2LocPortIfIndex,
                  lldpXdot1dcbxAdminApplicationVlanAESelector,
                  lldpXdot1dcbxAdminApplicationVlanAEProtocol
    }
    ::= { lldpXdot1dcbxAdminApplicationVlanAppTable 1 }

LldpXdot1dcbxAdminApplicationVlanAppEntry ::= SEQUENCE {
    lldpXdot1dcbxAdminApplicationVlanAESelector
        LldpXdot1dcbxAppSelector,
    lldpXdot1dcbxAdminApplicationVlanAEProtocol
        LldpXdot1dcbxAppProtocol,
    lldpXdot1dcbxAdminApplicationVlanAEVlanId
        VlanId
}

lldpXdot1dcbxAdminApplicationVlanAESelector OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppSelector
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "Indicates the contents of the protocol object
        (lldpXdot1dcbxAdminApplicationVlanAEProtocol)
        1: EtherType
        2: Well Known Port number over TCP, or SCTP
        3: Well Known Port number over UDP, or DCCP
        4: Well Known Port number over TCP, SCTP, UDP, and DCCP
        5: Differentiated Services Code Point (DSCP) value. The
           6 bit DSCP value is stored in the low order 6 bits of the
           protocol object. The higher order bits are set to zero.
           (See IETF RFC 2474 for the definition of the DSCP value.)"
    REFERENCE
        "D.2.12.3"
    ::= { lldpXdot1dcbxAdminApplicationVlanAppEntry 1 }

lldpXdot1dcbxAdminApplicationVlanAEProtocol OBJECT-TYPE
    SYNTAX        LldpXdot1dcbxAppProtocol
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "The protocol indicator of the type indicated by
        lldpXdot1dcbxAdminApplicationVlanAESelector."
    REFERENCE
        "D.2.14.3"
    ::= { lldpXdot1dcbxAdminApplicationVlanAppEntry 2 }

lldpXdot1dcbxAdminApplicationVlanAEVlanId OBJECT-TYPE
    SYNTAX        VlanId
    MAX-ACCESS    read-create
```

```
    STATUS        current
    DESCRIPTION
        "The VLAN Identifier that should be used in
        frames transporting the protocol indicated by
        lldpXdot1dcbxAdminApplicationVlanAESelector and
        lldpXdot1dcbxAdminApplicationVlanAEProtocol"
    REFERENCE
        "D.2.14.3"
    ::= { lldpXdot1dcbxAdminApplicationVlanAppEntry 3 }

-- ----------------------------------------------------------------------
-- IEEE 802.1 - DCBX Conformance Information
-- ----------------------------------------------------------------------
lldpXdot1dcbxConformance OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 6 }
lldpXdot1dcbxCompliances
    OBJECT IDENTIFIER ::= { lldpXdot1dcbxConformance 1 }
lldpXdot1dcbxGroups
    OBJECT IDENTIFIER ::= { lldpXdot1dcbxConformance 2 }

--
-- Compliance Statements
--

lldpXdot1dcbxCompliance MODULE-COMPLIANCE
    STATUS        current
    DESCRIPTION
         "A compliance statement for SNMP entities that implement
         the IEEE 802.1 organizationally defined DCBX LLDP
         extension MIB.

         This group is mandatory for agents that implement Enhanced
         Transmission Selection."
    MODULE        -- this module
        MANDATORY-GROUPS  { lldpXdot1dcbxETSGroup,
                            lldpXdot1dcbxPFCGroup,
                            lldpXdot1dcbxApplicationPriorityGroup,
                            lldpXdot1dcbxApplicationVlanGroup,
                            ifGeneralInformationGroup
        }
    ::= { lldpXdot1dcbxCompliances 1 }

--
-- MIB Groupings
--

lldpXdot1dcbxETSGroup  OBJECT-GROUP
    OBJECTS {
        lldpXdot1dcbxConfigETSConfigurationTxEnable,
        lldpXdot1dcbxConfigETSRecommendationTxEnable,
        lldpXdot1dcbxLocETSConCreditBasedShaperSupport,
        lldpXdot1dcbxLocETSConTrafficClassesSupported,
        lldpXdot1dcbxLocETSConWilling,
        lldpXdot1dcbxLocETSConPriTrafficClass,
        lldpXdot1dcbxLocETSConTrafficClassBandwidth,
        lldpXdot1dcbxLocETSConTrafficSelectionAlgorithm,
        lldpXdot1dcbxLocETSRecoTrafficClassBandwidth,
        lldpXdot1dcbxLocETSRecoTrafficSelectionAlgorithm,
        lldpXdot1dcbxRemETSConCreditBasedShaperSupport,
        lldpXdot1dcbxRemETSConTrafficClassesSupported,
        lldpXdot1dcbxRemETSConWilling,
        lldpXdot1dcbxRemETSConPriTrafficClass,
        lldpXdot1dcbxRemETSConTrafficClassBandwidth,
        lldpXdot1dcbxRemETSConTrafficSelectionAlgorithm,
        lldpXdot1dcbxRemETSRecoTrafficClassBandwidth,
        lldpXdot1dcbxRemETSRecoTrafficSelectionAlgorithm,
        lldpXdot1dcbxAdminETSConCreditBasedShaperSupport,
        lldpXdot1dcbxAdminETSConTrafficClassesSupported,
        lldpXdot1dcbxAdminETSConWilling,
        lldpXdot1dcbxAdminETSConPriTrafficClass,
        lldpXdot1dcbxAdminETSConTrafficClassBandwidth,
        lldpXdot1dcbxAdminETSConTrafficSelectionAlgorithm,
        lldpXdot1dcbxAdminETSRecoTrafficClassBandwidth,
```

```
        lldpXdot1dcbxAdminETSRecoTrafficSelectionAlgorithm
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used for Enhanced
        Transmission Selection."
    ::= { lldpXdot1dcbxGroups 1 }

lldpXdot1dcbxPFCGroup  OBJECT-GROUP
    OBJECTS {
        lldpXdot1dcbxConfigPFCTxEnable,
        lldpXdot1dcbxLocPFCWilling,
        lldpXdot1dcbxLocPFCMBC,
        lldpXdot1dcbxLocPFCCap,
        lldpXdot1dcbxLocPFCEnableEnabled,
        lldpXdot1dcbxRemPFCWilling,
        lldpXdot1dcbxRemPFCMBC,
        lldpXdot1dcbxRemPFCCap,
        lldpXdot1dcbxRemPFCEnableEnabled,
        lldpXdot1dcbxAdminPFCWilling,
        lldpXdot1dcbxAdminPFCMBC,
        lldpXdot1dcbxAdminPFCCap,
        lldpXdot1dcbxAdminPFCEnableEnabled
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used for Priority-
        base Flow Control."
    ::= { lldpXdot1dcbxGroups 2 }

lldpXdot1dcbxApplicationPriorityGroup  OBJECT-GROUP
    OBJECTS {
        lldpXdot1dcbxConfigApplicationPriorityTxEnable,
        lldpXdot1dcbxLocApplicationPriorityAEPriority,
        lldpXdot1dcbxRemApplicationPriorityAEPriority,
        lldpXdot1dcbxAdminApplicationPriorityAEPriority
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used for Application
        priority."
    ::= { lldpXdot1dcbxGroups 3 }

lldpXdot1dcbxApplicationVlanGroup  OBJECT-GROUP
    OBJECTS {
        lldpXdot1dcbxConfigApplicationVlanTxEnable,
        lldpXdot1dcbxLocApplicationVlanAEVlanId,
        lldpXdot1dcbxRemApplicationVlanAEVlanId,
        lldpXdot1dcbxAdminApplicationVlanAEVlanId
    }
    STATUS  current
    DESCRIPTION
        "The collection of objects used for Application
        VLAN."
    ::= { lldpXdot1dcbxGroups 4 }
END
```

D.5.6 EVB extensions to the IEEE 802.1 LLDP extension MIB module

In the following MIB definition, should any discrepancy between the DESCRIPTION text and the corresponding definition in D.2.1 through D.5 occur, the definition in D.2.1 through D.5 shall take precedence.

```
LLDP-EXT-DOT1-EVB-EXTENSIONS-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY,
    OBJECT-TYPE
        FROM SNMPv2-SMI
    TruthValue
        FROM SNMPv2-TC
    MODULE-COMPLIANCE,
    OBJECT-GROUP
        FROM SNMPv2-CONF
    ifGeneralInformationGroup
        FROM IF-MIB
    lldpV2LocPortIfIndex,
    lldpV2RemTimeMark,
    lldpV2RemLocalIfIndex,
    lldpV2RemLocalDestMACAddress,
    lldpV2RemIndex,
    lldpV2PortConfigEntry
        FROM LLDP-V2-MIB
    lldpV2Xdot1MIB
        FROM LLDP-EXT-DOT1-V2-MIB;

-- Define the MIB module
        lldpXDot1EvbExtensions MODULE-IDENTITY
    LAST-UPDATED "202211080000Z" -- November 8, 2022
    ORGANIZATION "IEEE 802.1 Working Group"
    CONTACT-INFO
        "  WG-URL: http://www.ieee802.org/1/
         WG-EMail: stds-802-1-l@ieee.org
          Contact: IEEE 802.1 Working Group Chair
           Postal: C/O IEEE 802.1 Working Group
                   IEEE Standards Association
                   445 Hoes Lane
                   Piscataway, NJ 08854
                   USA
          E-mail: stds-802-1-chairs@ieee.org"
    DESCRIPTION
            "The LLDP Management Information Base extension module for
            IEEE 802.1 organizationally defined discovery information
            for the EVB extension objects.

            This MIB module is rooted under the lldpXdot1StandAloneExtensions
            OID arc, in order to allow it to be defined independently
            of other 802.1 LLDP extension MIBs.

        Unless otherwise indicated, the references in this MIB
        module are to IEEE Std 802.1Q-2022.

        Copyright (C) IEEE (2022).
        This version of this MIB module is part of IEEE Std 802.1Q;
        see that standard for full legal notices."

    REVISION "202211080000Z" -- November 8, 2022
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q-2022.
            Cross references and contact information updated."

    REVISION "201807010000Z" -- July 1, 2018
    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2018 revision.
            Cross references updated and corrected."
```

```
    REVISION "201412150000Z" -- December 15, 2014

    DESCRIPTION
            "Published as part of IEEE Std 802.1Q 2014 revision.
            Cross references updated and corrected."

    REVISION "201202150000Z" -- February 15, 2012

    DESCRIPTION
            "Initial version published as part of IEEE Std 802.1Qbg"

-- Hang this MIB module under the stand-alone extension MIBs arc:
   ::= { lldpXdot1StandAloneExtensions 1 }

-- Define the root arc for stand-alone extension MIBs in 802.1
lldpXdot1StandAloneExtensions OBJECT IDENTIFIER ::= { lldpV2Xdot1MIB 7 }

-----------------------------------------------------------------------
-----------------------------------------------------------------------
--
-- Organizationally Defined Information Extension - IEEE 802.1
-- Definitions to support the evbSet TLV set (Table D-1)
-- for Edge Virtual Bridging
--
-----------------------------------------------------------------------
-----------------------------------------------------------------------

lldpXdot1EvbMIB OBJECT IDENTIFIER ::= { lldpXDot1EvbExtensions 1 }
lldpXdot1EvbObjects OBJECT IDENTIFIER ::= { lldpXdot1EvbMIB 1 }

-- EVB 802.1 MIB Extension groups

lldpXdot1EvbConfig OBJECT IDENTIFIER ::= { lldpXdot1EvbObjects 1 }
lldpXdot1EvbLocalData OBJECT IDENTIFIER ::= { lldpXdot1EvbObjects 2 }
lldpXdot1EvbRemoteData OBJECT IDENTIFIER ::= { lldpXdot1EvbObjects 3 }


-----------------------------------------------------------------------
-- IEEE 802.1 - EVB Configuration
-----------------------------------------------------------------------

--
--  lldpXdot1EvbConfigEvbTable : configure the
--  transmission of the EVB TLV on a set of ports
--

lldpXdot1EvbConfigEvbTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1EvbConfigEvbEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of EVB
         TLVs to be transmitted on individual ports."
    ::= { lldpXdot1EvbConfig 1 }

lldpXdot1EvbConfigEvbEntry OBJECT-TYPE
    SYNTAX        LldpXdot1EvbConfigEvbEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        EVB TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
```

```
    AUGMENTS      { lldpV2PortConfigEntry }
    ::= { lldpXdot1EvbConfigEvbTable 1 }

LldpXdot1EvbConfigEvbEntry ::= SEQUENCE {
    lldpXdot1EvbConfigEvbTxEnable TruthValue
}

lldpXdot1EvbConfigEvbTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1EvbConfigEvbTxEnable, which is
        defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined EVB TLV transmission is allowed
        on a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.12"
    DEFVAL         { false }
    ::= { lldpXdot1EvbConfigEvbEntry 1 }

--
--  lldpXdot1EvbConfigCdcpTable : configure the
--  transmission of the CDCP TLV on a set of ports
--

lldpXdot1EvbConfigCdcpTable OBJECT-TYPE
    SYNTAX        SEQUENCE OF LldpXdot1EvbConfigCdcpEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "A table that controls selection of EVB
         TLVs to be transmitted on individual ports."
    ::= { lldpXdot1EvbConfig 2 }

lldpXdot1EvbConfigCdcpEntry OBJECT-TYPE
    SYNTAX        LldpXdot1EvbConfigCdcpEntry
    MAX-ACCESS    not-accessible
    STATUS        current
    DESCRIPTION
        "LLDP configuration information that controls the
        transmission of IEEE 802.1 organizationally defined
        CDCP TLV on LLDP transmission-capable ports.

        This configuration object augments the lldpV2PortConfigEntry of
        the LLDP-MIB, therefore it is only present along with the port
        configuration defined by the associated lldpV2PortConfigEntry
        entry.

        Each active lldpConfigEntry is restored from non-volatile
        storage (along with the corresponding lldpV2PortConfigEntry)
        after a re-initialization of the management system."
    AUGMENTS      { lldpV2PortConfigEntry }
    ::= { lldpXdot1EvbConfigCdcpTable 1 }

LldpXdot1EvbConfigCdcpEntry ::= SEQUENCE {
    lldpXdot1EvbConfigCdcpTxEnable TruthValue
}

lldpXdot1EvbConfigCdcpTxEnable OBJECT-TYPE
    SYNTAX        TruthValue
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
        "The lldpXdot1EvbConfigCdcpTxEnable, which is
        defined as a truth value and configured by the network
        management, determines whether the IEEE 802.1 organizationally
        defined CDCP TLV transmission is allowed
```

```
        on a given LLDP transmission-capable port.

        The value of this object is restored from non-volatile
        storage after a re-initialization of the management system."
    REFERENCE
        "D.2.13"
    DEFVAL         { false }
    ::= { lldpXdot1EvbConfigCdcpEntry 1 }

-------------------------------------------------------------------------
-- IEEE 802.1 - EVB Local System Information
-------------------------------------------------------------------------

---
---
--- lldpV2Xdot1LocEvbTlvTable: EVB TLV Information Table
---
---

lldpV2Xdot1LocEvbTlvTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocEvbTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port of EVB
            TLV information (as a part of the LLDP
            802.1 organizational extension) on the local system
            known to this agent."
    ::= { lldpXdot1EvbLocalData 1 }

lldpV2Xdot1LocEvbTlvEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocEvbTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "EVB TLV information about a
            particular port component."
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocEvbTlvTable 1 }

LldpV2Xdot1LocEvbTlvEntry ::= SEQUENCE {
      lldpV2Xdot1LocEvbTlvString     OCTET STRING
      }

lldpV2Xdot1LocEvbTlvString OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (0..514))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the EVB TLV information string
            for the Port, as defined in D.2.13.
            As the elements within the string are not individually
            manipulated via SNMP (they are of concern only to the
            state machines), the sub-structure of the string
            is not visible as separate objects within the
            local database."
    REFERENCE
            "D.2.12"
    ::= { lldpV2Xdot1LocEvbTlvEntry 1 }


---
---
--- lldpV2Xdot1LocCdcpTlvTable: CDCP TLV Information Table
---
---

lldpV2Xdot1LocCdcpTlvTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1LocCdcpTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
```

```
            "This table contains one row per port of CDCP
            TLV information (as a part of the LLDP
            802.1 organizational extension) on the local system
            known to this agent."
    ::= { lldpXdot1EvbLocalData 2 }

lldpV2Xdot1LocCdcpTlvEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1LocCdcpTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "CDCP TLV information about a
            particular port component."
    INDEX   { lldpV2LocPortIfIndex }
    ::= { lldpV2Xdot1LocCdcpTlvTable 1 }

LldpV2Xdot1LocCdcpTlvEntry ::= SEQUENCE {
      lldpV2Xdot1LocCdcpTlvString     OCTET STRING
      }

lldpV2Xdot1LocCdcpTlvString OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE(0..514))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the CDCP TLV information string
            for the Port, as defined in D.2.14.
            As the elements within the string are not individually
            manipulated via SNMP (they are of concern only to the
            state machines), the sub-structure of the string
            is not visible as separate objects within the
            local database."
    REFERENCE
            "D.2.13"
    ::= { lldpV2Xdot1LocCdcpTlvEntry 1 }

-- ------------------------------------------------------------------------
-- IEEE 802.1 - EVB Remote System Information
-- ------------------------------------------------------------------------

---
---
--- lldpV2Xdot1RemEvbTlvTable: EVB TLV Information Table
---
---

lldpV2Xdot1RemEvbTlvTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemEvbTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port of EVB
            TLV information (as a part of the LLDP
            802.1 organizational extension) on the remote system
            known to this agent."
    ::= { lldpXdot1EvbRemoteData 1 }

lldpV2Xdot1RemEvbTlvEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemEvbTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "EVB TLV information about a
            particular port component."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemEvbTlvTable 1 }

LldpV2Xdot1RemEvbTlvEntry ::= SEQUENCE {
      lldpV2Xdot1RemEvbTlvString     OCTET STRING
```

```
      }

lldpV2Xdot1RemEvbTlvString OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (0..514))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the EVB TLV information string
            for the Port, as defined in D.2.13.
            As the elements within the string are not individually
            manipulated via SNMP (they are of concern only to the
            state machines), the sub-structure of the string
            is not visible as separate objects within the
            local database."
    REFERENCE
            "D.2.12"
    ::= { lldpV2Xdot1RemEvbTlvEntry 1 }


---
---
--- lldpV2Xdot1RemCdcpTlvTable: CDCP TLV Information Table
---
---

lldpV2Xdot1RemCdcpTlvTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF LldpV2Xdot1RemCdcpTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "This table contains one row per port of CDCP
            TLV information (as a part of the LLDP
            802.1 organizational extension) on the remote system
            known to this agent."
    ::= { lldpXdot1EvbRemoteData 2 }

lldpV2Xdot1RemCdcpTlvEntry OBJECT-TYPE
    SYNTAX      LldpV2Xdot1RemCdcpTlvEntry
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
            "CDCP TLV information about a
            particular port component."
    INDEX   { lldpV2RemTimeMark,
              lldpV2RemLocalIfIndex,
              lldpV2RemLocalDestMACAddress,
              lldpV2RemIndex }
    ::= { lldpV2Xdot1RemCdcpTlvTable 1 }

LldpV2Xdot1RemCdcpTlvEntry ::= SEQUENCE {
      lldpV2Xdot1RemCdcpTlvString     OCTET STRING
      }

lldpV2Xdot1RemCdcpTlvString OBJECT-TYPE
    SYNTAX      OCTET STRING (SIZE (0..514))
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
            "This object contains the CDCP TLV information string
            for the Port, as defined in D.2.14.
            As the elements within the string are not individually
            manipulated via SNMP (they are of concern only to the
            state machines), the sub-structure of the string
            is not visible as separate objects within the
            local database."
    REFERENCE
            "D.2.13"
    ::= { lldpV2Xdot1RemCdcpTlvEntry 1 }

-----------------------------------------------------------------------
-- IEEE 802.1 - EVB Conformance Information
-----------------------------------------------------------------------
```

```
lldpXdot1EvbConformance OBJECT IDENTIFIER ::= { lldpXDot1EvbExtensions 2 }

lldpXdot1EvbCompliances
    OBJECT IDENTIFIER ::= { lldpXdot1EvbConformance 1 }
lldpXdot1EvbGroups
    OBJECT IDENTIFIER ::= { lldpXdot1EvbConformance 2 }

--
-- EVB - Compliance Statements
--

lldpXdot1EvbCompliance MODULE-COMPLIANCE
    STATUS        current
    DESCRIPTION
         "A compliance statement for SNMP entities that implement
         the IEEE 802.1 organizationally defined Congestion
         Notification LLDP extension MIB.

         This group is mandatory for agents that implement the
         EVB evbSet TLV set."
    MODULE        -- this module
        MANDATORY-GROUPS  { lldpXdot1EvbGroup,
                            ifGeneralInformationGroup }
    ::= { lldpXdot1EvbCompliances 1 }


--
-- EVB - MIB groupings
--

lldpXdot1EvbGroup  OBJECT-GROUP
    OBJECTS {
      lldpXdot1EvbConfigEvbTxEnable,
      lldpXdot1EvbConfigCdcpTxEnable,
      lldpV2Xdot1LocEvbTlvString,
      lldpV2Xdot1LocCdcpTlvString,
      lldpV2Xdot1RemEvbTlvString,
      lldpV2Xdot1RemCdcpTlvString
      }
    STATUS  current
    DESCRIPTION
        "The collection of objects that support the
        EVB evbSet TLV set."
    ::= { lldpXdot1EvbGroups 1 }

END
```

Annex E

(normative)

Notational conventions used in state diagrams

State diagrams are used to represent the operation of the protocol by a number of cooperating state machines each comprising a group of connected, mutually exclusive states. Only one state of each machine can be active at any given time.

Each state is represented in the state diagram as a rectangular box, divided into two parts by a horizontal line. The upper part contains the state identifier, written in upper case letters. The lower part contains any procedures that are executed on entry to the state.

All permissible transitions between states are represented by arrows, the arrowhead denoting the direction of the possible transition. Labels attached to arrows denote the condition(s) that must be met in order for the transition to take place. All conditions are expressions that evaluate to TRUE or FALSE; if a condition evaluates to TRUE, then the condition is met. The label UCT denotes an unconditional transition (i.e., UCT always evaluates to TRUE). A transition that is global in nature (i.e., a transition that occurs from any of the possible states if the condition attached to the arrow is met) is denoted by an open arrow, i.e., no specific state is identified as the origin of the transition. When the condition associated with a global transition is met, it supersedes all other exit conditions including UCT. The special global condition BEGIN supersedes all other global conditions, and once asserted remains asserted until all state blocks have executed to the point that variable assignments and other consequences of their execution remain unchanged.

On entry to a state, the procedures defined for the state (if any) are executed exactly once, in the order that they appear on the page. Each action is deemed to be atomic, i.e., execution of a procedure completes before the next sequential procedure starts to execute. No procedures execute outside of a state block. The procedures in only one state block execute at a time, even if the conditions for execution of state blocks in different state machines are satisfied. All procedures in an executing state block complete execution before the transition to and execution of any other state block occurs, i.e., the execution of any state block appears to be atomic with respect to the execution of any other state block and the transition condition to that state from the previous state is TRUE when execution commences. The order of execution of state blocks in different state machines is undefined except as constrained by their transition conditions. A variable that is set to a particular value in a state block retains this value until a subsequent state block executes a procedure that modifies the value.

On completion of all of the procedures within a state, all exit conditions for the state (including all conditions associated with global transitions) are evaluated continuously until one of the conditions is met. The label ELSE denotes a transition that occurs if none of the other conditions for transitions from the state are met (i.e., ELSE evaluates to TRUE if all other possible exit conditions from the state evaluate to FALSE). Where two or more exit conditions with the same level of precedence become TRUE simultaneously, the choice about which exit condition causes the state transition to take place is arbitrary.

Where it is necessary to split a state machine description across more than one diagram, a transition between two states that appear on different diagrams is represented by an exit arrow drawn with dashed lines, plus a reference to the diagram that contains the destination state. Similarly, dashed arrows and a dashed state box are used on the destination diagram to show the transition to the destination state. In a state machine that has been split in this way, any global transitions that can cause entry to states defined in one of the diagrams are deemed to be potential exit conditions for all of the states of the state machine, regardless of which diagram the state boxes appear in.

Should a conflict exist between a state diagram and either the corresponding global transition tables or the textual description associated with the state machine, the state diagram takes precedence. The interpretation of the special symbols and operators used in the state diagrams is as defined in Table E-1; these symbols and operators are derived from the notation of the "C++" programming language, ISO/IEC 14882. If a Boolean variable is described in this clause as being set it has or is assigned the value TRUE, if reset or clear the value FALSE.

Table E-1—State machine symbols

Symbol	Interpretation
( )	Used to force the precedence of operators in Boolean expressions and to delimit the argument(s) of actions and conditional actions within state boxes.
{}	Used to group multiple actions.
;	Used as a terminating delimiter for actions within state boxes. Where a state box contains multiple actions, the order of execution follows the normal English language conventions for reading text.
=	Assignment action. The value of the expression to the right of the operator is assigned to the variable to the left of the operator. Where this operator is used to define multiple assignments, e.g., a = b = X the action causes the value of the expression following the right-most assignment operator to be assigned to all of the variables that appear to the left of the right-most assignment operator.
!	Logical NOT operator.
&&	Logical AND operator.
||	Logical OR operator.
if <expr> <action>	Conditional action. If the Boolean expression, <expr>, evaluates to TRUE, then the <action> following the expression is executed. If multiple actions are to be executed, they are grouped together by means of {}.
!=	Inequality. Evaluates to TRUE if the expression to the left of the operator is not equal in value to the expression to the right.
==	Equality. Evaluates to TRUE if the expression to the left of the operator is equal in value to the expression to the right.
*	Arithmetic multiplication operator.
-	Arithmetic subtraction operator.

Annex F

(informative)

Shared and Independent VLAN Learning (SVL and IVL)

This standard provides for a variety of approaches to the implementation of Bridges from the point of view of the way that individual MAC addresses are learned, and how that learned information is used in subsequent forwarding/filtering decisions. Two mechanisms are used as a basis for these variants:

a) Making use of address information learned across a number of VIDs in order to make learning decisions relative to any one of those VIDs. This is referred to as Shared VLAN Learning (SVL, 3.238).
b) Making use of address information learned in association with one VID only in order to make learning decisions relative to that VID, and ensuring that it is not used in learning decisions relative to any other VID. This is referred to as *Independent VLAN Learning* (IVL, 3.111).

These mechanisms lead to the SVL/IVL model for how a Bridge implements learning and filtering for MAC addresses. Using the terminology of 8.8.8, an SVL/IVL Bridge supports multiple FIDs (which effectively equates to supporting multiple FDBs), and multiple VIDs can use each FID. By varying the number of FIDs supported, and the number of VIDs that can share each FID, the following simplifications of the SVL/IVL model can be created:

c) *SVL only*. The implementation supports only one FID, so all VIDs share the same learned MAC address information, regardless of which VID the information was learned in.
d) *IVL only*. Multiple FIDs are supported, but each FID can support only one VID, so each VID makes use only of MAC address information learned within the context of that VID.

All three approaches are permitted by this standard, and each has advantages in particular circumstances. The remainder of this annex discusses the following:

e) The requirements for IVL, SVL, or both.
f) How Bridges are made aware of the requirement for particular VLANs to be “shared” or “independent.”
g) How Bridges based on one of these models can interoperate with Bridges based on a different model, in the same network.

F.1 Requirements for Shared and Independent Learning

Under most circumstances, the SVL and IVL approaches work equally well, and Bridges adopting either approach can be freely intermixed within a network. There are, however, a small number of configuration cases where, in order to prevent undue flooding of unicast frames, and in some cases, to make communication between the affected end systems possible, it is necessary to make specific choices about how Bridges that adopt these different learning models are deployed in a network. The following subclauses give examples of some of these configurations and provide a generic statement of the requirements that must be met in order for each learning model to be successfully deployed.

F.1.1 Connecting independent VLANs

Figure F-1 illustrates how a device that connects two VLANs together, and which therefore itself shares learning between those VLANs, creates a need for those VLANs to be independent in other Bridges.

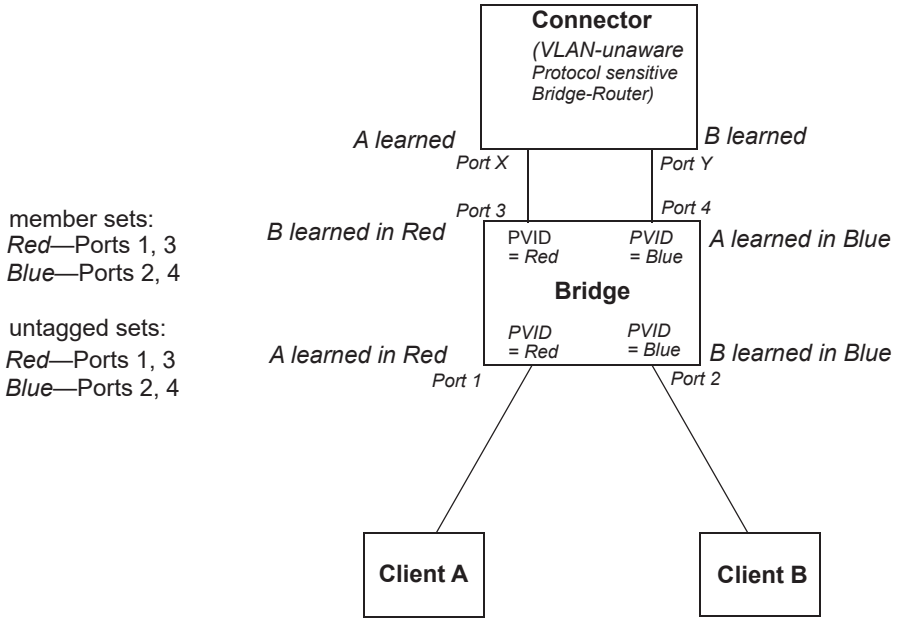


Figure F-1—Connecting independent VLANs—1

Clients A and B are connected via the protocol sensitive Bridge-Router (Connector), with an intervening VLAN Bridge. The fact that all Ports of the Bridge carry untagged traffic neatly conceals the fact that the Connector has the effect of connecting VLANs Red and Blue together with regard to bridged traffic. The Connector learns A and B in the same database, as it has no knowledge of VLANs Red and Blue. This prevents any traffic transmitted on the Red VLAN (Port X of the Connector) that is destined for A, from being bridged to Port Y and transmitted on the Blue VLAN.

The VLAN Bridge must keep its learning separate for Red and Blue; otherwise, the addresses of the two clients would be alternately learned on diagonally opposite Ports as, for example, traffic sourced by A reenters the Bridge on Port 4 having previously been seen on Port 1.

NOTE—This example assumes that the spanning tree protocol is disabled in the Connector, so that the VLAN Bridge does not attempt to suppress the loop that apparently exists if VLANs are not taken into account.

A simpler example can be constructed, with a single Port connecting the Connector and the VLAN Bridge, if the Connector is itself VLAN aware and transmits and receives only VLAN-tagged traffic. In this case, the Connector would allocate a single FID for use by Red and Blue. This is shown in Figure F-2.

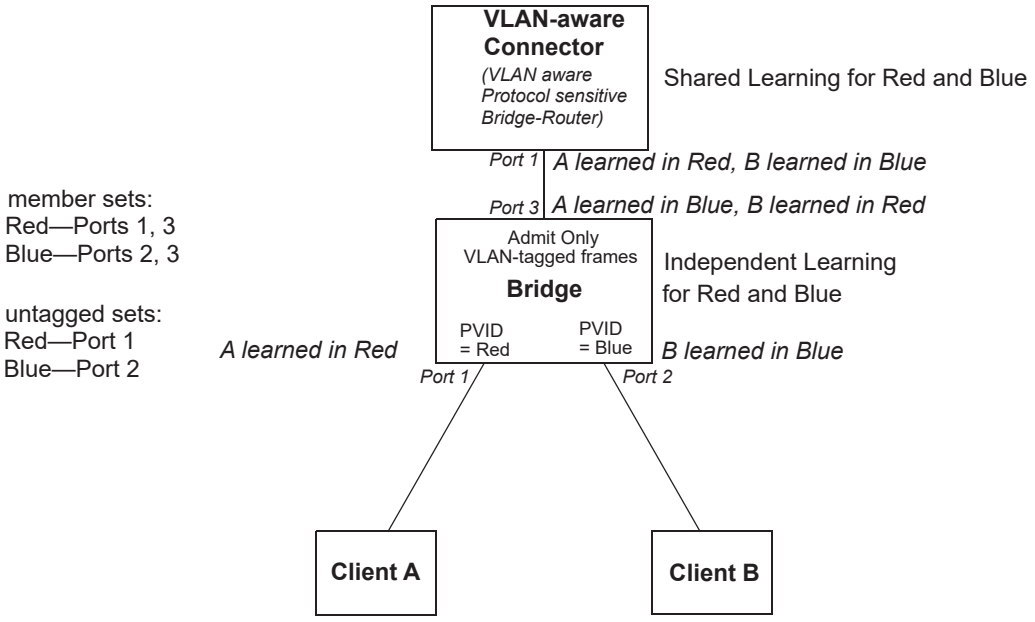


Figure F-2—Connecting independent VLANs—2

F.1.2 Duplicate MAC addresses

The simplest example of a need for IVL occurs where two (or more) distinct devices in different parts of the network reuse the same individual MAC address, or where a single device is connected to multiple LANs, and all of its LAN interfaces use the same individual MAC address. This is shown in Figure F-3.

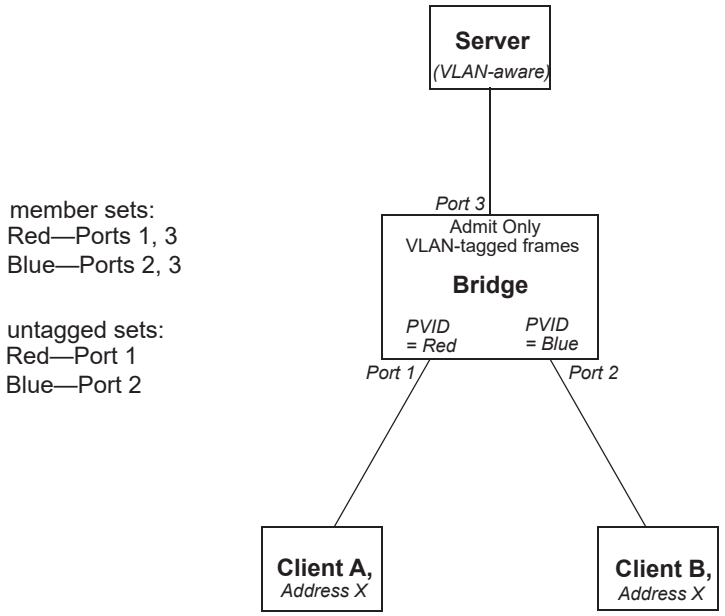


Figure F-3—Duplicate MAC addresses

The example shows two clients with access to the same server; both clients are using the same individual MAC address, X. If the Bridge shares learning between VLAN Red (which serves Client A) and VLAN Blue (which serves Client B), i.e., the Bridge uses the same FID for both VIDs, then Address X will appear to move between Ports 1 and 2 of the Bridge, depending on which client has most recently transmitted a frame. Communication between these Clients and the server will therefore be seriously disrupted. Assignment of distinct FIDs for Red and Blue ensures that communication can take place correctly.

Hence, in order to construct this particular VLAN configuration, either an IVL Bridge or an SVL/IVL Bridge would be required.

F.1.3 Asymmetric VLANs and Rooted-Multipoint connectivity

A primary example of the requirement for SVL is found in “asymmetric” uses of VLANs. Under normal circumstances, a pair of devices communicating in a VLAN environment will both send and receive using the same VID; however, there are some circumstances in which it is convenient to make use of two distinct VIDs, one used for A to transmit to B and the other used for B to transmit to A. Examples of such applications include configuring multi-netted servers, and configuring rooted-multipoint services.

F.1.3.1 Multi-netted Server

An example of Multi-netted Server application of asymmetric VLANs is shown in Figure F-4. Note that:

a) In the example, the server and both clients are assumed to be VLAN-unaware devices, i.e., they transmit and receive untagged frames only.
b) The ingress classification rules assumed by the example are as defined in this standard, i.e., Port-based classification only.
c) The configuration shown can only be achieved by management configuration of appropriate values in Static VLAN Registration Entries (8.8.10) in order to configure the indicated member sets and untagged sets.

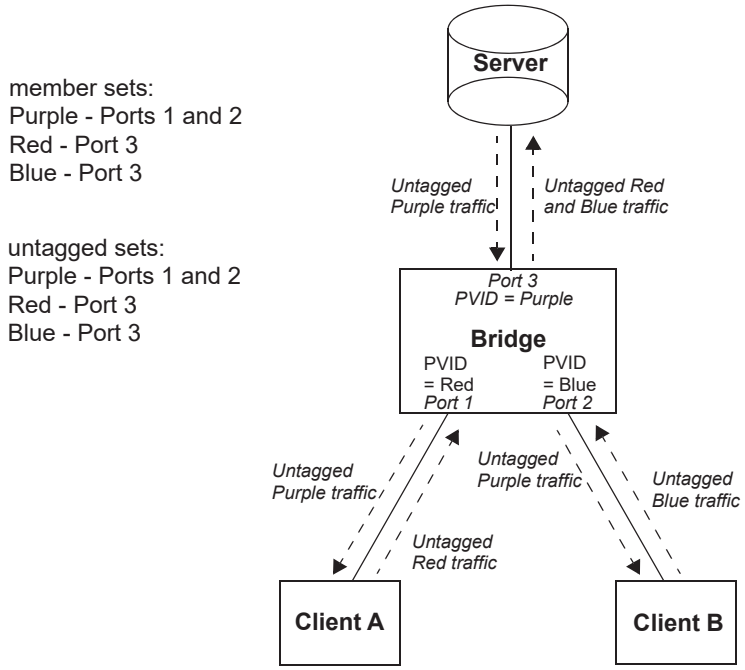


Figure F-4—Asymmetric VID use: “multi-netted server”

In the example, Port-based tagging and an asymmetric VLAN configuration is used in order to permit Clients A and B access to a common server, but to prohibit Clients A and B from talking to each other. Examples of where this type of configuration might be required are if the clients are on distinct IP subnets, or if there is some confidentiality-related need to segregate traffic between the clients.

Client A transmits to the server via Port 1, which will classify this traffic as belonging to VLAN Red; the Bridge therefore learns Client A's MAC address on Port 1 in association with VLAN Red's VID. The Server transmits its responses to Client A via Port 3, which classifies the return traffic as belonging to VLAN Purple. If individual MAC address learning is configured in the Bridge such that learning is independent between Red and Purple (the VIDs for Red and Purple are allocated to distinct FIDs), then the Bridge will have no knowledge of A in VLAN Purple and will therefore flood the server's responses to Client A on both Port 1 and Port 2. Conversely, if the VIDs for Red and Purple are defined to share the same FID, then the address information learned in Red will be available for use in forwarding the Purple traffic, and the responses to Client A are forwarded only through Port 1.

Similarly, there is a need in this configuration for Blue and Purple to share learning information; hence, in order for this configuration to achieve its objectives, the Red, Blue, and Purple VIDs must be allocated to the same FID in the Bridge.

Hence, in order to construct this particular VLAN configuration, either an SVL Bridge or an SVL/IVL Bridge would be required.

NOTE—The example has been deliberately simplified; in practical applications, the central Bridge would likely be replaced by a number of VLAN Bridges, interconnected with links that would carry the traffic between clients and server as VLAN-tagged frames, with VLAN-tagging and untagging occurring only at the "edge" Ports of the network. An alternative approach to the one described here could also be achieved either by using a VLAN-aware server or by use of more sophisticated ingress classification rules.

F.1.3.2 Rooted-Multipoint

An example of a rooted-multipoint application of asymmetric VLANs is shown in Figure F-5. The defining characteristic of a rooted-multipoint service is that all Bridge Ports that provide access points to the service are designated as either a Root Port or a Leaf Port, and that the Root Ports can communicate with all other Root Ports and all Leaf Ports, whereas the Leaf Ports can communicate with all Root Ports but not with any other Leaf Ports. Services based on rooted-multipoint connectivity are also known as "Rooted-Multipoint EVC" services as defined in MEF 10.3. Rooted-multipoint connectivity would typically be used by an Internet access provider or a video content provider, where the provider of the service connects to Root Ports, and the subscribers of the service connect to Leaf Ports. This connectivity can be achieved with the "multi-netted server" configuration shown in Figure F-4, but it consumes one VID per subscriber. Figure F-5 shows an alternative that uses just two VIDs: a "Trunk" VID for traffic from Root Ports to Leaf Ports (and to other Root Ports) and a "Branch" VID for traffic from Leaf Ports to Root Ports.

To allow the servers to communicate with all other servers and all subscribers, and to allow the subscribers to communicate with all servers but not with other subscribers, the rooted-multipoint connectivity requires the following configuration:

a) The server(s) and all subscribers transmit and receive untagged frames only. Note that for a rooted-multipoint service on a PBN, this means the frames do not contain S-TAGs at the customer service interface (in other words, the User Network Interface (UNI)). Therefore, rooted-multipoint can be supported at Port-based service interfaces (15.3) and C-tagged service interfaces (15.4).
b) The ingress C-VLAN classification may be Port-based or Port-and-Protocol-based for rooted-multipoint on CBNs. The ingress S-VLAN classification may be Port-based or C-TAG-based for rooted-multipoint on PBNs.
c) In Customer Bridges and S-VLAN Bridges, the indicated values of the member sets and untagged sets (8.8.10) are achieved by management configuration of Static VLAN Registration Entries

(8.8.2). In Provider Edge Bridges the Trunk and Branch VIDs are also mapped to the appropriate CNP/PEP pair by management configuration of the PEP Table (12.13.2.4, ieee8021PbEdgePortTable 17.6.1.2). Note that connectivity between Leaf Ports is blocked by not including Leaf Ports in the member set associated with the Branch VID.

d) In Customer Bridges and S-VLAN Bridges the indicated values of the PVID parameters are configured by management. In Provider Edge Bridges the equivalent configuration is achieved by management configuration of the C-VID Registration Table (12.13.2.2, ieee8021PbCVidRegistrationTable 17.6.1.2).

e) The Enable Ingress Filtering parameter (8.6.2) is reset, i.e., ingress VLAN filtering is disabled, on Leaf Ports.

f) The Trunk and Branch VIDs share the same FID (to enable SVL).

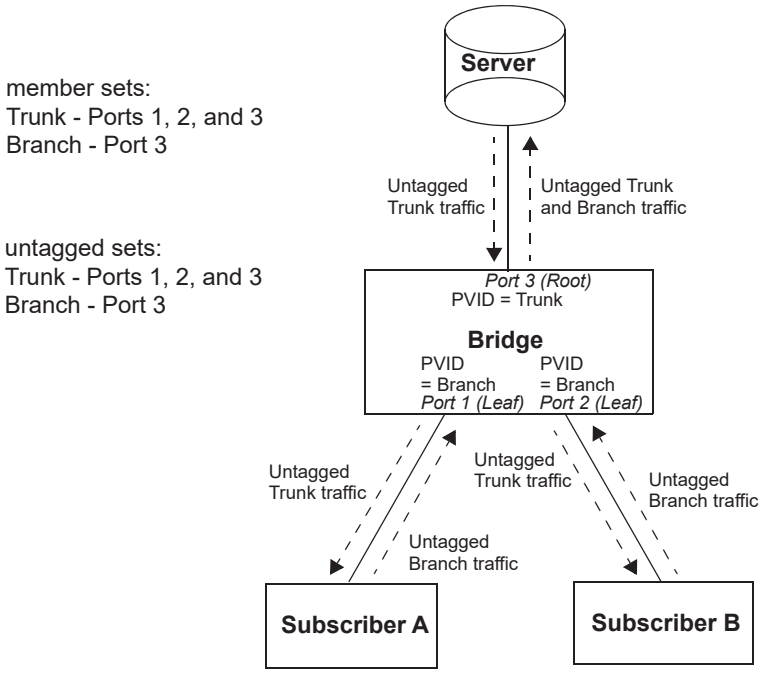


Figure F-5—Asymmetric VLAN use: "Rooted-Multipoint"

NOTE 1—The example has been deliberately simplified; in practical applications, the central Bridge would likely be replaced by a number of VLAN Bridges, interconnected with links that would carry the traffic between subscribers and servers as VLAN-tagged frames, with only the Root and Leaf Ports of the network carrying untagged frames.

Rooted-multipoint services can be carried on PBBNs by configuring Trunk and Branch S-VIDs as described above, with the Root and Leaf Ports at CNPs either at an I-component of a BEB, or at a Provider Edge Bridge of a PBN that then connects to the PBBN. The I-component of a BEB can then either map the Trunk and Branch S-VIDs to separate backbone service instances (i.e., mapped to separate I-SIDs) or bundle them into a single backbone service instance.

Rooted-multipoint connectivity can also be created on a PBBN by configuring Trunk and Branch B-VIDs as described above, with the Root and Leaf Ports at CBPs of a B-component in a BEB. One or more backbone service instances can then be mapped to the Trunk and Branch B-VIDs to take advantage of the rooted-multipoint connectivity.

As noted in item a) above, the configurations described above apply to scenarios where the ingress and egress frames at a Root or Leaf Port on a Customer Bridge or S-VLAN Bridge are untagged. Customer Bridges and S-VLAN Bridges that support both the VID Translation Table and Egress VID Translation Table (6.9) can support tagged ingress and egress frames at a Root or Leaf Port. Figure F-6 shows the configuration where the server(s) and subscribers transmit and receive tagged frames. The server uses VID R for frames associated with the rooted-multipoint service, and the subscribers use VIDs L1 and L2. The values of R, L1, and L2 could be, but are not necessarily, the same. The configuration of the Bridge(s) with Root and Leaf Ports are shown in the diagram. All Root and Leaf Ports are included in the member set of the Trunk and Branch VIDs, but not in the untagged set (including the Leaf Ports in the member set of the Branch VID allows ingress VLAN filtering to be enabled at these ports if desired). The VID translation at a Root Port ensures that ingress frames go to the Trunk VID, and egress frames come from both the Trunk and Branch VIDs. The VID translation at a Leaf Port ensures that ingress frames go to the Branch VID, and egress frames come from the Trunk VID (translating the Branch VID to 0xFFF on egress frames at Leaf Ports causes these frames to be discarded).

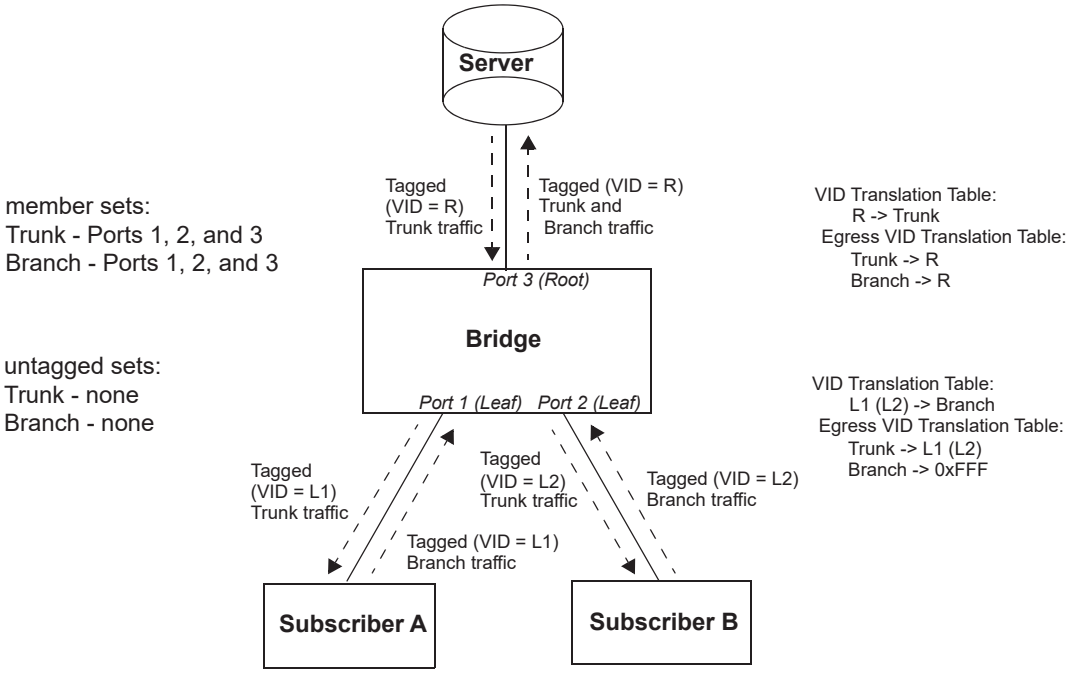


Figure F-6—Rooted-Multipoint with tagged interfaces

NOTE 2—The example has been deliberately simplified; in practical applications, the central Bridge would likely be replaced by a number of VLAN Bridges, interconnected with links that would carry the traffic between subscribers and servers as frames tagged with either the Trunk or Branch VID. VLAN translation occurs only at the Root and Leaf Ports of the network.

F.1.4 Shared learning and Shortest Path Bridging VID (SPBV) mode

SPBV mode uses shared learning among the set of SPVIDs that support a given SPBV VLAN. Each SPT Bridge supporting an SPBV VLAN is assigned a unique VID (SPVID) for transmitting VLAN frames into the SPT Region. This SPVID is registered by the ISIS-SPB control plane along an SPT rooted at the SPT Bridge to which it is assigned. The SPTs determined by ISIS-SPB provide symmetric bidirectional paths (i.e., congruent paths) between any pair of SPT Bridges within an SPT Region. The congruency of the paths is essential to allow shared learning. Shared learning is required because frames forwarded from a given SPT Bridge will contain a different SPVID from frames being forwarded to that SPT Bridge.

Figure F-7 shows an example of a simple SPBV VLAN operating in an SPT Region comprising three Bridges A, B, and C. Each of the Bridges is assigned an SPVID, in this example using the same letter designation as the Bridge to which it is assigned. ISIS-SPB maintains the VID member sets such that the SPVID of an SPT Bridge follows an SPT rooted at that particular SPT Bridge. The SPT includes all boundary ports participating in the SPBV VLAN (in this example the ports connected to stations A, B, and C).

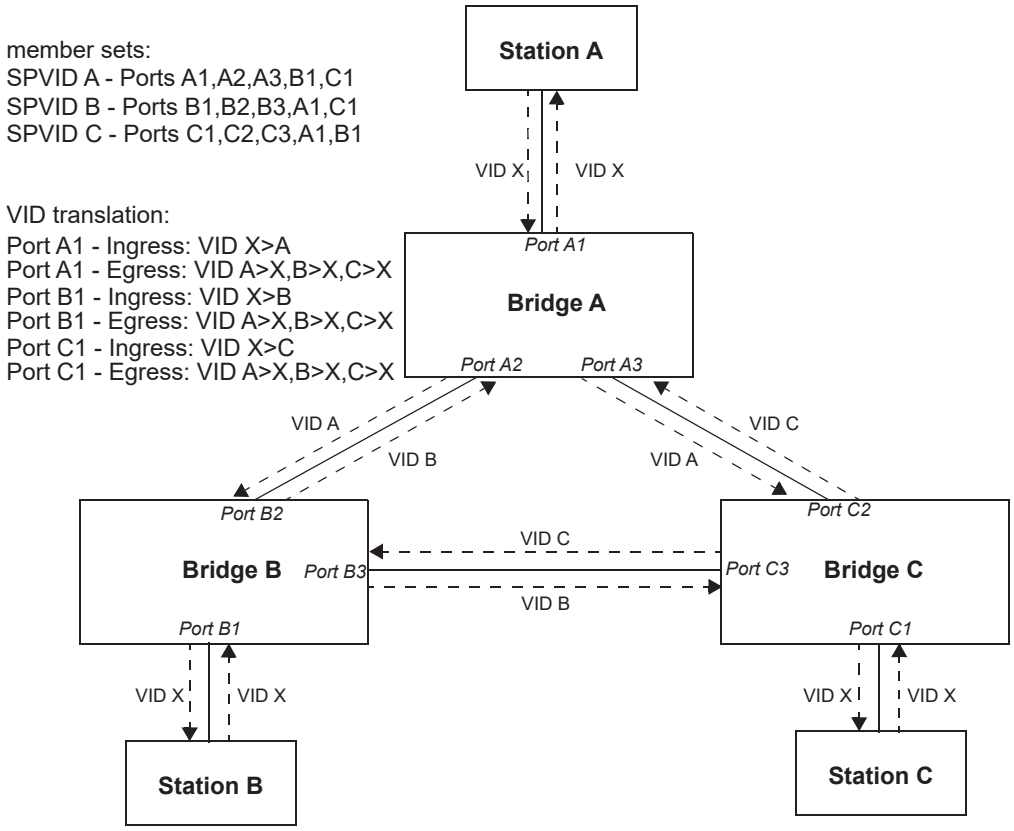


Figure F-7—SPBV VLAN Shared Learning and VID Translation

Shared learning is used among all the SPVIDs belonging to the SPBV VLAN. This enables the filtering information learned from frames transmitted from a Bridge (with that Bridge's SPVID) to be applied to frames being transmitted to that Bridge from other Bridges using the other Bridges' SPVIDs. For example, a frame sent from station A to station B will be transmitted by Bridge A using SPVID A. At Bridge B the frame's source address will be learned at port B2. When station B later sends a frame to station A, Bridge B will assign the frame SPVID B. Shared learning enables Bridge B to use the MAC address previously learned from the frame with SPVID A to filter the frame with SPVID B to transmit only on port B2.

Enhanced VID translation capabilities allow a single VID to be used for VLANs on boundary ports connected to an SPT Region even though many SPVIDs with shared learning are used within the SPT Region. In this example stations A, B, and C all use VID X. At each boundary port ingress translation is set to translate the external VID (usually the Base VID) to the SPVID for the Bridge on which the boundary port resides. Egress VID translation is set to translate all the SPVIDs belonging to the SPBV VLAN to the external VID.

F.1.5 Generic constraints on SVL and IVL use

This subclause describes the general constraints on the mapping of VIDs to FIDs, from the point of view of a given Bridge that learns from or forwards frames on a set of VIDs (the Bridge's "active set" of VIDs). If:

a) The individual MAC addresses associated with each point of attachment to the active set of VIDs are unique (i.e., the "Duplicate MAC Address problem" is not present), and
b) There is no Bridge or Bridge-like device that takes frames from one VID in the active set and subsequently transmits them on another VID in the active set, then

every VID in the active set may share the same FID; in other words, individual MAC address information learned in the context of any one VID may be used in forwarding decisions taken relative to any of the others, so the SVL approach can be used in that Bridge.

Furthermore, if:

c) Each bidirectional, individual MAC-Addressed, conversation between pairs of end stations makes use of the same VID in both directions, then

every VID in the active set may be allocated a distinct FID (with the possibility of a little extra flooding as learning of addresses in the context of one VID does not contribute to forwarding decisions for that address relative to any other VID). Under these circumstances, rule b) may also be relaxed and restated as follows:

d) Frames associated with one VID in the active set may be received by (up to) one Bridge and transmitted using another VID in the active set, provided that there is no loop in such VLAN to VLAN forwarding, e.g., for a set of VIDs Red, Blue, and Green, there is no logical loop in copying frames between VIDs, such as copying from Red to Green by one Bridge, Green to Blue by another, and Blue back to Red by a third.

So:

e) If rules a), b), and c) are true, and d) is false, for all VIDs in the active set, then either an SVL or an IVL Bridge can be deployed;
f) If rules a) and b) are true, and c) and d) are false for all VIDs in the active set, then only an SVL Bridge can be deployed;
g) If rules a) or b) or d) are false, and c) is true for all VIDs in the active set, then only an IVL Bridge can be deployed.

These conditions are all on the basis that they apply "for all VIDs in the active set." Clearly, in more complex scenarios, some VIDs in the active set will have requirements that dictate SVL behavior on the part of a given Bridge, while others will have requirements that dictate IVL behavior. Under such circumstances, an SVL/IVL Bridge is required, allowing those VIDs that need to be shared to be mapped to a single FID, while those that need to be independent are mapped to distinct FIDs. Needless to say, wherever an SVL or IVL Bridge can be deployed, it can successfully be replaced by an appropriately configured SVL/IVL Bridge.

Annex G

(informative)

MAC method-dependent aspects of VLAN support

G.1 Example tagged IEEE 802.3 EtherType-encoded frame format

Figure G-1 provides an illustrative example of a single tagged EtherType-encoded frame format as used in an Ethernet to Ethernet Bridge. This illustration is only of the simplest case, that is, a single-level, fixed-size tagging between identical MACs.[62]

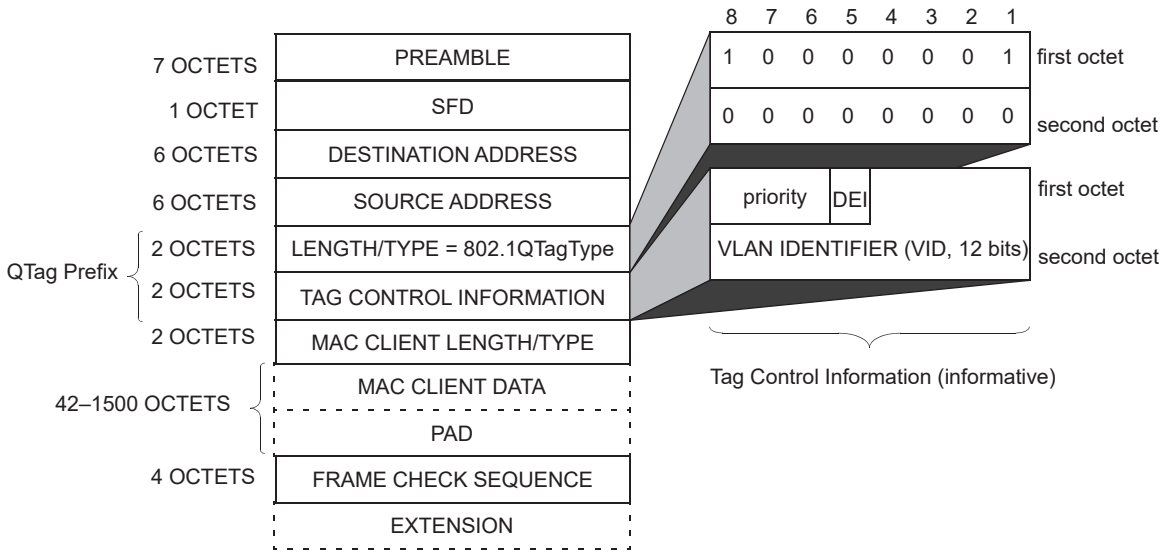


Figure G-1—Example of IEEE 802.3 MAC frame format

G.2 Padding and frame size considerations

G.2.1 Treatment of PAD fields in IEEE 802.3 frames

The minimum frame size constraint placed on IEEE 802.3/Ethernet frames requires frames to carry zero or more pad octets following the MAC client data, in order to ensure that no frame of total length less than 64 octets is transmitted on the medium. This requirement means that frames whose overall length would otherwise be less than 64 octets in length have (64-len) octets of padding added after the MAC client data, where len is the size of the frame before padding.

[62] Figure G-1 was part of Clause 3 of IEEE Std 802.3-2005.

When tagged frames are transmitted by a Bridge on an IEEE 802.3 MAC, there are two permissible approaches, as follows:

a) Keep the minimum frame size generated by the Bridge equal to 64 octets. This implies that the number of pad octets in a received untagged IEEE 802.3 frame would be reduced by up to 4 octets when that frame was tagged.
b) Adopt a minimum tagged frame length of 68 octets. This implies that the number of pad octets in a received untagged IEEE 802.3 frame would not be adjusted when tagging such frames; equally, if subsequently untagged, no pad adjustment would be necessary before transmission on IEEE 802.3/ Ethernet.

There is a similar choice to be made in end stations that generate tagged frames:

c) In some existing implementations, the decision about whether pad octets are needed will be made at a point where it is impractical to distinguish between tagged and untagged frames. In these cases, the end station will use a minimum frame size of 64 octets for all frames.
d) In other cases, the padding decision will be taken at a point before it is known whether the frame will be transmitted tagged or untagged. In these cases, the end station will use a minimum tagged frame size of 68 octets and a minimum of 64 octets for untagged frames.

These approaches are all consistent with the IEEE 802.3 frame specification.

The implication is that, for correct operation on IEEE 802.3/Ethernet, all devices have to be capable of correctly handling tagged frames of less than 68 octets in length (G.2.3).

G.2.2 Maximum PDU size

VLAN tagging of an untagged frame, or relaying frames in tagged frame format, can result in an increase in the length of the original frame. If transmission of a given frame in tagged frame format through a given destination Port would result in violation of the maximum PDU size for the destination MAC method, the Bridge discards the frame for that destination Port.

NOTE—Violation of the maximum PDU sizes for destination MAC methods can produce undefined results in networks that contain devices that adhere strictly to these maxima, or in MAC methods where these maxima are inherently constrained by the operation of the MAC method itself (e.g., constrained by timing considerations in the MAC state machines).

IEEE Std 802.3 defines an extension to the normal IEEE 802.3 maximum frame size for the specific purpose of accommodating the additional octets of the VLAN tag header. The example frame translations in this annex make use of this extension to the IEEE 802.3 frame size.

G.2.3 Minimum PDU size

VLAN untagging of a tagged frame results in the original frame decreasing in length.

Where the destination MAC is Ethernet:

a) If untagging a given frame would result in violation of the minimum frame length requirements of Ethernet, the Bridge is required to adjust the PAD field to ensure that the frame length equals the minimum length of 64 octets (G.2.1).
b) If a frame is transmitted in tagged frame format, the Bridge may adopt a minimum tagged frame length of either 64 or 68 octets, as an implementation option. If the latter is chosen, the Bridge adjusts the size of the PAD field on transmission for any tagged frame that is less than 68 octets in length (G.2.1).

G.3 Tag insertion and removal for LLC media

In IEEE Std 802.1Q-2014 and all previous revisions of IEEE Std 802.1Q, the method of inserting and deleting tags was independent of whether a Length/Type field is used for protocol type encoding. The tag was inserted into or deleted from the first octets of the mac_service_data_unit and the remainder of the mac_service_data_unit was unchanged.

That deletion/insertion method did not provide for interoperability between VLAN-aware end stations where only one used a Length/Type field to encode protocol identifiers. It specified that the station on the LLC media used a SNAP-encoded VLAN tag followed by a SNAP-encoded data unit, whereas on the station using Length/Type, the VLAN tag was followed by an EtherType protocol identifier. These multiple encodings required a bridge to translate both the VLAN tag and the following protocol identifier, along with any other tags defined previously or subsequently. Translation of the second and any subsequent protocol identifiers is impossible if the contents of the frame are protected against modification or rendered confidential, as in the case of a frame protected by MAC Security (IEEE Std 802.1AE).

To avoid this problem, revisions of IEEE Std 802.1Q subsequent to 2014, and IEEE Std 802.1AC subsequent to 2012, specify that following the first protocol identifier, all subsequent protocol identifiers (if any) use Length/Type encoding.

The net result was that the expected format for a tagged frame changed. For example, on LLC media, the first 18 octets of a VLAN-tagged SNAP-encoded MSDU carrying an EtherType of 08-00 (hexadecimal) for the user data, priority 0, VLAN 123, was, in revisions prior to IEEE Std 802.1Q-2018:

AA-AA-03-00-00-00-81-00-01-23-AA-AA-03-00-00-00-08-00

and subsequently, is:

AA-AA-03-00-00-00-81-00-01-23-08-00

The underlined octets are no longer present. That is, on LLC media, all tags and protocol identifiers after the first are Length/Type encoded.

G.4 IEEE 802.11 and PMPN media

Figure G-2 illustrates an example of a five-port Bridge that uses three of the methods defined by IEEE Std 802.1AC whereby a Bridge can connect to an IEEE 802.11 medium, or to a Point-to-Multipoint Network (PMPN). The following subclauses describe these methods.

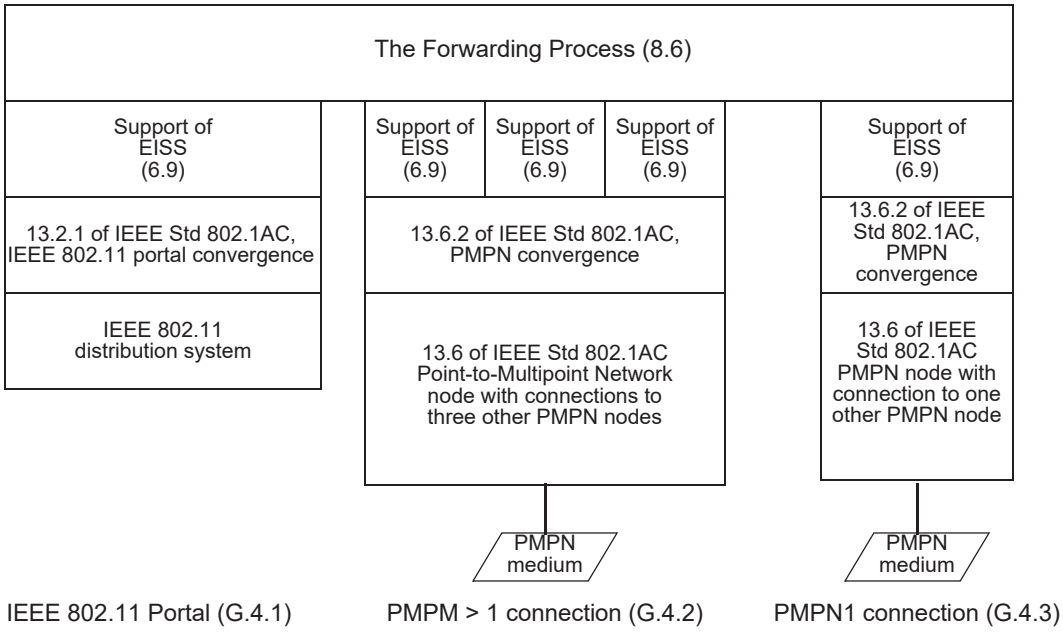


Figure G-2—Methods for Bridge access to IEEE 802.11 and PMPN media: example

G.4.1 IEEE 802.11 Portal convergence

A Bridge, along with the portal convergence function defined in 13.2.1 of IEEE Std 802.1AC-2016 [B8], together constitute an example of an IEEE 802.11 Portal.

G.4.2 Point-to-Multipoint Network convergence: multiple connections

The PMPN convergence function, defined in 13.6.2 of IEEE Std 802.1AC-2016 [B8], provides a set of virtual point-to-point instances of the ISS, one to each PMPN node to which an underlying PMPN node is associated. The convergence function maps this set of ISS instances to a single instance of the service defined for the PMPN node. This interface supports PMPN media interior to a Bridged Network or Virtual Bridged Network. In Figure G-2, the center block in the diagram has three Bridge Ports connecting to three of these instances.

G.4.3 Point-to-Multipoint Network convergence: single connection

The PMPN convergence function, defined in 13.6.2 of IEEE Std 802.1AC-2016 [B8], is also used between the ISS and the MAC service interface defined for a PMPN node that has, or is capable of, only a single connection.

Annex H

(informative)

Interoperability considerations

VLAN Bridges are able to interoperate in networks with other VLAN Bridges. However, the VLAN-based filtering service defined in this standard, as provided in the context of a single spanning tree for the network, involves some constraints on the network topology and individual device configurations that differ from the set of constraints that apply to the building and configuration of networks based only on MAC Bridges.

In addition, VLAN Bridges are able to interoperate with MAC Bridges, as well as with both priority-aware and VLAN-aware end systems. Both the VLAN-based filtering service and the tag insertion and removal service specified in this standard cause constraints on intermixed network topologies and device configurations that again differ from the building and configuration of networks containing MAC Bridges.

The implications of certain device configurations may not be immediately apparent from the technical detail of this standard. In order to clarify the nature of the additional constraints, H.1 through H.4

a) Describe the basic requirements for interoperability.
b) Discuss those requirements in the context of homogeneous and heterogeneous configurations, with examples of some of the problems that can occur if these requirements are not adhered to.

H.1 Requirements for interoperability

Two primary aspects of the configuration of a network are of concern from the point of view of interoperability:

a) Establishing a consistent view of the static filtering configuration of Bridges in the network.
b) Ensuring that untagged frames are VLAN-tagged (and that the tag is subsequently removed) consistently regardless of spanning tree reconfigurations.

H.1.1 Static filtering requirements

Static filtering controls allow the network administrator to impose a level of control over the permitted connectivity in the network, by setting static MAC address filters in the FDBs of Bridges, and by controlling the extent of particular VLANs by manipulation of Static VLAN Registration Entries (8.8.2).

In order to ensure that end station-to-end station connectivity (or the lack of it) is consistent in all possible spanning tree configurations, any static filters need to be established taking account of the full mesh topology of the physical interconnections between Bridges in the network, not just the “normal” spanning tree topology to which the network is configured when all Bridges and LANs are operating correctly. An example of the consequences of failure to establish consistent controls for static VLAN filtering is given in H.2.1.

H.1.2 Configuration requirements for VLAN-tagging

VLAN Bridges classify incoming untagged frames by applying either a Port-based tagging rule on ingress that uses the PVID for the reception Port as the VLAN classification for such frames or a Port-and-Protocol-based rule that uses the frame’s ULP to select one of a port’s VIDs. Maintaining

consistent connectivity between any pair of end stations that are on the same VLAN, and where one or both of those end stations is VLAN-unaware, requires that:

a) All VLAN Bridge Ports that are connected to the same LAN apply a consistent set of ingress rules (8.6).
b) All VLAN Bridge Ports that are connected to the same *legacy region* of a network apply a consistent set of ingress rules.
c) All VLAN Bridge Ports that serve LANs to which members of the same VLAN are (or can be) attached apply a consistent set of ingress rules.

A legacy region of a network consists of any set of LANs that are physically interconnected via MAC Bridges. A legacy region has the property that, by appropriate configuration of the spanning tree, a spanning tree path could be created between any pair of LANs in the region such that the path would pass only through MAC Bridges.

NOTE—In case b), spanning tree reconfiguration within the legacy region can change the logical connectivity between the VLAN Bridge Ports and the LANs that they (directly or indirectly) serve. Hence, a spanning tree reconfiguration could result in any end stations connected to the legacy region being serviced via any VLAN Bridge Port. In effect, such a reconfiguration reduces case b) to case a). Figure H-2 and Figure H-3 give examples of this type of configuration. In Figure H-2, the legacy region consists of all three LANs and both MAC Bridges. In Figure H-3, the legacy region consists of the MAC Bridge and both LANs to which it is attached. An example of case c) is where an end station attached to a leaf LAN is in the same VLAN as a server that is attached to a distinct LAN, i.e., all possible spanning tree paths between the two stations pass through a VLAN-aware region of the network.

The essence of what these rules express is that if a given untagged frame belongs on a given VLAN, then the classification and tagging behavior of any VLAN Bridges that are required to tag that frame needs to be the same, regardless of the logical connectivity that is created by the spanning tree configuration of the network. Examples of the consequences of failure to apply these rules appear in H.3 and H.4.

H.2 Homogeneous VLAN-aware networks

This standard requires new considerations in building a network in which all Bridges are VLAN Bridges. The arbitrary plug-and-play capability of MAC Bridges in creating a network topology is restricted when making use of the VLAN extensions defined in this standard.

H.2.1 Consistency of static VLAN filtering

In order for stations that are members of a given VLAN to be able to reach other members of the same VLAN elsewhere in the network, all Bridge Ports that are part of the spanning tree active topology (i.e., all Bridge Ports that are in a forwarding state) connecting the stations must be included in the member set (8.8.10) for the VID that identifies that VLAN. In order for this connectivity to be independent of any reconfiguration of the spanning tree topology, all paths among those stations, both forwarding and blocked, must have this characteristic. Use of management controls to manipulate the member set (e.g., filters for security) must be applied in a manner consistent with requirements of the full mesh topology of the network.

An inconsistency occurs, for example, if a VID is restricted from an active path, but not from a redundant path currently blocked by the operation of spanning tree. Should a spanning tree reconfiguration enable the previously blocked path, the restriction will no longer be in place. In the reverse, a spanning tree reconfiguration may suddenly impose a restriction that had not existed. A common use of such management restriction will likely arise from managers who make use of an “access” port construct. An access port may be a port that is absent from the member set (8.8.10) for all VIDs but the untagged, default VID. Should such an access port become the active connection between two portions of the network as a result of a spanning tree reconfiguration, all VLANs but the one identified by the default VID will be partitioned at that point in the topology.

In Figure H-1, the trunk style link and access style link cause a loop through the left and right portions of the network. STP will block one or the other. Should the spanning tree block at point #1, all 2000 users may communicate on any of the 50 VLANs. However, should the spanning tree block at point #2, the left and right portions of the network will be partitioned on all VLANs excepting VLAN 3 (the VLAN carried via the access style link.)

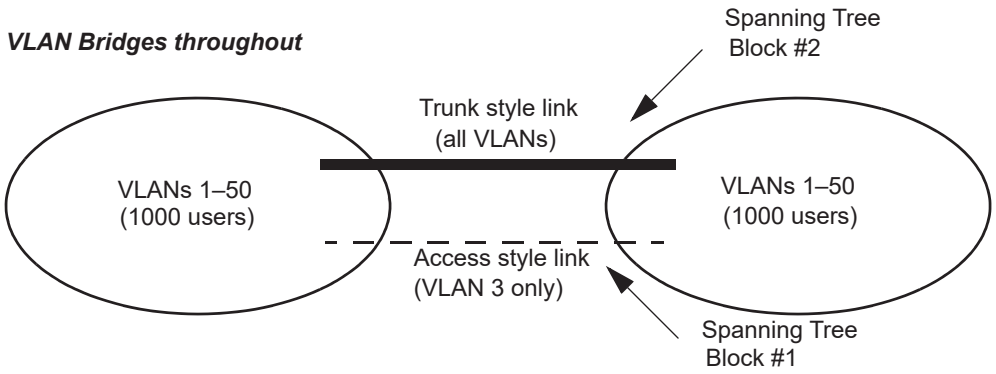


Figure H-1—Static filtering inconsistency

H.2.2 Consistent view of the “untagged VLAN(s)” on a given LAN

In the Port-based VLAN model defined in this standard, the PVID for a Bridge Port provides the VLAN classification for all frames on the attached LAN that are received in untagged form. Any LAN with more than one VLAN Bridge attached has such an “untagged VLAN” for each VLAN Bridge. No explicit requirement that PVID be consistent for all VLAN Bridges on the same LAN, nor mechanism to ensure such, has been included in this standard.

Similarly, in the Port-and-Protocol-based VLAN model defined in this standard, one member of the VID Set for a Bridge Port provides the VLAN classification for all frames on the attached LAN that are received in untagged form with a particular ULP. Any LAN with more than one such VLAN Bridge attached has such a set of “untagged VLANs” for each VLAN Bridge. No explicit requirement that these be consistent for all VLAN Bridges on the same LAN, nor mechanism to ensure such, has been included in this standard.

Consider the case of a LAN to which are attached three VLAN Bridges, each of which is using Port-based classification and is capable of transmission of untagged frames onto the LAN. An untagged frame placed on that LAN by any one of the VLAN Bridges will be associated by each of the other two VLAN Bridges with its own configured PVID for its reception Port on that LAN. The VLAN model requires that each frame have a unique VLAN association, and that association is represented by a single, global VID value. Therefore, it follows that all VLAN Bridges on that LAN must make use of the same classification rules (in this case, the same PVID) for their ports connected to that LAN.

It has been suggested that in the special case of a direct point-to-point connection between two VLAN Bridges or other VLAN-aware devices, other rules might apply. No mechanism for identifying such links has yet been suggested.

This creates a configuration challenge for installers of VLAN Bridges that conform to this standard. Initial management configuration of the VLAN Bridges (the setting of PVIDs, VID Sets, and Protocol Group Databases) must be made consistent among the VLAN Bridges, in a manner that takes into account the actual physical topology. Changes to the physical topology may require specific changes to the configuration of all affected switches. These requirements effectively disallow a plug-and-play installation as supported by MAC Bridges, unless all VLAN Bridges are left with their default Port-based classification rules and with each PVID = 1.

H.3 Heterogeneous networks: Intermixing MAC Bridges (M) and VLAN Bridges (V)

This subclause discusses networks in which VLAN Bridges are intermixed with MAC Bridges.

A principal limitation in intermixing VLAN Bridges with MAC Bridges is that the VLAN filtering services are not universally available throughout the network. Also, services for the insertion and removal of tags are not universally available. Furthermore, spanning tree reconfigurations may cause filtering services, as well as tag insertion and removal services, to become available or become unavailable independent of actions of affected users.

H.3.1 Example: Adding a VLAN Bridge to provide filtering to a MAC Bridged Network

Example problems can be shown with the following topology diagrams. Figure H-2 includes one V Bridge and two M Bridges.

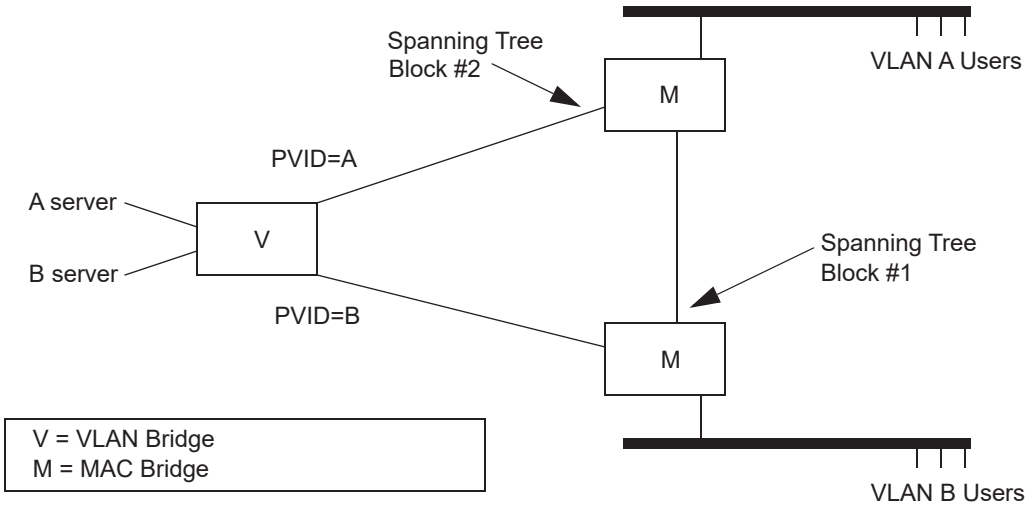


Figure H-2—Interoperability with MAC Bridges: example 1

If the spanning tree protocol determines to break the loop among the three Bridges by blocking at point #1, connectivity within each VLAN is as desired. However, should the block occur at point #2, traffic from VLAN A users will pass through both M Bridges and be treated as VLAN B traffic upon arrival in the V Bridge. Connectivity to the A server will be lost for the A users.

H.3.2 Example: Adding a MAC Bridge to a (previously) Homogeneous VLAN Bridged Network

A similar problem, demonstrating the impact of placing an M Bridge within an otherwise homogeneous V topology, can be shown by the configuration in Figure H-3. This figure includes two V Bridges and adds a single redundant M Bridge.

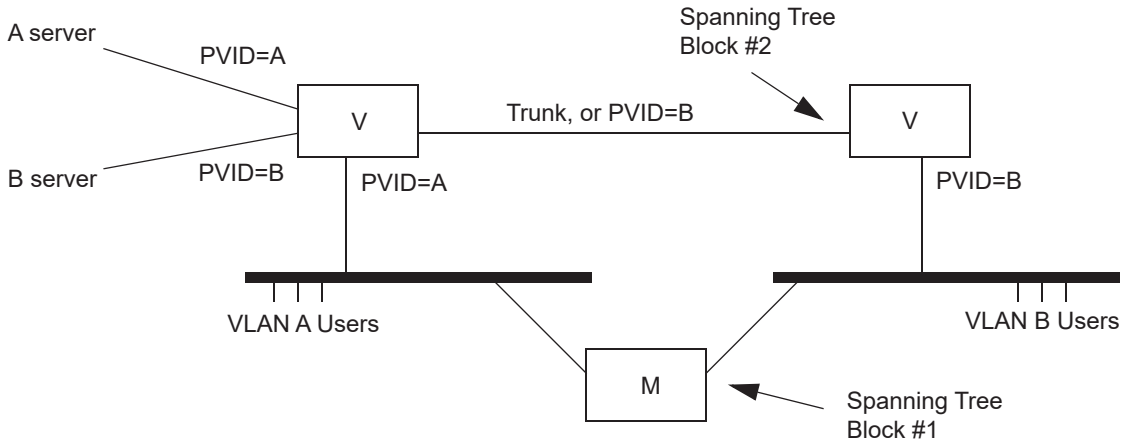


Figure H-3—Interoperability with MAC Bridges: example 2

If STP determines to break the loop among the three Bridges by blocking at point #1, connectivity within each VLAN is as desired. The two V switches operate as expected. A and B VLAN frames are VLAN-tagged on arrival in either V Bridge and forwarded only to the appropriate servers. Now suppose an STP reconfiguration results in a block at point #2, but not at #1. This redirects VLAN B user traffic through the M Bridge. VLAN B users no longer have their traffic identifiably distinct from VLAN A. An immediate consequence is that the VLAN B users will no longer have access to the "B server."

H.4 Intermixing Port-based classification and Port-and-Protocol-based classification or future enhancements in VLAN Bridges

Intermixing V Bridges with M Bridges has a direct analogue in the mixing of Bridges implementing only Port-based and Port-and-Protocol-based classification of frames in VLAN Bridged networks. This revision and potential subsequent editions of this standard extend the VLAN classification capabilities to support more sophisticated ingress rules for frame classification.

In VLAN configurations that use both Port-based and Port-and-Protocol-based VLAN classification, a Bridge that supports only Port-based VLAN classification will merge VLANs that would otherwise be classified separately by a Bridge that supports Port-and-Protocol-based VLAN classification. To get around this problem, it may be possible to dedicate specific Ports to specific protocols in Bridges that support only Port-based VLAN classification, as in the example shown in Figure H-4. However, such solutions may not be possible where there are multiprotocol end stations in the network.

H.4.1 Example: Intermixing Protocol-based ingress rules

Consider the case where Bridges implement a configuration mechanism to select between Port-based classification rules (a "V-Port Bridge") and Port-and-Protocol-based rules (a "V-Port/Protocol Bridge"). This case would allow, for example, for support for IP and IPX as distinct VLANs. The topology shown in Figure H-4 might apply when a V-Port/Protocol Bridge is added to a topology; otherwise, using only V-Port Bridges allows users of two protocols to participate in two separate VLANs.

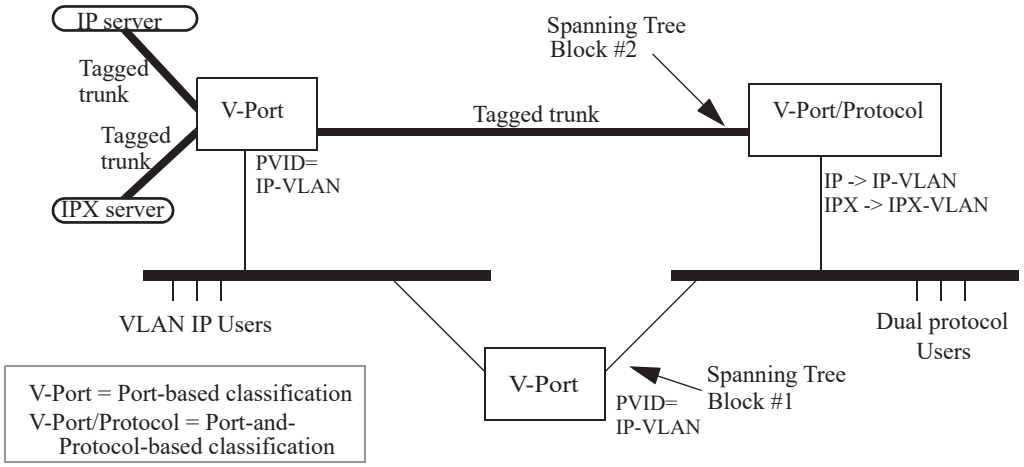


Figure H-4—Interoperability between Port-based and Port-and-Protocol-based classification

Consider this network, when STP has blocked at point #1, and not at #2. The upper V-Port Bridge operates as expected, and the V-Port/Protocol Bridge provides Port-and-Protocol-based classification for the frames received from the dual protocol users on the right-hand LAN. IP-VLAN and IPX-VLAN frames are VLAN-tagged on the trunks to and from the uppermost Bridges and servers. But if a STP reconfiguration should result in a block at point #2, but not at #1, activating traffic through the lower V-Port Bridge, dual protocol users will have all their traffic treated as part of the IP-VLAN. An immediate consequence is that the uppermost Bridge will no longer provide them access to the "IPX server." It is the fact that the lower V-Port Bridge must have just one of the two VLANs configured for all untagged traffic, regardless of its protocol, that leads to this lack of connectivity.

H.4.2 Differing views of untagged traffic on a given LAN

Further challenges arise when one considers the case where several V Bridges, some implementing Port-based and some implementing Port-and-Protocol-based classification, all attach to the same LAN. Again, the rule that any given frame exists in exactly one VLAN requires that all of these Bridges be configured with consistent ingress rules. In this case, the V-Port Bridges will provide a least common capability, and this further requires common configuration of the PVID in the V-Port and V-Port/Protocol Bridges.

Annex I

(informative)

Priority and drop precedence

This standard allows management of priorities, flow metering, queue assignment, and queue servicing. This annex documents the rationale for the recommended and default priority to traffic class mappings in Table 8-5 and the encoding of priority and drop eligibility in Table 6-2 and Table 6-3.

Classification of user data frames into a small number of behavior aggregates, together with aggregate dependent forwarding behavior in each Bridge, allows signaling of application requirements to the network. Frame classification, aggregate bandwidth metering, policing, and drop precedence marking also facilitate network scaling and provision of services to independent customers through allocation of those functions to appropriate Bridges in the network.

While there are many possible ways to classify frames and to specify forwarding behaviors, it is widely appreciated that a set of well-known and easily understood defaults can facilitate interoperability and the deployment of services. The defaults described in this annex and supported by this standard were chosen to support integrated and differentiated services, to minimize the burden of management, to reduce the possibility of misconfiguration and out-of-order frame delivery, and to provide useful service without management in many networks.

This standard mandates support for strict priority frame transmission (8.6.6) but permits the use of additional traffic class-based transmission selection algorithms. The default assignments of frames to traffic classes on the basis of frame priority, as described in this annex, also support the use of frame priority to select general traffic class-based forwarding behavior.

NOTE—Annex W provides references to the IETF work on integrated and differentiated services ([B21] through [B25] and [B26] through [B33]).

I.1 Traffic types

A full description of the QoS needs of applications and network services is too complex to be represented by a simple number 0 through 7. The pragmatic aim of traffic classification is to simplify requirements to preserve the high-speed, low-cost characteristics of Bridges. At the margin, potential bandwidth efficiency is traded for simplicity and higher speed operation—historically a good decision in the LAN.

The following list of traffic types, each of which can benefit from simple segregation from the others, are of general interest:

a) Network Control—characterized by a guaranteed delivery requirement to support configuration an maintenance of the network infrastructure.
b) Internetwork Control—in large networks comprising separate administrative domains there is typically a requirement to distinguish traffic supporting the network as a concatenation of those domains from the Network Control of the immediate domain.
c) Voice—characterized by less than 10 ms delay and, hence, maximum jitter (one way transmission through the LAN infrastructure of a single campus).
d) Video—characterized by less than 100 ms delay, or other applications with low latency as the primary QoS requirement.
e) Critical Applications—characterized by having a guaranteed minimum bandwidth as their primary QoS requirement and subject to some form of admission control to ensure that one system or application does not consume bandwidth at the expense of others. The admission control mechanism

can range from preplanning of the network requirement at one extreme to bandwidth reservation per flow at the time the flow is started at the other.

f) Excellent Effort—or "CEO's best effort," the best-effort type services that an information services organization would deliver to its most important customers.

g) Best Effort—for default use by unprioritized applications with fairness only regulated by the effects of TCP's dynamic windowing and retransmission strategy.

h) Background—bulk transfers and other activities that are permitted on the network but that should not impact the use of the network by other users and applications.

I.2 Managing latency and throughput

Use of priorities and queuing by traffic classes, each class encompassing one or more priorities, facilitates improvement and management of latency and throughput, allowing QoS goals to be supported at higher levels of network loading than would otherwise be possible.

Congestion, resulting in QoS degradation, is not equally likely at all Bridges in a network. Transient traffic patterns are likely to result in congestion in only a few Bridges at a time, while over an extended period, momentary congestion is more likely to occur in the network core than at Bridge Ports attached to one or a relatively small number of end stations. Use of fewer traffic classes for those Ports can lower the cost of implementation and management, and this standard facilitates the use of Bridges supporting differing numbers of classes within a single network that delivers a consistent set of QoS parameters for each frame priority level. Although the number of traffic classes supported by each Bridge Port along the path taken by a given flow of data can vary, the default mappings of priorities to classes ensures that frame ordering is preserved as required by 8.6.6.

With few classes, the focus is on meeting latency requirements—the bandwidth surplus required in a bursty data environment to guarantee sub-10 ms delays without a distinct traffic classification is uneconomically large. As the number of traffic classes that can be used increases, the focus shifts to managing throughput.

The simple default queue servicing policy defined in this standard, strict priority, supports latency management. Active management of bandwidth sharing necessarily requires some management.

I.3 Traffic type to traffic class mapping

Table I-1 is an example of how traffic types can be grouped to match the number of traffic class queues supported by a Bridge Port. Each grouping of types is shown as {*Distinguishing type*, Type, Type, . . .}. The "distinguishing type" is not treated in any way differently in a Bridge but is italicized here to illustrate, for any given number of queues, which traffic types have driven the allocation of types to classes.

The step-by-step breaking out of traffic types as more classes are available proceeds as follows:

a) With a single queue, there are no choices. All traffic is Best Effort.

b) To support integrated services in the presence of bursty best effort data, it is necessary to segregate all time-critical traffic. The amount of high-priority traffic will be restricted by the need to support low latency for Voice, which becomes the defining type for the additional queue.

c) Two queues may be adequate for Bridge Ports attaching to end stations. The stability of the network as a whole may be unaffected by the performance of configuration protocols on those Ports, and in-band management of the Bridge is likely to occur through another Port. For Bridges within the network infrastructure, a further queue is used to isolate Network Control from the user data traffic.

d) Traffic for business Critical Applications is separated from Best Effort to allow a bandwidth guarantee to be provided.

e) The queue separation so far provided can support a large network. The next queue is allocated to distinguishing Internetwork Control traffic from local Network Control.

f) Background is separated from Best Effort to minimize the effect of bulk transfers on ordinary network use.

g) Excellent Effort is separated from Critical Applications, either to provide a simple superior service based on policy controlled access or to provide an additional segregated bandwidth guarantee.

h) The final provides increased network utilization as the higher bandwidth traffic associated with Video is no longer given the same latency guarantee as Voice.This description is illustrative rather than definitive of the logic of allocating traffic types to classes. The mappings in Table 8-5 support the assignment of other semantics to each traffic type identified by priority values, e.g., the identification of all three illustrative types “Video,” “Critical Applications,” and “Excellent Effort” with ensured forwarding classes that provide segregated bandwidth guarantees. However, alternate semantics should take into account the service provided by Bridges with limited traffic class queuing; e.g., of the foregoing, only “Video” would receive priority treatment by default at a Bridge Port supporting queuing for only two classes.

Table I-1—Traffic type to traffic class mapping

Number of queues	Traffic types
1	{*Best Effort*, Background, Excellent effort, Critical Applications, Voice, Video, Internetwork Control, Network Control}
2	{*Best Effort*, Background, Excellent effort, Critical Applications} {*Voice,* Video, Internetwork Control, Network Control}
3	{*Best Effort,* Background, Excellent effort, Critical Applications} {*Voice,* Video} {*Network Control,* Internetwork Control}
4	{*Best Effort,* Background} {*Critical Applications,* Excellent effort} {*Voice,* Video} {*Network Control,* Internetwork Control}
5	{*Best Effort,* Background} {*Critical Applications,* Excellent effort} {*Voice,* Video} {*Internetwork Control*} {*Network Control*}
6	{*Background*} {*Best Effort*} {*Critical Applications,* Excellent effort} {*Voice,* Video} {*Internetwork Control*} {*Network Control*}
7	{*Background*} {*Best Effort*} {*Excellent effort*} {*Critical Applications*} {*Voice,* Video} {*Internetwork Control*} {*Network Control*}
8	{*Background*} {*Best Effort*} {*Excellent effort*} {*Critical Applications*} {*Video*} {*Voice*} {*Internetwork Control*} {*Network Control*}

I.4 Traffic types and priority values

Table I-2 shows the correspondence between traffic types and priority values used to select the defaults in Table 8-5. The default priority used for transmission by end stations is 0. Changing this default would result in confusion and likely in interoperability problems. At the same time, the default traffic type is definitely Best Effort. 0 is thus used both for default priority and for Best Effort, and Background is associated with a priority value of 1. This means that the value 1 effectively communicates a lower priority than 0.

Table I-2—Traffic type acronyms

Priority	Acronym	Traffic type
1	BK	Background
0 (Default)	BE	Best Effort
2	EE	Excellent Effort
3	CA	Critical Applications
4	VI	“Video,” < 100 ms latency and jitter
5	VO	“Voice,” < 10 ms latency and jitter
6	IC	Internetwork Control
7	NC	Network Control

Table I-3 summarizes Table I-1, showing just the defining traffic types. By maintaining the groupings of types established for a given number of queues for all less numbers, the table preserves the order of frames of any given type, independent of the number of queues.

Table I-3—Defining traffic types

Number of queues	Defining traffic type							
1	BE							
2	VO				BE			
3	NC		VO		BE			
4	NC		VO		CA		BE	
5	NC	IC	VO		CA		BE	
6	NC	IC	VO		CA		BE	BK
7	NC	IC	VO		CA	EE	BE	BK
8	NC	IC	VO	VI	CA	EE	BE	BK

This discussion of traffic types, and the suggested association of each with a priority value, differs from the similar discussion in Annex G of IEEE Std 802.1D-2004 [B12] and prior revisions of that standard. The latter was developed contemporaneously with IETF Intserv and predates Diffserv. The discussion in this

annex better aligns with current practice; in particular, Voice is associated with priority 5, matching the setting of the relevant bits for Expedited Forwarding (EF) in the DSCP (Differentiated Services Code Point) for IP and in the common use of the EXP bits for MPLS. Standards for DSCPs are believed to be the prime reference for use of priority by end stations, and there is no direct change to the behavior of Bridge implementations conforming to this standard as a result of this change.

The priority to traffic class mappings in Table 8-5 differ in one minor respect from those specified in prior revisions of this standard and in IEEE Std 802.1D-2004 [B12] and its prior revisions. Priority value 2 was previously described as ‘Spare’ and positioned lower than 0 (Best Effort) in priority order. This change may result in networks, including Bridges, conformant to prior revisions of this standard, and implementing four or more traffic classes, providing less-than-expected priority to traffic described in this annex as Excellent Effort, and misordering drop eligible traffic for Critical Applications. The change allows better use of the available traffic classes, given the low demand for two distinct priorities of lesser importance than Best Effort, and the best use of Priority Code Point when encoding drop eligibility.

I.5 Supporting the credit-based shaper algorithm

Table 34-1 and Table 34-2 define a set of recommended priority to traffic class mappings where the credit-based shaper algorithm (8.6.8.1) is supported by one or two of the available traffic classes; the recommended mappings shown are intended for use where priority 3 is used to support SR class A and priority 2 is used to support SR class B.

In order for the credit-based shaper algorithm to operate in the way it is intended, it is necessary to ensure that the shaper algorithm is supported on the numerically highest traffic class(es). Hence, if two traffic classes are used to support the shaper algorithm, it follows that the minimum useful number of traffic classes that a Port could support is three.

Table I-4 redraws Table I-3 for the case where only SR class B (SR-B) is supported. The defining traffic type for the numerically highest traffic class is SR-B in all cases. VI does not appear in this table since SR-B is used for the video traffic.

Table I-4—Defining traffic types—Credit-based shaper support of SR class B only

Number of queues	Defining traffic type							
2	SR-B	BE						
3	SR-B	NC		BE				
4	SR-B	NC		CA		BE		
5	SR-B	NC	IC		CA		BE	
6	SR-B	NC	IC		CA		BE	BK
7	SR-B	NC	IC		CA	EE	BE	BK
8	SR-B	NC	IC	VO	CA	EE	BE	BK

NOTE—When one or more SR classes are supported, the primary distinction being made is between traffic that requires bandwidth reservation and latency guarantees on the one hand, and different types of “best effort” traffic on the other. The audio and video traffic types identified in Table I-1 are therefore not applicable.

Table I-5 redraws Table I-3 for the case where SR classes A (SR-A) and B (SR-B) are supported in place of VO and VI. The defining traffic types for the two numerically highest traffic classes are SR-A and SR-B in all cases; for 4 through 8 traffic classes, the remaining traffic types are broken out in the same order as in Table I-3.

Table I-5—Defining traffic types—Credit-based shaper support of SR classes A and B

Number of queues	Defining traffic type							
3	SR-A	SR-B	BE					
4	SR-A	SR-B	NC		BE			
5	SR-A	SR-B	NC		CA		BE	
6	SR-A	SR-B	NC	IC	CA		BE	
7	SR-A	SR-B	NC	IC	CA		BE	BK
8	SR-A	SR-B	NC	IC	CA	EE	BE	BK

I.6 Supporting drop precedence

It is often desirable to meter traffic from different users to ensure fairness or to meet bandwidth guarantees; however, dropping all traffic in excess of a committed rate is likely to result in severe under-utilization of the networks, because most traffic sources are bursty in nature. At the same time, it is burdensome to meter traffic at all points in the network where bandwidth contention occurs. One solution is to mark those frames in excess of the committed rate as drop eligible on admission to the network.

This standard allows drop eligibility to be conveyed separately from priority in VLAN tags so that all previously introduced traffic types can be marked as drop eligible. To provide compatibility with previous revisions of this standard while allowing drop eligibility to be conveyed in C-TAGs, this standard also allows a subset of the priorities to be conveyed along with drop eligibility marking for some of those priorities within the PCP field of both S-TAGs and C-TAGs.

I.7 Priority Code Point allocation

The Priority Code Point of VLAN tags allows encoding of five, six, seven, or eight distinct priorities, with a single level of drop eligibility on three, two, one, or zero of those priorities, respectively. Table 6-2 and Table 6-3 specify encoding and decoding for five through eight priorities. The tables are consistent with the following step-by-step reduction in the number of distinct priorities to provide drop eligibility for certain traffic types:

a) If eight distinct priorities are required, drop eligibility cannot be encoded in the Priority Code Point (but may be encoded in VLAN tags using the DEI).
b) Drop eligibility in support of QoS maintenance for traffic conforming to a committed rate is most effective when used to support time-critical traffic. If seven priorities, one of which can be marked as drop eligible, are required, then the traffic class queuing distinction between Voice and Video is sacrificed to providing drop eligibility for the combined traffic types. This does not preclude marking all Video traffic as drop eligible upon ingress to a network to provide the same guarantee to Voice as a distinct priority.

c) The distinctions between Critical Applications and Excellent Effort, and between Best Effort and Background traffic types, is removed to provide drop eligibility for Critical Applications and for Best Effort.
d) Although the use of four priorities, each with drop eligibility, is possible, it is not recommended. Combining Network Control with Internetwork Control could only serve to increase the guarantees provided to the latter at the expense of the former, which if not delivered threatens the stability of the overall network in any case. Moreover, both traffic types should be supportable with guaranteed bandwidth if the network is to be operated successfully.

Choosing first to combine Video and Voice, and then Critical Applications with Excellent Effort (for six queues), provides consistency with the allocation of priorities to traffic classes in the absence of drop eligibility. Bridges that do not implement drop eligibility, but are configured to use the same number or fewer traffic classes, will not misorder frames. If such a Bridge is configured to use only five traffic classes, and in accordance with Table 8-5, it will not misorder frames with a Priority Code Point encoded using any of the alternatives provided by Table 6-2.

I.8 Interoperability

Encoding of drop eligibility within the Priority Code Point, as opposed to explicitly with the DEI, provides interoperability with Bridges that are not capable of supporting the DEI. It also provides compatibility with the use of the MPLS EXP bits to convey priority and drop eligibility.

However, the requirement to provide different combinations of priorities with drop eligibility within the confines of the Priority Code Point means that priority and drop eligibility information can be lost for frames traversing a network if the combinations used on individual LANs differ. Use of the DEI does not suffer from this problem. In some cases, loss of drop eligibility information at the boundary between administrative domains risks impacting profile conformant traffic from some users with out-of-profile drop eligible traffic from others; in other cases, the drop eligible marking has already done its job (the next LAN, for example, might deliver traffic to a single customer). Without explicit management, a Bridge Port cannot decide, so the Require Drop Encoding parameter (8.6.7) has been provided.

If Bridges attached to the same LAN encode and decode the Priority Code Point differently, then incorrect priority values can be attributed and subsequent misordering of frames can occur. Misordering will not occur, with the recommended priority to traffic class mappings of Table 8-5 and the recommended Priority Code Point encoding and decoding in Table 6-2 and Table 6-3, if the Bridge performing the incorrect decoding assumes fewer priorities than are actually encoded or if all Bridges subsequently transited by the frame use the same number or fewer traffic classes than those used for the encoding. However, incorrect decoding will in all probability affect other service guarantees that the network is intended to support. If a Bridge can be used in a network that encodes drop eligibility in the Priority Code Point, and there is any likelihood of the Bridge being brought into service prior to the network-dependent service-level configuration, then five priorities, three with drop eligibility (5P3D encoding and decoding), should be used. Bridges that do not support drop precedence should be configured to support five or fewer traffic classes in the same circumstances.

The use of separate Priority Code Point Encoding and Priority Code Point Decoding Tables for each Bridge Port allows adaptation between the encoding scheme in one domain of the network and the encoding scheme used in another to be accomplished in only one of any pair of Bridges, each serving as a boundary of its domain, connected by a point-to-point LAN. However, if more than two Bridges are attached to a LAN, all need to use the same encoding so that each of its recipients can assign the correct priority to the frame.

The default Priority Code Point encoding and decoding, as documented in Table 6-2 and Table 6-3, are reproduced in Table I-6 and Table I-7, with the addition of the default allocation of priorities to traffic classes to the latter.

NOTE—The sequence of the columns for the priority values of 0 and 1 in Table I-6 and Table I-7 are reversed from the sequence in Table 6-2 and Table 6-3 in order to show the alignment with the traffic classes in Table I-3.

Table I-6—Priority Code Point encoding

priority drop_eligible		7	7DE	6	6DE	5	5DE	4	4DE	3	3DE	2	2DE	0	0DE	1	1DE
PCP	8P0D	7	7	6	6	5	5	4	4	3	3	2	2	0	0	1	1
	7P1D	7	7	6	6	5	4	5	4	3	3	2	2	0	0	1	1
	6P2D	7	7	6	6	5	4	5	4	3	2	3	2	0	0	1	1
	5P3D	7	7	6	6	5	4	5	4	3	2	3	2	1	0	1	0

Table I-7—Priority Code Point decoding

PCP		7	6	5	4	3	2	0	1
priority drop_eligible	8P0D	7	6	5	4	3	2	0	1
	7P1D	7	6	4	4DE	3	2	0	1
	6P2D	7	6	4	4DE	2	2DE	0	1
	5P3D	7	6	4	4DE	2	2DE	0DE	0
number of traffic classes	1	BE							
	2	VO				BE			
	3	NC		VO		BE			
	4	NC		VO		CA		BE	
	5	NC	IC	VO		CA		BE	
	6	NC	IC	VO		CA		BE	BK
	7	NC	IC	VO		CA	EE	BE	BK
	8	NC	IC	VO	VI	CA	EE	BE	BK

Annex J

(informative)

CFM protocol design and use

J.1 Origin of CFM

Operations, Administration, and Maintenance (OAM) functions are a product of the world of telephony. As Ethernet, which has traditionally been an Enterprise network technology, expands into the realm of service providers, such useful notions as OAM become important. The OAM work conducted in various standards bodies and in various vendors' products can be classified into five groups:

a) Provider Edge OAM, as defined by IEEE Std 802.3.
b) Ethernet Local Management Interface (E-LMI), as defined by MEF 16 [B52].
c) Underlying layers of OAM, such as MPLS OAM [B57] or ATM OAM [B2], used on various sorts of emulated Ethernet links, carrying Ethernet frames as a higher layer.
d) Ethernet frames carrying End-to-End CFM PDUs, defined by this standard and by ITU-T G.8013/Y.1731.
e) Network performance measurement, defined by the MEF Forum in MEF 35.1 [B54] and ITU-T, including ITU-T G.8013/Y.1731.

CFM is one part of the whole OAM picture. It defines group in item d), Ethernet frames carrying End-to-End CFM PDUs, defined by this standard and by ITU-T G.8013/Y.1731. This standard does not explicitly address the subject of the configuration or provisioning of MEF services, but it does generate significant requirements on configuration and provisioning. Certain CFM PDU formats are also useful for network performance measurement [item e)] and are defined in this standard. Additional PDUs for these operations are defined in ITU-T G.8013/Y.1731.

Finally, unlike OAM in the telephony world, CFM does not address recovery from a loss of connectivity. That is the function of the various Layer 2 control protocols such as spanning tree (see Clause 13).

J.2 Deployment of CFM

It is critical to the early deployment of CFM that no hardware changes be required to achieve a significant level of CFM functionality. However, if the MEPs in a large number of large MAs issue Continuity Check Messages (CCMs) at the highest allowed rates, a Provider Bridge's ability to generate and/or absorb these CCMs could be overwhelmed. To achieve its full potential, CFM could require hardware modifications to existing Provider Bridges.

a) The CFM shims shown in Figure 22-4 are an abstract concept. They have been defined so that it should be possible to emulate their functions on most existing platforms, though perhaps not at high rates of CFM PDU transmission and reception. Hardware assistance can enable higher CFM PDU rates and can enable the implementation of the Shared MP address model of operation instead of the Individual MP address model (J.6).
b) Directing CFM PDUs to the appropriate ports of a Provider Bridge could necessitate a separate MAC Address Registration Entry for each VID in the FDB. Some means whereby this large number of entries could be abstracted would reduce the load on the FDB and enable the use of a larger number of MD Levels.
c) The reception of an LBM and generation of the corresponding LBR have been defined in a manner that is amenable to implementation in hardware. If so implemented, then the providers' ability to support a particular requirement for bandwidth in a service instance can easily be tested.

J.3 MD Level allocation alternative

There are eight Maintenance Domain Levels (MD Levels) as shown in Table J-1. In order to allow administrations to configure different Maintenance Domains in the same Bridge without having to resort to detailed inter-organizational agreements about which MD Levels are available for use, an administrator of a Maintenance Domain can decide which of three roles that Maintenance Domain will play: the “customer” role, the “service provider” role, or the “operator” role. The administrator would then be free to assign an MD Level to a Maintenance Domain within the range shown in Table J-1 according to the Maintenance Domain’s role. If two administrations can operate Maintenance Domains using the same role in one Bridge at different MD Levels.

Table J-1—Provider MD Level allocation

MD Level	7	6	5	4	3	2	1	0
Use	customer			service provider		operator		
	Highest	<- Higher lower->						Lowest

This method of MD Level allocation attempts to minimize the likelihood of incompatibilities caused by MD Level selection among separate administrative organizations that interconnect in a manner such that their MD Levels are visible to each other. Due to the addition of encapsulations such as VLAN tags that can hide one organization’s MD Levels from another, it is considered unlikely that the allocation method shown in Table J-1 will be necessary and that the method described in 22.3 will be sufficient.

J.4 Relationship of IEEE Std 802.1Q CFM to other standards

ITU-T G.8013/Y.1731 is a compatible extension of CFM. Certain terminology is different between ITU-T G.8013/Y.1731 and this standard. These differences are summarized in Table J-2 .

Table J-2—IEEE / ITU-T terminology differences

IEEE Std 802.1Q	ITU-T G.8013/Y.1731
Maintenance Association (MA)	Maintenance Entity Group (MEG)
Maintenance Association Identifier (MAID)	Maintenance Entity Group Identifier (MEGID)
Maintenance Domain	(No such construct present)
Maintenance Domain Level (MD Level)	Maintenance Entity Group Level (MEG Level)

ITU-T G.8013/Y.1731 includes a number of OpCodes in addition to the CCM, LBM, LBR, LTM, and LTR defined in this standard. ITU-T G.8013/Y.1731 also specifies that the LBM can have a Group destination_address, in addition to the ability of using an Individual destination_address, as defined in this standard. It is for this reason that the MP Loopback Responder’s ProcessLBM() procedure (20.28.1) is required to respond to an LBM whose destination_address is the appropriate CCM Group address, even though this standard specifies no means for generating such a frame.

The MIP is defined as two MHFs in this standard, but not in ITU-T G.8013/Y.1731. This is because ITU-T G.8013/Y.1731 is not concerned with the details of the implementation.

ITU-T G.8013/Y.1731 does not include an LTM Egress Identifier TLV (21.8.8) or LTR Egress Identifier TLV (21.9.7). For compatibility with early implementations of ITU-T G.8013/Y.1731, this standard does not require that these TLVs be present on received LTMs or LTRs. However, this standard does require these TLVs to be transmitted in LTMs and LTRs.

ITU-T G.8013/Y.1731 specifies that, if an LTM passes through MPs on both the ingress and egress ports, the TTL field of the LTM will be decremented twice. This standard requires, in that case, that the Bridge decrement the TTL field only once, and return a single LTR. The ITU-T G.8013/Y.1731 behavior is compatible with the LTR analysis presented in J.5, as long as each of the MPs that decrement the LTM's TTL field also return an LTR. If a Bridge decremented the TTL twice, but returned only a single LTR, it would be impossible for the originating MEP to tell whether an LTR was lost in transit.

The Flags field (21.9.1) returned in the LTR contains two extra bits of information in this standard that are not in ITU-T G.8013/Y.1731.

J.5 Interpreting Linktrace results

The LTR entries are retrieved from the Linktrace Database in the order the LTRs were received by the MEP. There is no way to determine when the last LTR has been received, except to wait for some number of seconds (e.g., long enough for a worst-case delay through the Bridged Network plus a few seconds), after the successful completion of the Transmit Linktrace Message command, before assuming that no further LTRs are likely to be received.

Because of the timer used by the LTR Transmitter state machine (20.5.1), the order in which the LTRs are received (time order) is likely to be different from the order of the MPs reached by the LTM as it was forwarded, MP by MP (path order). It is possible for an LTM to take more than one path, so that the LTRs report a tree, rooted at the originating MEP, rather than a simple linear series of zero or more MHFs terminating at a MEP or an MHF. If there are no network topology changes during the Linktrace operation, and if all systems' behavior conforms to this standard, the following can be said about constructing this path tree from the list of LTR entries returned by the Read Linktrace Reply command:

a) Sort the returned LTR entries by decreasing value of ltrReplyTTL (20.41.2.2). The highest reported value is one less than the initial LTM TTL field value [item d) in 12.14.7.4.2] used in the Transmit Linktrace Message command, and corresponds to the first Linktrace Responder reached by the initial LTM. This Linktrace Responder resides in the same Bridge as the MEP, in the case of an LTM originated by an Up MEP. The next-lower value corresponds to the MHF(s) or MEP(s) reached by the first forwarded copy of that LTM, and so on. Any gaps in the sequence of Reply TTL values indicate lost LTRs.
b) The ltrNextEgressId variable (20.41.2.4) in every LTR entry returned from a given Transmit Linktrace Message command is unique among the LTR entries in a given LTM entry in the Linktrace database, since no Linktrace Responder transmits more than one copy of an LTM.
c) The ltrLastEgressId variable (20.41.2.3) in any LTR entry is unique only over those LTR entries with matching values of the ltrReplyTTL variable.
d) The ltrLastEgressId variable (20.41.2.3) in any LTR entry whose ltrReplyTTL variable is one less than the initial LTM TTL field also matches the original LTM's LTM Egress Identifier TLV value, as returned from the Transmit Linktrace Message command [item c) in 12.14.7.4.3].
e) In the absence of lost LTRs, the ltrLastEgressId variable of any LTR whose ltrReplyTTL variable contains x will match the ltrNextEgressId variable of one of the LTRs whose ltrReplyTTL variable contains $(x + 1)$. For LTR entry x, this match indicates which of the Linktrace Responders $(x + 1)$ forwarded the LTM that was received by the Linktrace Responder that returned LTR entry x, and thus turns the list of LTR entries at each ltrReplyTTL value into a tree.

f) Along any given path from the root of the reply tree, the last reply can report any of the following conditions that terminate the forwarding of the LTM:
   1) FwdYes bit of the ltrFlags variable is reset (false); or
   2) TerminalMEP of the ltrFlags variable is set (true); or
   3) ltrRelayAction variable contains the value, RlyHit; or
   4) ltrReplyTTL variable contains 0.

g) If any path does not terminate with one of the conditions 1) through 3) in the previous item f), then either the initial LTM TTL field was insufficiently large to trace the complete path (and the last ltrReplyTTL variable of the end MP in the path contains 0), or a data frame addressed to the target MAC address of the LTM would be flooded after being forwarded from the Bridge that returned the last LTR in the path.

h) If the first Bridge encountered by the original LTM (which is the Bridge on which the LTM was originated, if originated from an Up MEP) would have flooded a data frame addressed to the target MAC address of the LTM, no LTRs will be returned in response to the LTM.

i) A gap in the ltrReplyTTL value sequence indicates the loss of (or failure to transmit) one or more LTRs. Similarly, a gap in the chain of ltrNextEgressId and ltrLastEgressId variables can be caused by the loss of LTRs. These conditions can make the construction of a reply tree impossible, if multiple LTRs have been returned with the same ltrReplyTTL value. If the last LTR along the path is lost, there is no gap in the ltrReplyTTL sequence to indicate the loss.

j) The Transmit Linktrace Message command can be reissued, and the resultant LTRs correlated with the results of a previous LTM, to improve the reliability of the results.

Diagnosing whether an anomalous result from a Read Linktrace Reply command, i.e., one that violates any of the prior assertions, is the result of ordinary frame loss (caused, e.g., by congestion), transitory network behavior (e.g., the loss of a LAN during the Linktrace procedure), a permanent malfunction (e.g., a Bridge is behaving in a noncompliant manner due to a hardware or software malfunction), or some other reason, is beyond the scope of this standard.

J.6 MP addressing: Individual and Shared MP addresses

It is stated in 21.3.2 that the source MAC address for a frame carrying a CFM PDU is the MAC address of the MP transmitting the PDU. This does not necessarily mean that the MP's physical implementation is tied to a particular Bridge Port, and that the MAC addresses used in the frames carrying CFM PDUs are the MAC addresses of those Bridge Ports. While this method of MAC address assignment produces the best protection that this standard can provide for a network, it is not required that every MP use its Bridge Port's MAC address.

CFM does not require the MPs configured on a single Bridge Port, e.g., all of the MPs illustrated in Figure 22-4, to have MAC addresses that are different from each other, nor does CFM require that they be the same. If the MPs in Figure 22-4 all have the same MAC address, CFM frames can be directed to the different MPs on that Bridge Port based on VID and MD Level. Choices can be made, however, with regard to whether MPs on different Bridge Ports can share the same MAC address. Two models are presented in this subclause for the assignment of MAC addresses to MPs:

a) **Individual MP address model:** The individual MAC address assigned to an MP associated with a particular MA, and hence that MA's MD Level and set of VIDs, is unique over all service instances associated with that same set of VIDs, such that those service instances' CFM PDUs can be distinguished only by their MD Levels that can pass through that MP's Bridge Port.

b) **Shared MP address model:** The same as the Individual MP address model, except that Up MPs (but not Down) in the same MA and in the same Bridge can share a (i.e., can all have the same) MAC address.

Down MPs in different Bridge Ports have different MAC addresses. If two Bridge Ports are connected to the same LAN, but have the same MAC address, then both would respond to an LBM sent to that MAC address.[63] This is true, even though one of those two Bridge Ports would be Blocked (it would be either a Backup or an Alternate Port, see 13.12), because Down MEPs are between the LAN and the Port filtering entities (8.6.1, 8.6.2, 8.6.4) that enforce the blocking. This placement allows Down MEPs to test their service instances even when their Port is blocked, so that the system administrator knows that the failover links will be ready to carry data when a network event causes the Port to become Forwarding.

A Bridge can use the Shared MP address model, or the Individual MP address model, on any given Bridge Port. This is an implementation decision; no managed objects are provided to select one or the other model of operation.

A Bridge using either of these two models can also make use of a third scheme for configuring MPs:

c) **Management Port MEPs:** Up MEPs (not Up MHFs, not Down MPs) are configured on a Management Port, a Bridge Port that does not connect to any LAN exterior to the Bridge. (See 8.3 and Figure 8-8.) Typically, this would be the same MAC address, and the same Bridge Port, that used for the Bridge's Management Port (see Figure 8-8).

The Individual MP address model is described in J.6.1, Shared MP address model in J.6.2, and Management Port MEPs in 22.7.

J.6.1 Individual MP address model

The purpose of CFM is to detect and diagnose connectivity errors. If a Bridge implements its Up MPs as close to the physical layer hardware as possible, it maximizes the capability of CFM to detect connectivity errors caused by malfunctions in that Bridge. In particular, giving each Up MP a MAC address that is tied to its particular Bridge Port means that an LBM/LBR exchange tests the Frame filtering entity (8.6.3) at both ends of the path. Figure 22-5 illustrates this fact. Any LBMs or LBRs passing between the Up MEPs and MHFs at the ends of the grayed service instance traverse exactly the same path through the Frame filtering entity as ordinary data frames carried from the left-most LAN to the right-most LAN.

J.6.2 Shared MP address model and the CFM Port

Although the Individual MP address model (J.6.1) gives the best detection and diagnostic capabilities, not all Bridge implementations are capable of inserting and removing CFM PDUs at points close to the physical layer. For example, the reflection of a high-speed LTM/LTR test stream by an Up MEP configured on a Port that is also receiving normal traffic from its LAN implies the presence of prioritization, data path, queuing, and bandwidth resources not otherwise required by this standard. This does not mean that Bridges lacking those resources cannot support CFM. The Shared MP address model provides one way for these Bridges to maximize their CFM capabilities.

Consider Figure 20-16, case c), but assume that the PDU entering Port 5, instead of being an LTM, is an LBM addressed to the Up MEP on Port 3. One cannot discern, from observing the external behavior of a Bridge, whether that LBM was actually delivered to the Up MEP on Port 3 or to some other entity within the Bridge. The Shared MP address model takes advantage of this fact by allowing Up MPs in different Bridge Ports to share the same MAC address. The Up MPs are still configured on different Bridge Ports according to the managed objects in Clause 12. For the most part, they have distinct identities. They share their MAC addresses and, as discussed more fully in 20.53, certain state machines and variables.

[63] Bridge implementations are known that use the same source MAC address for different Bridge Ports. As long as the Bridge Port or Management Port to which higher layer entities (e.g., an IP/TCP stack) are attached has its own unique MAC address, and as long as those Bridge Ports that share an address transmit only frames, such as BPDUs that do not traverse other Bridges, and as long as those Ports are not running any protocols that expect unicast frames to pass through a Bridge to reach them, Bridges of this description can interoperate each other and can interoperate with Bridges that follow the requirement to have a different MAC address for every Port. However, CFM PDUs do traverse other Bridges, and the LBM protocol does utilize individual MAC addresses. Therefore, the CFM protocols do not meet the goals of Clause 18 in all network topologies if Bridge Ports' Down MPs share MAC addresses.

In a Bridge configured according to the Shared MP address model, whether an LBM (or other PDU) that enters Port 5 in Figure 20-16 is addressed to the Up MEP on Port 3, or the Up MHF on Port 2, it is delivered to the same physical Bridge Port, called a "CFM Port." This could be a normal Bridge Port, e.g., one with more capability than the Bridge Port on which the addressed MP is configured, or it could be a Port that is attached to no LAN, in the manner of a Management Port (8.3, 22.7). A Bridge can have more than one CFM Port, but within that Bridge, each CFM Port has a MAC address that is different from the other CFM Ports. In the limiting case, each CFM Port is also a Bridge Port, and is associated with only its own Up MPs; this is indistinguishable from the Individual MP address model. A CFM Port, for which the MPs of three different Bridge Ports are residing, is illustrated in Figure J-1.

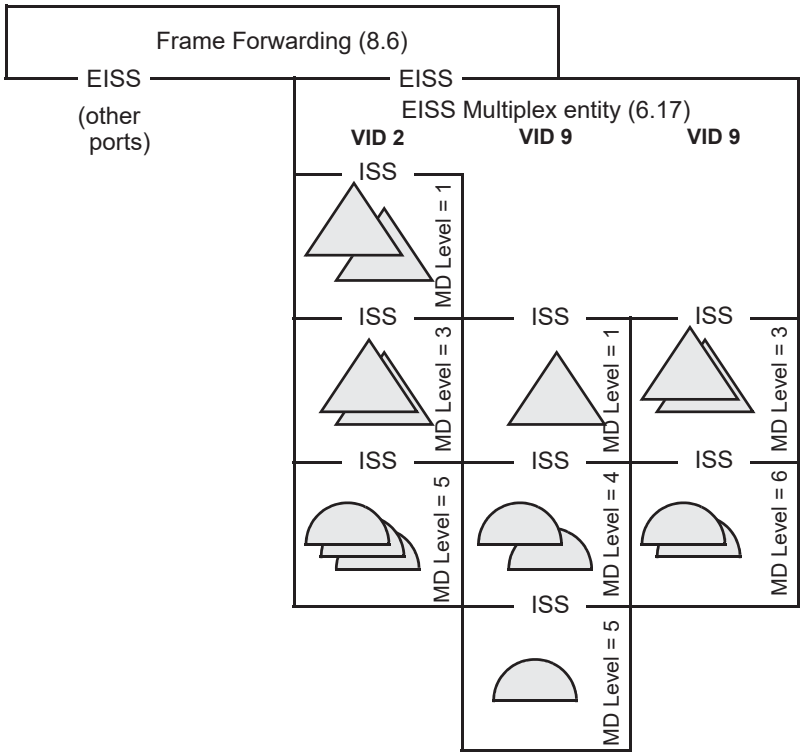


Figure J-1—Up MPs in a CFM Port

NOTE 1—Unlike normal Bridge Ports or a Management Port, multiple levels of MHFs can be present on a CFM Port for the same service instance, because they belong to different MAs on different Bridge Ports.

MPs on this CFM Port are distinguished by VID and by MD Level. However, those criteria are insufficient when Up MPs configured on different Bridge Ports are in the same MA, and thus in the same VID and at the same MD Level. There is no way of distinguishing, in that case, to which of those Up MPs a given CFM PDU is addressed. For the PDUs defined in this standard, this is not a problem.

Each MEP, even when multiple MEPs reside on a single CFM Port, has its own MEP Continuity Check Initiator state machine (20.12) and associated variables. Each MEP is responsible for transmitting its own CCMs, carrying information (e.g., the optional Sender ID TLV, 21.5.3) peculiar to its configured Bridge Port.

On the other hand, otherwise indistinguishable MEPs sharing a MAC address share a single LTR Transmitter state machine (20.50) and a single MEP Loopback Initiator transmit state machine (20.32), and their associated variables. The managed objects in 12.14.7.1.3 support this sharing.

When any CFM PDU arrives at the CFM Port, it is copied and delivered to each of the MPs that share the same MA. Each of these MPs responds to the CFM PDU separately and responds as if it resided in its configured Bridge Port. Since a multicast would be delivered to all of the MPs anyway, there is no harm in placing all of them in a single CFM Port, with a single MAC address.

Unicast CCMs, LTMs, LBRs, and LTRs present no issues. CCMs require no response. The LTMs all go to the Bridge's single Linktrace Responder. Even when an LTM is multicast, only one LTR and/or forward LTM is produced, so delivering a unicast LTM to multiple MPs causes no additional problems. Since the MEPs sharing a single CFM Port also share a single MEP Loopback Initiator transmit state machine (20.32) and a single MEP Loopback Initiator receive state machine (20.34), and since they all share a single set of variables, particularly those related to the LTM Transaction Identifier fields in these PDUs, there is no confusion about which MEP the LBR or LTR is directed.

The remaining PDU type is the LBM. Consider what would happen if the MEPs and their associated MP Loopback Responders (19.2.10) resided on separate Bridge Ports, but all shared the same MAC address. Assuming that the Frame filtering entity had learned that MAC address, the LBM would be forwarded to exactly one of those MEPs, namely the one that, by chance, last happened to transmit a frame, thus causing the Learning Process (8.7) to associate the shared MAC address with that transmitter's Bridge Port. Thus, exactly one LBR would be returned, not one per Bridge Port. The MEP receiving that LBR would not know from which MP the LBR was returned, because there is nothing in the LBR to indicate the identity of the responding MP. Therefore, only one response to a unicast LBM is returned from a CFM Port, no matter how many MPs on that LBM's MA reside on the CFM Port.

On the other hand, a multicast LBM could cause any number of Up MPs configured in the same MA, but on different Bridge Ports in a single Bridge, to respond. Thus, a high-speed stream of multicast LBMs could impose an arbitrarily large burden upon a single CFM Port that is supporting a large number of Bridge Ports' MPs, if each MP responded to that LBM. Therefore, among a set of MPs for a single MA that all share the same MAC address (i.e., reside on the same CFM Port), one or more, but not all, of their MP Loopback Responders (19.2.10) can be disabled by not configuring any group MAC address for them to recognize. This configuration is accomplished automatically by a Bridge that utilizes CFM Ports and is not controlled by any managed object.

The externally visible behaviors that can be discerned from outside a Bridge that uses the Shared MP address model are as follows:

a) An external MEP can regularly receive CFM PDUs other than LTRs, from two different MPs in the same MA that have the same source_address.
b) A multicast LBM can regularly receive only one reply from among a set of MPs that normally all respond to unicast LBMs, but all with the same source_address, without implying the presence of an intermittent network failure.
c) A system administrator can see unexpected advances in a MEP's managed objects that count LBMs and LBRs, apparently due to activity on another MEP.
d) If conceptual rows in the Interface MIB module of IETF RFC 2863 are instantiated for individual MPs, the packet and frame counts of those interfaces count both CFM PDUs and ordinary data frames passing through the Active and Passive SAPs, and thus can indicate whether an MP is instantiated on the Bridge Port on which it is configured, or on a separate CFM Port through which no ordinary data frames pass.

NOTE 2—None of these behaviors is impossible for a Bridge using the Individual MP address model; MAC addresses can change faster than CCMs time out, momentary congestion can cause frame loss, multiple administrators can access different MEPs' managed objects, and ordinary data frames can be absent. It is only the frequency of these behaviors that distinguishes the Individual MP address model from the Shared MP address model.

Annex K

(informative)

TPMR use cases

This material is intended to assist the reader of this standard in putting the operation of a TPMR in context with the operation of Bridged Networks as a whole, by illustrating some of the uses of a TPMR in conjunction with other types of Bridge. The set of cases is not, and is not intended to be, exhaustive in terms of all of the possible usage scenarios.

K.1 Use case 1—TPMR as User to Network Interface (UNI) demarcation device

Figure K-1 illustrates a use case where the TPMR performs the function of a UNI demarcation device between an customer network and a provider network. In this illustration, the user link between the customer Bridge and the TPMR, and the extension link between the TPMR and the provider Bridge, are both assumed to be IEEE 802.3 links, although, with the exception of the use of IEEE 802.3 EFM OAM on the extension link, these links could in principle be provided by use of any IEEE 802 LAN technology.

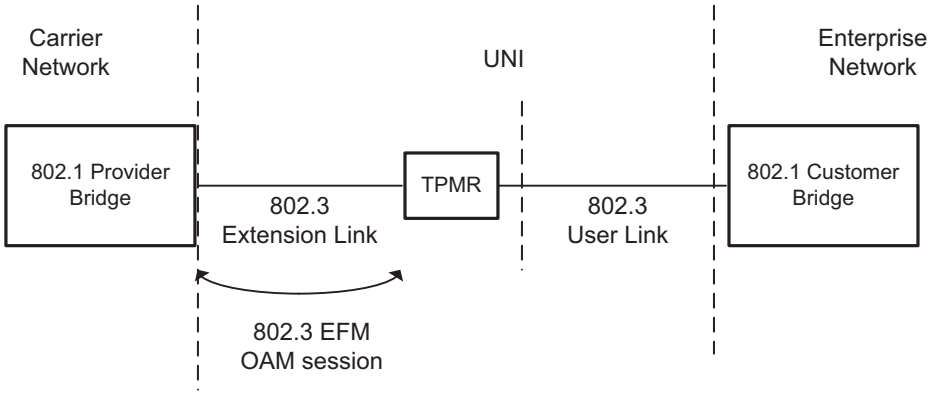


Figure K-1—TPMR as UNI demarcation device

The use of EFM OAM on the extension link allows the service provider to:

a) Put the TPMR into an intrusive loopback for out-of-service testing.
b) Query the IEEE 802.3 MIB in the TPMR.
c) Be notified of critical events (Link Fault, Dying Gasp, Critical Event).
d) Be notified of link performance events (Errored Symbol Period event, Errored Frame event, Errored Frame Period event, Errored Frame Seconds Summary event).

The potential exists with EFM OAM (on the extension link) to make use of extensions, via organization-specific OAMPDUs, to manage the Port of the TPMR that faces the user link.

Alternatively, the TPMR might be managed using SNMP over UDP/IP either in-band on the IEEE 802.3 extension link or out-of-band through separate management connector on the TPMR.

K.2 Use case 2—TPMRs with aggregated links

Figure K-2 illustrates a use case where two TPMRs are used within paired extension/user links that are aggregated at their endpoints (the Bridges). The TPMRs are transparent to the operation of the IEEE 802.1AX Link Aggregation Control Protocol (LACP), because the Provider Bridge and Customer Bridge are configured to use the "Nearest non-TPMR Bridge group address" as the destination address for LACP; from the point of view of Link Aggregation, each paired extension link and user link, with the TPMR joining them together, appears to be a single IEEE 802.3 LAN.

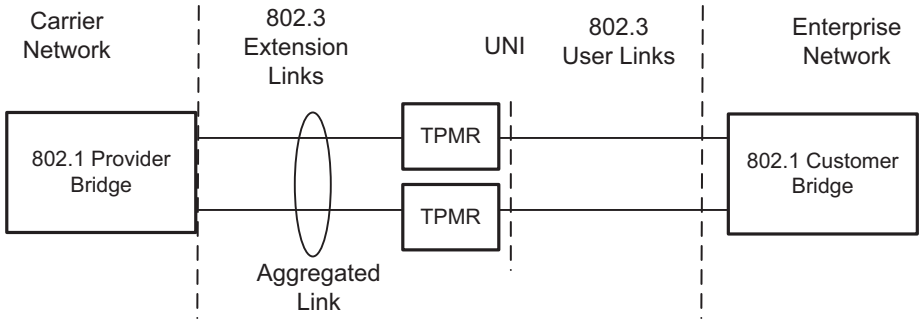


Figure K-2—TPMRs with aggregated links

The TPMRs would be managed separately, via EFM OAM, as in use case 1 (K.1). It should be noted that the use of SNMP to manage the TPMRs in this scenario is problematic, as the aggregated link appears to the higher layers to be a single link, but individual conversations are allocated by the frame distributor in the aggregator to the links in the aggregation in a nondeterministic manner.

K.3 Use case 3—Multiple TPMRs

Figure K-3 shows a variant of use case 1 (K.1) where two extension links and a user link are used, interconnected using two TPMRs.

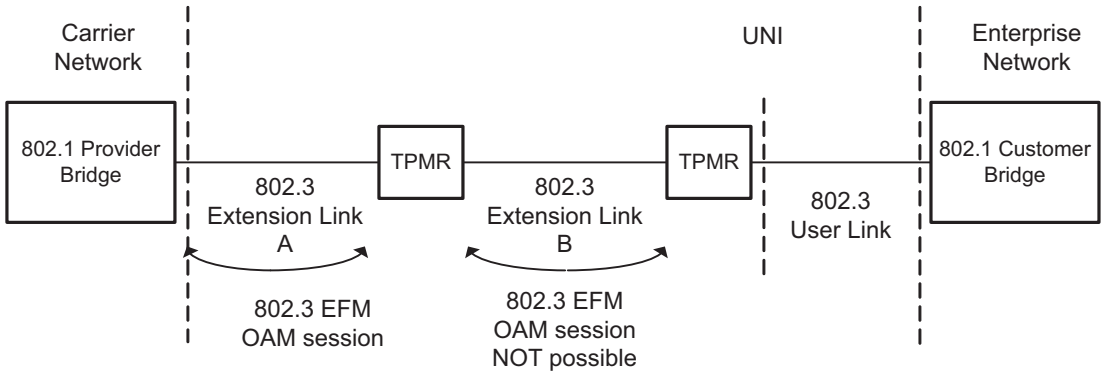


Figure K-3—Multiple TPMRs

Some commercial TPMRs used as demarcation devices power up in EFM OAM Passive mode, waiting to hear from the Active mode master device at the edge of the provider network. A passive-to-passive EFM OAM session, as would occur on extension link B, would never activate, making it impossible to manage the customer-facing TPMR by this means, unless significant changes were made to the capabilities of EFM OAM to allow some kind of relay capability. On the other hand, by using SNMP as the management protocol, this problem would be avoided.

K.4 Special cases

Figure K-4 (new connectivity) and Figure K-6 (connectivity failure) represent the target cases for the MAC status propagation design.

Figure K-4 shows recovery of the individual LAN at one end of at TPMR chain. The result is to "blip" the MAC_Operational status at the other end of the chain, delaying availability of the recovered link by slightly more than $T_{w+}T_d$. The figure also shows a possible effect of timing relationships between T_r and T_d, as the initiator of the change retries its Add message transmission just as the TPMR at the other end of the chain returns a confirm. The crossing of messages shown is unlikely, as the time sequence diagrams overemphasize the delay experienced by the Add and Confirm messages, but the effect is benign in any case.

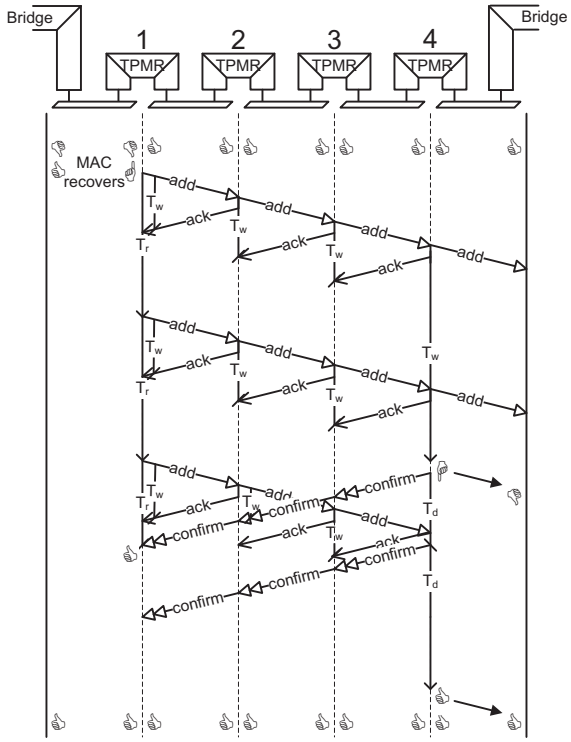


Figure K-4—Recovery at the end of a chain

If the LAN between the end system and the first TPMR in the chain (TPMR 1) had failed instead of recovering, the rest of Figure K-4 would have looked the same, with the exception of the final state of that first LAN. The net effect of the status notification protocol is to transfer the change in MAC_Operational to the other end of the chain so that both ends see the transition. For best effects the transfer should complete in a short enough time so that the end system protocols at the initiating end of the link are still executing their initial state.

Figure K-5 shows what happens if both ends of the link come up at the same time, the net effect is simply to delay the simultaneous start.

Figure K-6 shows simultaneous transitions of one LAN in the chain to OperUp and the other to OperDown, and illustrates a number of points about how the protocol or protocols do or should operate.

First, signaling of addition or loss can be somewhat arbitrary and depend on the relative timing of transitions on separate individual LANs. The same final connectivity can be represented by a loss followed by an

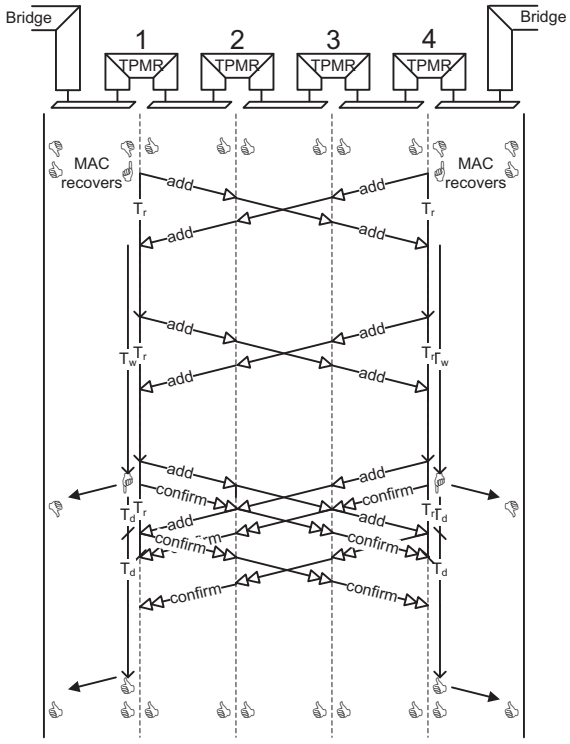


Figure K-5—Near simultaneous recoveries

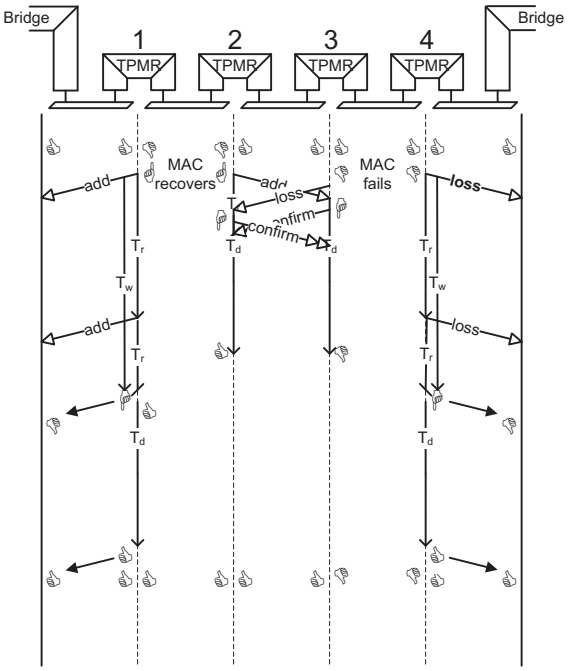


Figure K-6—Near simultaneous failure and recovery

addition, or an addition followed by a loss. If the implied resulting state is to mean anything then the information “connected as far as,” or “connected to and beyond” also needs to be communicated. However, while this is a candidate for inclusion in any new protocol, support by existing protocols is unlikely. However, this clause persists with distinguishing Add and Loss messages, and their confirmations, because that ensures that closely spaced transitions, which might otherwise disguise unusual loss of higher layer

protocol messages, are not missed by the systems connected to the TPMR chain. Figure K-7 shows a loss followed by recovery of the same LAN.

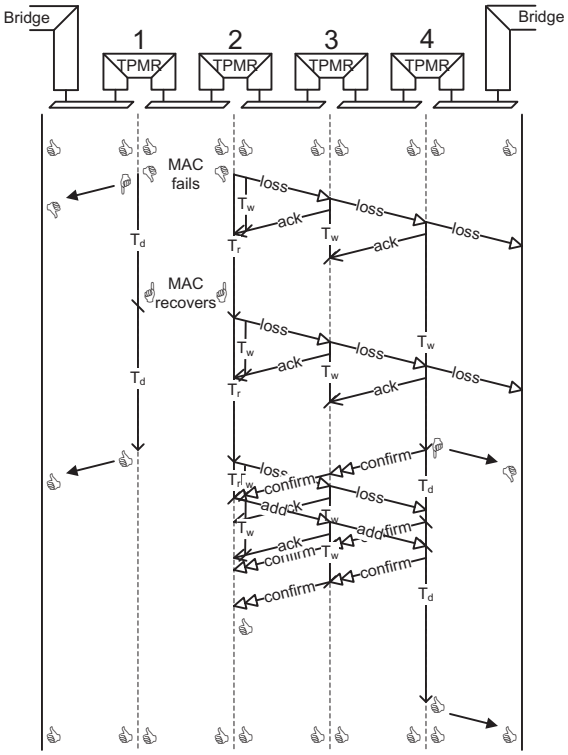


Figure K-7—Loss with quick recovery

Second, no message is sent across the LAN between TPMRs 1 and 2 when the MAC is OperDown from the protocol client's point of view. That allows support of the protocol to be architected such that a message that signals "add(ition)" or "loss" is forwarded through the normal bridged path so its speed of propagation does not depend on scheduling or notifying a status propagation process in each TPMR. Also, users have a free choice about what additional functionality can reside between the entities responsible for status propagation and the "real" MAC.

One last common case of simultaneous transitions is what happens when the two ports of a TPMR power up or are enabled at the same time. Each tries to send a link notification through the other, and each link notification is discarded as the Port is not yet available (mssOperUp FALSE). The result is to "blip" each LAN. The ends of the TPMR chain see an Add Loss Add sequence, if they are protocol capable, and a blip in MAC_Operational otherwise. If T_w is less than T_d, this will be a single blip.

Annex L

(informative)

Operation of the credit-based shaper algorithm

This annex contains a more detailed analysis of the way the credit-based shaper algorithm (8.6.8.2) operates, and how its operation affects the performance of the network, from the point of view of traffic that uses a credit-based shaped queue, and also from the point of view of other queues associated with the Port. The analysis and description in this annex does not take into account any interruption to bandwidth availability resulting from the operation of stream gates.

L.1 Overview of credit-based shaper operation

The credit-based shaper algorithm has a single externally determined parameter, *idleSlope* (see 8.6.8.2), that determines the maximum fraction of the *portTransmitRate* that is available to the queue associated with a traffic class (*bandwidthFraction*), as follows in Equation (L-1):

$$bandwidthFraction = idleSlope/portTransmitRate \quad \text{(L-1)}$$

where *portTransmitRate* is the maximum transmit data rate that the port supporting the outbound queue is able to deliver. The detailed derivation of Equation (L-1) can be seen in Equation (L-5) through Equation (L-8).

If a traffic class supported by the credit-based shaper algorithm uses less than the bandwidth allocated to it, then the unused bandwidth can be used by other traffic classes, in accordance with the relative priorities of the traffic classes and the transmission selection algorithms that are associated with them.

NOTE 1—It is a natural consequence of the way transmission selection operates that if a given traffic class does not have a frame available for transmission, then a lower priority traffic class that does have a frame available for transmission is able to transmit. Hence, if a given traffic class that uses the credit-based shaper algorithm has been allocated X% of the available bandwidth on a Port, but only uses (X-Y)%, then the unused portion of its allocation (Y%) is available for other traffic classes to use if they are in a position to do so. Whether this unused bandwidth can be used use by a traffic class depends upon the transmission selection algorithm that is associated with it. For example, a traffic class that has been allocated a specific bandwidth, such as one that uses the credit-based shaper algorithm, would be unable to use any bandwidth allocation not used by a higher priority traffic class, as that would result in it exceeding its bandwidth allocation; however, a traffic class that uses the strict priority algorithm, which is not associated with a bandwidth allocation, would be able to use bandwidth allocated to, but not used by, a higher priority traffic class.

The *idleSlope* parameter, in conjunction with the size of the frames that are being transmitted using the queue, and the maximum time delay that a queue can experience before it is able to transmit a queued frame, places an upper bound on the burst size that can be transmitted from queues that use the algorithm.

In order to describe the operation of the algorithm, it is useful to define the following values, in addition to the formal parameters of the algorithm described in 8.6.8.2:

a) ***maxFrameSize.*** The maximum sized frame that can be transmitted through the Port for the traffic class concerned. This value can be determined by admission control algorithms, or can be simply a function of the transmission behavior of the traffic source. Either way, the value can be smaller than would be allowed by the normal operation of the underlying MAC Service.
b) ***hiCredit.*** The maximum value that can be accumulated in the *credit* parameter. This parameter is a function of the operation of the algorithm, and cannot be controlled by management.

c) ***loCredit.*** The minimum value that can be accumulated in the *credit* parameter. The value of *loCredit* is a function of the values of *maxFrameSize*, *portTransmitRate*, and *sendSlope*, as follows in Equation (L-2).

$$loCredit = maxFrameSize \times (sendSlope/portTransmitRate) \quad \text{(L-2)}$$

d) ***maxInterferenceSize.*** The maximum size, in bits, of any burst of traffic that can delay the transmission of a frame that is available for transmission for this traffic class. For the numerically highest traffic class, *maxInterferenceSize* is exactly equal to the maximum sized frame that can be transmitted through the Port (the maximum frame size supported by the underlying MAC). For all other traffic classes, the derivation of *maxInterferenceSize* becomes more complex, owing to the possibility that any higher traffic classes that support the credit-based shaper algorithm can delay the transmission of a frame. *maxInterferenceSize* must also account for any media access delay, such as the recovery time in Energy Efficient Ethernet. A detailed analysis can be found in L.3.1.1.

NOTE 2—The definition of *maxInterferenceSize* assumes that any traffic classes that support the shaper algorithm are numerically higher than any traffic classes that support the default strict priority algorithm (8.6.8.1). If this is not true, then the value of *maxInterferenceSize* is infinite, and the operation of the credit-based shaper algorithm cannot provide the bandwidth that has been reserved for it. A detailed analysis of how *maxInterferenceSize* can be determined for a given traffic class is contained in L.3.

The value of *hiCredit* is determined by the worst-case interfering traffic, as follows in Equation (L-3).

$$hiCredit = maxInterferenceSize \times (idleSlope/portTransmitRate) \quad \text{(L-3)}$$

The value of *hiCredit* can therefore be considered as a “high water mark”; the operation of the algorithm is such that the value of the *credit* parameter will never exceed *hiCredit.*

The choice of value for *idleSlope,* and the calculated value of *hiCredit*, can be used to determine the maximum burst size that can be output from the queue, as follows in Equation (L-4).

$$maxBurstSize = (portTransmitRate \times ((hiCredit - loCredit)/(-sendSlope))) \quad \text{(L-4)}$$

NOTE 3—There is an interrelationship between the maximum burst size and the buffer size available to the traffic class. There is no point in accumulating more credit than the traffic class can handle in queued frames, as the limiting factor is the discarding of frames when the queue overflows. This means that the amount of bandwidth that can be reserved on a given Port for a given traffic class depends upon the amount of buffering available to that traffic class. This in turn, combined with the port’s transmission rate, will determine the maximum value of idle slope that can be supported for that traffic class on that Port.

The operation of the credit-based shaper algorithm is illustrated in the examples shown in Figure L-1 through Figure L-3. In Figure L-1, a frame is queued at a time when the *credit* value is zero, and there is no conflicting traffic (there is no higher priority traffic awaiting transmission, and there is no frame being transmitted on the Port). The frame is immediately selected for transmission, and *credit* decreases at the rate of *sendSlope* as the transmission proceeds. Once the frame transmission is complete, *credit* increases back to zero at the rate of *idleSlope*, at which point, a further frame can be selected for transmission.

If a continuous stream of frames is made available to the shaper algorithm, i.e., there is always one frame queued awaiting transmission when the *credit* value reaches zero, then the fraction of the *portTransmitRate* that is available to the queue (*bandwidthFraction*) is equal to the fraction of time that frames are being transmitted from the queue. Assuming that *credit* decreases to value *loCredit* at the end of each frame transmission, then the following shows the detailed derivation of Equation (L-1):

$$bandwidthFraction = (-loCredit/sendSlope)/[(-loCredit/sendSlope) + (loCredit/idleSlope)] \quad \text{(L-5)}$$

$$= (-1/sendSlope)/[(1/idleSlope) - (1/sendSlope)] \quad \text{(L-6)}$$

$$= (-idleSlope)/(sendSlope - idleSlope) \quad \text{(L-7)}$$

$$= idleSlope/portTransmitRate \quad \text{(L-8)}$$

This fraction of the bandwidth is available to the stream even in the presence of conflicting traffic, as illustrated in the following examples.

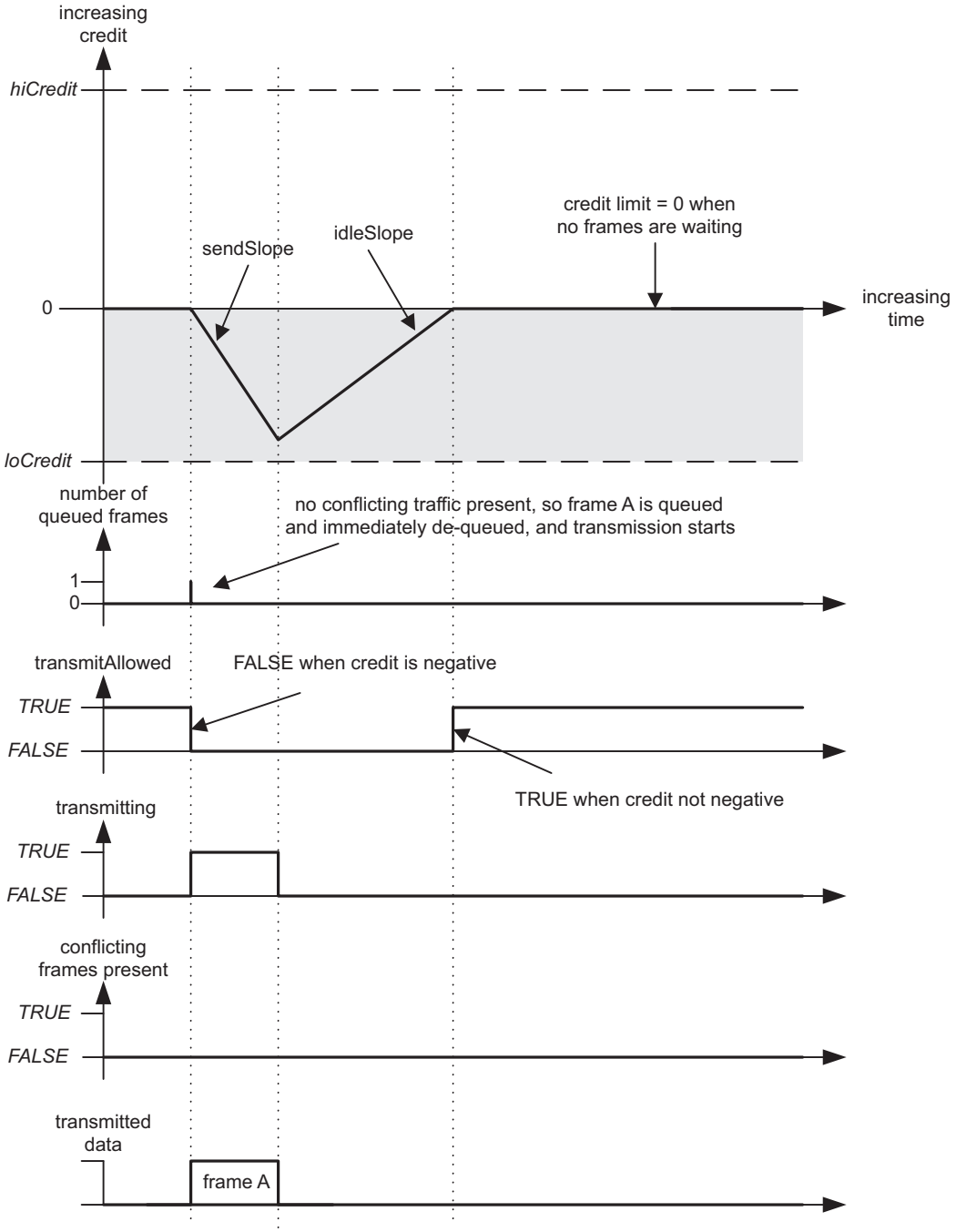


Figure L-1—Credit-based shaper operation—no conflicting traffic

In Figure L-2, a frame is queued at a time when the Port is transmitting conflicting traffic. The value of *credit* increases at the rate of *idleSlope* while the queued frame waits for the Port to become available. Transmission of the conflicting traffic completes before the value of *credit* is limited by *hiCredit*, and transmission of the queued frame starts. The value of *credit* starts to decrease at the rate of *sendSlope*; however, as the frame is not large enough to consume all of the available *credit*, and there are no further frames queued, *credit* is reduced to zero on completion of the transmission.

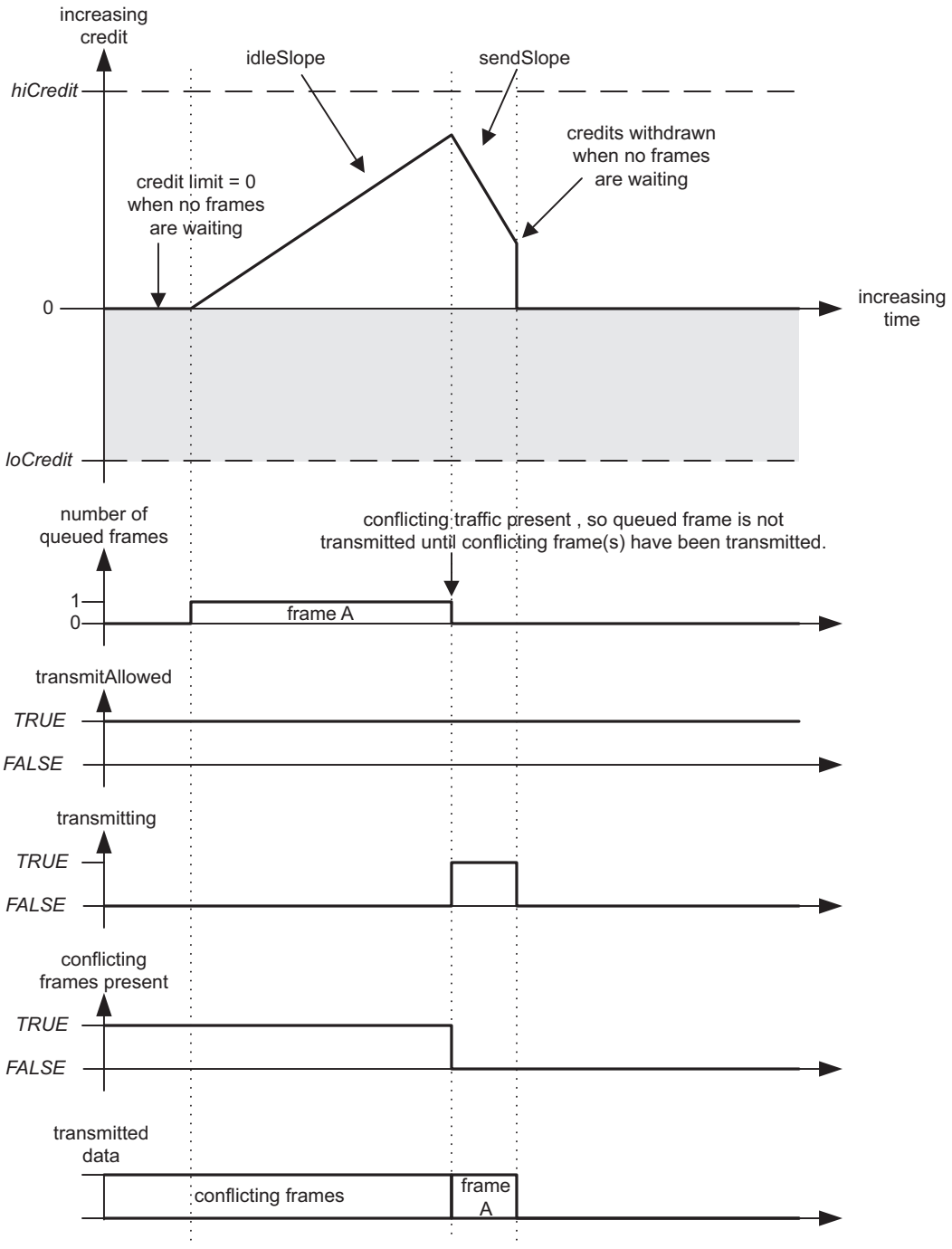


Figure L-2—Credit-based shaper operation–conflicting traffic

In Figure L-3, three frames are queued while the Port is transmitting conflicting traffic, and *credit* accumulates at the rate of *idleSlope*. Once the conflicting traffic has been transmitted, the first and second frames are transmitted back-to-back, because transmitting the first frame leaves *credit* ≥ 0. However, as transmitting the second frame causes credit to become negative, transmission of the third frame is delayed until *credit* returns to zero.

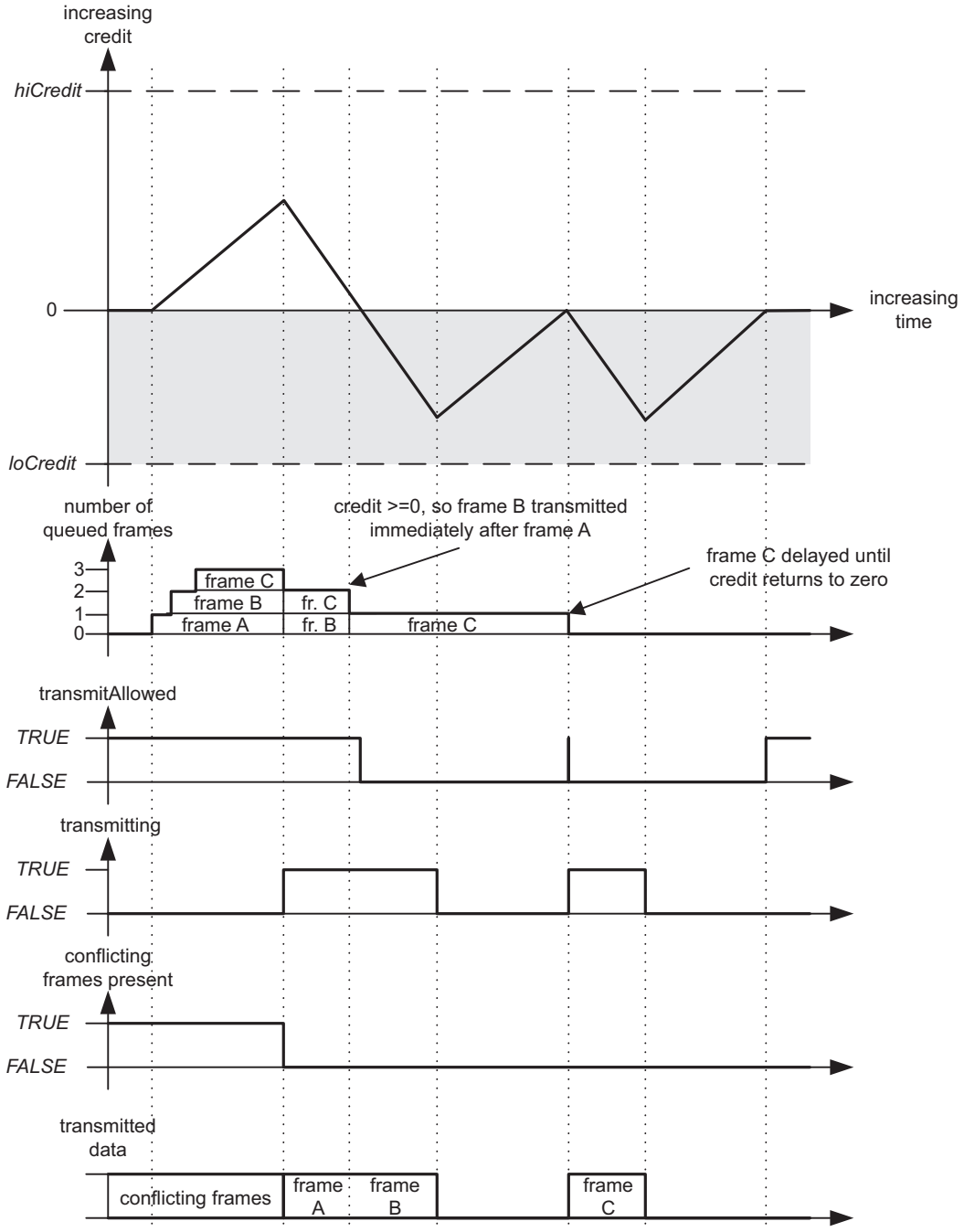


Figure L-3—Credit-based shaper operation—burst traffic

L.2 “Class measurement intervals” in Bridges

The “class measurement interval” defines acceptable Talker behavior with respect to per-stream transmission (see 34.6.1.1); however, it does not directly impact the operation of the credit-based shaper algorithm in Bridges.

The maximum fraction of the available bandwidth that a queue operating the credit-based shaper algorithm consumes is determined by *idleSlope*, as discussed in L.1; if *idleSlope* is 75% of the link transmission rate, then the algorithm gets a maximum of 75% of the link, averaged over some time period (the class measurement interval) at the Talker. For a Bridge, where transmission becomes bursty due to interfering transmission from other traffic classes, the minimum measurement interval that is meaningful (i.e., the minimum period over which it is still possible to observe that the 75% maximum bandwidth is not exceeded) is the time taken for the traffic class concerned to transmit a maximum sized burst, multiplied by 100/75. In the case of the 125 μs class measurement interval for SR class A traffic, on 100 Mb/s Ethernet, and with 75% reservation, the approximate calculation is (ignoring interframe gaps)

a) The maximum interference size (*maxInterferenceSize*) is one maximum sized Ethernet frame, which is 2000 octets, or 16 000 bits, so *hiCredit* would be 75% of that, or 12 000 bits.

NOTE 1—Media access delays, such as those imposed by Energy Efficient Ethernet, could be more significant than the interference created by a maximum sized frame.

NOTE 2—The figure of 2000 octets is a maximum for Ethernet and therefore a worst case for an interfering frame; in a specific implementation, the maximum frame size that is used could be smaller. In implementations where the maximum frame size is known to be less than 2000, the smaller value could be used.

b) The maximum frame size for this traffic class is 75% of the number of bits that can be transmitted in 125 μs, so 75% of 12 500 bits in the case of a 100 Mb/s LAN, or 9375 bits (including up to 500 or so possible “overhead” octets—used for, e.g.,Tag headers, physical layer overhead). As this is not an integral number of octets, this figure is rounded down to 9368. *loCredit* is 25% of that, or –2342.

c) The maximum burst size, for frames no greater than 9368 bits long, would occur if *credit* reached 12 000, then a series of frames were transmitted that exactly took credit to 0, followed by a final 9368 bit frame that would take credit down to –2342. This maximum burst is therefore calculated as (12 000 + 2342) • (*portTransmitRate/(-sendSlope))* or 57 368 bits.

d) The minimum measurement interval over which one can expect to be able to measure the bandwidth utilization for SR class A, and observe that it does not exceed its 75% allocation, is therefore 57 368 bit times multiplied by 100/75, which is 76 491 bit times, rounded up to the nearest integer, or 764.91 μs.

NOTE 3—The maximum sized burst will be preceded by a *maxInterferenceSize* event, and at the end of the burst, *credit* will have been reduced to –2342; it will therefore take 2342/*idleSlope* seconds, or nearly 3123 bit times, for *credit* to return to zero, and for SR Class A to be allowed to transmit again. In addition, the actual utilization for SR Class A is 57368/(57368+16000+ (2342/0.75)) = 75%.

For the SR class B traffic, all that really changes is the potential size of any interference, which increases from the SR class A *maxInterferenceSize* to the maximum burst size for SR class A plus the class A *maxInterferenceSize*.

So, the smallest possible measurement interval over which the ratio *idleSlope*/*portTransmitRate* will be seen to hold good is dependent on the maximum interference size for the SR class, the maximum frame size for the SR class, and the value of *idleSlope*.

L.3 Determining worst-case latency contribution and buffering requirements

From the point of view of the operation of AV Bridges, it is important to be able to assess the contribution that each Bridge makes to the worst-case latency that stream data frames can be subject to during their transmission along the path from Talker to Listener. Closely related to the latency contribution that a Bridge makes is the buffering requirement that is required in the Bridge in order for the delay not to result in frame discard; if a Bridge can potentially delay a frame of a given SR class for a given period of time, then it must be capable of buffering the worst-case number of frames of that same SR class that could be received for onward transmission on each Port. The following discussion looks at the factors that contribute to the delay that could be experienced by a frame as it passes through a Bridge, and how the delay can be accurately determined.

NOTE 1—This discussion is also useful to guide designers of Talker stations in determining the delay added by the Talker's network interface.

The worst-case latency for a single hop from Bridge to Bridge, measured from arrival of the last bit at Port *n* of Bridge A to the arrival of the last bit at Port *m* of Bridge B, can be broken out into the following components:

a) Input queuing delay. (There are no input queues in the IEEE 802.1 architecture, but if present, the implementation must account for them.)
b) Interference delay (L.3.1).
c) Frame transmission delay. (The time taken to transmit one maximum frame at *portTransmitRate*.)
d) LAN propagation delay. (A variable delay that depends on the length of the LAN connection to the next Bridge; this is measurable using the mechanisms defined in IEEE Std 802.1AS.)
e) Store-and-forward delay. This includes all other elements of forwarding delay that are a consequence of the internal processing of the Bridge, assuming that the input and output queues are empty, such as:
    1) The time needed to pass a frame from the input port to the output port, assuming empty queues.
    2) The time delay between a frame being available for transmission on a Port and the Port being ready to transmit the frame.

NOTE 2—For example, in the case where the MAC/PHY has entered a power saving mode, there may be a delay incurred in switching the Port back to normal operation.

    3) The difference, if any, in the delay incurred by a frame that bypasses an empty queue, vs. that incurred by a frame that must be enqueued.
    4) The time added (subtracted) by the lengthening (shortening) of the frame due to addition (removal) of frame headers such as Q-tags or MACSec-tags.
    5) The time needed to encrypt a MACSec frame.

In the remainder of this clause, the following abbreviations are used:

M_0 Maximum sized frame for non-SR classes
M_x Maximum sized frame for SR class x
R_0 portTransmitRate
R_x idleSlope for SR class x
T_{xy} Time interval between events x and y
W_x -sendSlope$_x$
variable$_{<x}$ The sum of the values of the named *variable* for all SR classes with a higher priority (and therefore earlier letter in the collating sequence) than x

L.3.1 Interference delay

The interference delay for frame X can be broken out into the following components:

a) **Queuing delay:** The delay caused by the frame that was selected for transmission an arbitrarily small time before frame X became eligible for transmission selection, plus the delay caused by queued-up frames from all stream frames with higher priority than frame X's class (i.e., the "*maxBurstSize*" for SR Classes with higher priority than X—see L.1). This is what is referred to as *maxInterferenceSize* in L.1. Queuing delay is analyzed in detail in L.3.1.1.

b) **Fan-in delay:** The delay caused by other frames in the same class as frame X that arrive at more-or-less the same time from different input Ports. Fan-in delay is analyzed in detail in L.3.1.2.

c) **Permanent delay:** The delay caused by frames that reside in a buffer for a long time, relative to the output queuing delay, because of the history of activity in the network. Permanent delay is analyzed in detail in L.3.1.3.

L.3.1.1 Queuing delay

The queuing delay for frame X can be broken out into the following components:

a) The delay, *maxInterferenceTime*, before a frame X queued for an SR class, and that is eligible for transmission, can actually be transmitted. This delay is experienced when a frame, of any priority, is selected for transmission an arbitrarily small time before frame X became eligible for transmission; it is also experienced in LAN media, such as Ethernet, where there can be a low energy consumption mode that is entered under idle conditions, and where there is a significant delay, *mediumAccessDelay,* before the LAN returns to normal operation and is able to transmit. The value of *maxInterferenceTime* is therefore equal to whichever is the greater of the following:
   1) The time taken to transmit the maximum frame size supported by the medium, i.e., $maxFrameSize_{(m)}$ / *portTransmitRate*.
   2) The *mediumAccessDelay* for the medium.

b) The delay caused by any queued-up frames associated with the next higher priority SR class than frame X's SR class (i.e., *maxBurstSize* for the next higher priority SR class), if frame X does not belong to the highest SR class.

For SR class A, only the first of these components applies, as there is no higher SR class.

Suppose that the queue for SR class A is full, and it has accumulated the maximum amount of *credit (hiCredit)*. Because SR class A frames have priority over all other traffic (even BPDUs), *hiCredit* for SR class A is merely the credit accumulated during the *maxInterferenceTime* required to transmit a lower-priority frame. Until that accumulated credit is exhausted, SR class B (C, D,...) frames cannot be transmitted.

If SR class A were permitted to use 100% of the LAN bandwidth, then the SR class A queue would never catch up, because it would use credit as fast as it was gained, and there would never be a chance for any other traffic class to transmit a frame. If SR class A were permitted to use 99% of the LAN bandwidth, then SR class A can transmit back-to-back frames and the accumulated *credit* would be drained at 1% of the LAN bandwidth until it goes negative; at that point, SR class A cannot transmit further frames until its *credit* returns to a non-negative value, which ensures that at least 1% of the bandwidth is available to other traffic classes.

NOTE—In general, if SR Class A is permitted to use X% of the bandwidth, then only (100-X)% remains available for use by lower priority traffic classes. In practice, as 75% is the default value for the highest percentage of *portTransmitRate* that can be used by all SR classes, there is always at least 25% of *portTransmitRate* available for use by the non-SR traffic classes.

Figure L-4 illustrates this burst transmission behavior, and the effect of *maxInterferenceTime* on the latency of SR class frames. At point *a* on the time line, the queues for SR classes A and B are empty, and a maximum sized frame (M_0 bits long) belonging to a non-SR traffic class starts transmission. An instant later, SR class A and B frames arrive that are all of the maximum size that the classes are currently experiencing (M_A and M_B bits long, respectively); however, as there is a frame already being transmitted, they are queued. At point *b*, transmission of the non-SR class frame completes, and the first of a burst of four SR class A frames are transmitted. By point *d*, SR class A's credit has been taken negative by the transmission of the last of its burst of frames, and therefore no further SR Class A frames can be transmitted until its credit is no longer negative; this allows SR Class B to transmit a frame. What happens at the end of the class B frame will depend on what frames are queued waiting for transmission, and whether the credit available to either of the SR classes is non-negative.

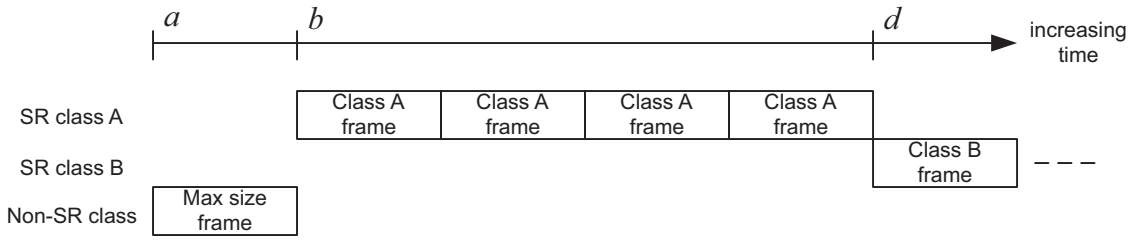


Figure L-4—Interference and latency

The queuing delay experienced by the first SR Class A frame is therefore the time interval between *a* and *b*, T_{ab}. If R_0 is the transmission rate (*portTransmitRate*), then:

$$T_{ab} = M_0 / R_0 = maxInterferenceTime \quad \text{(L-9)}$$

Figure L-5 shows how credit changes for SR Class A during this sequence.

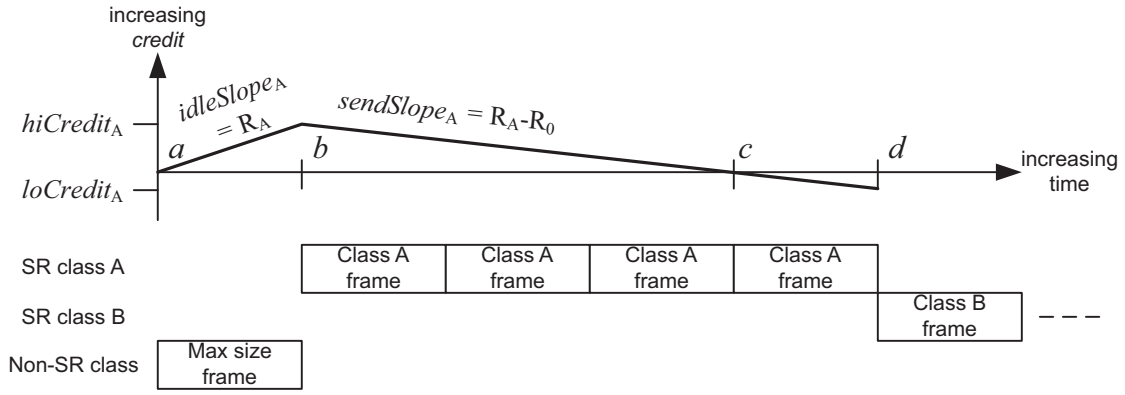


Figure L-5—Burst behavior and credit

R_A is the reserved data rate for SR Class A (which is the *idleSlope* for class A), R_B is the reserved data rate for SR Class B, and so on. The value of $credit_A$ accumulates up to $hiCredit_A$ during the transmission of the maximum sized non-SR frame so that:

$$hiCredit_A = R_A \times M_0 / R_0 = \text{idleSlope}_A \times maxInterferenceTime \quad \text{(L-10)}$$

credit is drained during the transmission of the SR Class A frames, at the rate $sendSlope_A$, as follows:

$$sendSlope_A = (R_A - R_0) \quad \text{(L-11)}$$

credit reaches zero at point *c* in Figure L-5, which, for the purposes of this discussion, is assumed to happen exactly at the point where transmission of the third class A frame finishes. Since a frame can be transmitted when *credit* = 0, Class A's credits continue to drain to the following value:

$$loCredit_A = (R_A - R_0) \times M_A / R_0 \quad \text{(L-12)}$$

during the transmission of the fourth class A frame (M_A bits long, transmitted in time M_A / R_0). At point *d*, transmission of the fourth frame completes; as $credit_A$ is now negative, no more class A frames can be transmitted, and transmission of a class B frame starts.

So, for class A, the maximum burst size is equal to the transmission rate, R_0, multiplied by the time interval between points *b* and *d* in Figure L-5:

$$\text{max Class A burst size} = R_0 \times (-(hiCredit_A - loCredit_A) / sendSlope_A) \quad \text{(L-13)}$$

Substituting $hiCredit_A$, $sendSlope_A$, and $loCredit_A$ from Equation (L-10), Equation (L-11), and Equation (L-12), respectively, results in the following:

$$\text{max Class A burst size} = R_0 \times (-(R_A \times M_0 / R_0 - (R_A - R_0) \times M_A / R_0) / (R_A - R_0)) \quad \text{(L-14)}$$

$$= R_0 \times (R_A \times M_0 / R_0) / (R_0 - R_A) + M_A / R_0 \quad \text{(L-15)}$$

$$= (R_A \times M_0) / (R_0 - R_A) + M_A \quad \text{(L-16)}$$

The queuing delay experienced by SR class B is the time interval between *a* and *d* in Figure L-5, T_{ad}:

$$T_{ad} = T_{ab} + T_{bc} + T_{cd} \quad \text{(L-17)}$$

$$= M_0 / R_0 + hiCredit_A / (-sendSlope_A) + M_A / R_0 \quad \text{(L-18)}$$

$$= M_0 / R_0 + (R_A \times M_0 / R_0) / (R_0 - R_A) + M_A / R_0 \quad \text{(L-19)}$$

$$= M_0 / (R_0 - R_A) + M_A / R_0 \quad \text{(L-20)}$$

This can be generalized to calculate the queuing delay experienced by any SR class, X, by using the sum of the credits available to all higher priority SR classes. In the following, the subscript "<X" is used to indicate the sum of the values for all SR classes with higher priority (and therefore, earlier letters in the collating sequence) than X.

The credit acquisition rate $idleSlope_{<X}$ for SR classes A through X – 1 is the sum of the data rates for all higher priority classes so that:

$$idleSlope_{<X} = \sum_{K<X} R_K \quad \text{(L-21)}$$

This is just the sum of the $idleSlope_K$ values for the higher classes. However, the combined classes accumulate credits only until the single interfering non-SR interfering frame stops transmitting, and then the credits start decreasing linearly. So, the upper limit for the combined credits is not the sum of the individual Class's credits; it is the number of bits divided by the slope, or:

$$hiCredit_{<X} = (\sum_{K<X} R_K) \times M_0 / R_0 \quad \text{(L-22)}$$

Similarly, the combined $sendSlope_{<X}$ is:

$$sendSlope_{<X} = -(R_0 - \sum_{K<X} R_K) \quad \text{(L-23)}$$

These combined rates hold true until some class's buffer empties and its credits are forced to 0. In the worst-case scenarios examined here, this does not happen.

Defining:

$$W_{<X} = -\mathit{sendSlope}_{<X} = R_0 - \sum_{K<X} R_K \quad \text{(L-24)}$$

leads to:

$$\mathit{sendSlope}_{<X} = -W_{<X} \quad \text{(L-25)}$$

and:

$$\mathit{hiCredit}_{<X} = (R_0 - W_{<X}) \times M_0 / R_0 \quad \text{(L-26)}$$

For all combined classes, T_{ab} is the same as for SR class A, the time for the non-SR frame to transmit:

$$T_{ab} = M_0 / R_0 \quad \text{(L-27)}$$

The combined classes A through X – 1 drain from $\mathit{hiCredit}_{<X}$ to 0 in time $\mathit{hiCredit}_{<X} / W_{<X}$ so that:

$$T_{bc} = ((R_0 - W_{<X}) \times M_0 / R_0) / W_{<X} \quad \text{(L-28)}$$

The worst-case value of $\mathit{loCredit}_{<X}$ for the combined <X classes is not the sum $\sum_{K<X} \mathit{loCredit}_K$ as this would overestimate the worst case. Only one of the <X classes can be transmitting a frame at a given time, so the end of the burst for the <X classes occurs when one of the <X classes, Q say, starts transmitting a frame at a point where all the other <X classes have negative credit, and their credit is therefore rising. If, by the time Q's frame transmission finishes, the other <X classes still have negative credit, then Q's frame is the last frame of the <X burst; but at that point, all the other <X classes must, by definition, have more credit than their respective *loCredit* values (i.e., for these other classes, *credit* > *loCredit*) because even if they were at their respective *loCredit* values when Q started transmitting, they have been gaining credit during the transmission of Q's frame.

It is also not possible to decide that $\mathit{loCredit}_{<X}$ is simply the time needed to transmit one copy of each Class's maximum-length frame; for some classes it could be possible transmit more than a single last frame after the total credits = 0, even if all Classes' credits reach 0 simultaneously. For example, classes A and B reach *credit* = 0 at the same time; A transmits a frame, then B transmits a frame. By the end of the B frame, A's *credit* has returned to zero, and so A can transmit a further "last" frame.

Some class must transmit the last frame, and for it to be the worst case, that last frame is a maximum length frame. If it were not, then either:

c) Extending it to the maximum length still leaves the other classes at negative *credit*; or
d) Extending it to the maximum length leaves one or more other class with 0 or positive *credit*, in which case they will transmit more frames.

So, for class Q to be the class that transmits the last frame of the <X burst, the following condition must be true for all other <X classes, P:

$$M_q \times R_P > (R_0 - R_P) \times M_p \quad \text{(L-29)}$$

Equation (L-29) follows from the fact that the increase in credits of class P during the transmission of M_q, which is equal to $(M_q/R_0) \times R_P$ is greater than the absolute value of the *loCredit* of P, which is equal to $(R_0 - R_P) \times M_p$. So,

$$(M_q/R_0) \times R_P > (R_0 - R_P) \times M_p / R_0 \quad \text{(L-30)}$$

This statement is true because the other classes P must have low enough *credit* that their *credit* cannot climb above 0 during the transmission of M_q.

The very lowest that $credit_{<X}$ might reach for three SR classes, Q, P, and S is shown in Equation (L-31).

$$loCredit_{<X} \geq loCredit_Q + loCredit_P + loCredit_S + R_S \times M_q/R_0 + R_P \times M_q/R_0 \quad \text{(L-31)}$$

However, even this is pessimistic, as it assumes that more than one class can be at their *loCredit* at the same time, which is not the case. What this shows, however, is that if R_K is small for all K<X (i.e., $R_K << R_0$), then the $R_K \times M_q/R_0$ terms all approach zero, and therefore $loCredit_{<X}$ approaches the sum $\sum_{K<X} loCredit_K$. So,

$$loCredit_{<X} = \sum_{K<X} loCredit_K \quad \text{(L-32)}$$

$$= \sum_{K<X} (R_K - R_0) \times M_K / R_0 \quad \text{(L-33)}$$

But in this worst case, $R_K << R_0$; therefore,

$$loCredit_{<X} = \sum_{K<X} (-M_K) \quad \text{(L-34)}$$

Putting together these various components, the queuing delay for SR Class X, $qDelay_X$, is as follows:

$$qDelay_X = M_0 / R_0 + (hiCredit_{<X} - loCredit_{<X}) / |sendSlope_{<X}| \quad \text{(L-35)}$$

$$= M_0 / R_0 + ((R_0 - W_{<X}) \times M_0 / R_0 + \sum_{K<X} M_K) / W_{<X} \quad \text{(L-36)}$$

$$qDelay_X = (M_0 + \sum_{K<X} M_K) / W_{<X} \quad \text{(L-37)}$$

For SR class A, this equation reduces to Equation (L-38):

$$qDelay_A = M_0/W_{<A} \quad \text{(L-38)}$$

As there is not a "<A" class, A being the highest priority class, $W_{<A}$ is simply R_0, so this reduces to Equation (L-39):

$$qDelay_A = M_0/R_0 \quad \text{(L-39)}$$

This agrees with the earlier discussion in L.1.

For SR class B, the equation reduces to Equation (L-40):

$$qDelay_B = (M_0 + M_A) / W_A \quad \text{(L-40)}$$

As W_A is $-sendSlope_A$, which is just $R_0 - R_A$, this can be rewritten as shown in Equation (L-41):

$$\mathbf{qDelay_B = (M_0 + M_A) / (R_0 - R_A)} \quad \text{(L-41)}$$

The maximum burst size for a given class, X, is the number of bits that can be transmitted in "back-to-back" frames by class X. The maximum burst occurs when that class has experienced the maximum queuing delay for that class, $qDelay_X$, and class X is then able to transmit frames, uninterrupted by any higher priority classes, until it reaches $loCredit_X$. The size of this burst, $maxBurst_X$, is equal to the number of bits that can be transmitted at line rate, R_0, in the time it takes for creditX to reduce from $hiCredit_X$ to $-loCredit_X$, as follows in Equation (L-42):

$$maxBurst_X = (hiCredit_X - loCredit_X) \times R_0 / W_X \quad \text{(L-42)}$$

From the earlier results, the worst case for $loCredit_X$ is just $(-M_X)$ so that:

$$= hiCredit_X \times R_0 / W_X + M_X \times R_0 / W_X \quad \text{(L-43)}$$

and $hiCredit_X$ is the amount of credit that can be accumulated during $qDelay_X$ seconds, which is $qDelay_X$ multiplied by the idle slope, R_X, so that:

$$maxBurst_X = (M_0 + \sum_{K<X} M_K) \times R_X \times R_0 / (W_{<X} \times W_X) + M_X \times R_0 / W_X \quad \text{(L-44)}$$

L.3.1.2 Fan-in delay

The delay caused by other frames in the same class as frame X that arrive at more-or-less the same time from different input Ports. Consider the scenario in Figure L-6, where a Bridge has a number of Ports on which it receives frames for a given SR Class and the frames will be queued on a single outbound Port. Imagine that the "upstream" Bridge Ports feeding every reception Port of the Bridge all encounter a maximum interference event for Class X at the same time. The output Port will be starved of data. Then, once the interference events complete, the "upstream" Bridges start to transmit frames and the input Ports all receive a frame at the same moment; all received frames are delivered to the output queue.

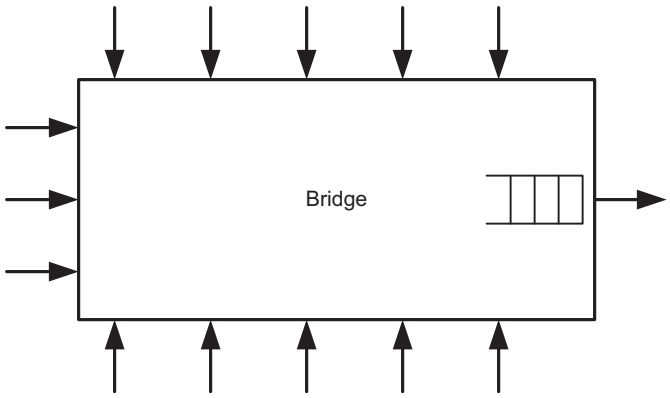


Figure L-6—Fan-in scenario

Assuming that all of the Ports of the Bridge support the same data rate, and the outbound queues of the upstream Bridges are all configured the same as the outbound queue of this Bridge, then the outbound Port would not be able to transmit frames from its queue at the desired, combined data rate of the incoming traffic, as this would require the outbound Port (in this example) to transmit at 20 times its reserved data rate, which would not be permitted by the Stream Reservation Protocol (SRP). It follows that whatever the reserved data rate is on the outbound Port, this must be the same as the sum of the reserved data rates being fed into the inbound Ports.

By allocating the majority of the reserved bandwidth to one of the inbound Ports (shown in gray in Figure L-6) and a very small amount of bandwidth to all of the other inbound Ports, the amount of fan-in data that will be received can be maximized; the gray Port will receive $maxBurst_X$ bits of burst data, and all other Ports will receive a single frame of length M_X. Hence, the data that the outbound queue has to handle in this scenario is $maxBurst_X + 12 \times M_X$ bits of fan-in data.

NOTE 1—The reason that this choice maximizes the fan-in data burst size is that regardless of how little bandwidth is allocated to the black Ports, they still get to burst a complete frame.

The following is a procedure (not a formula) for determining the maximum amount of fan-in data for a given SR class and output port:

a) Determine B_O, the maximum possible bandwidth for class X on the output port.
b) For each possible input port *i*, determine the maximum possible bandwidth B_i for Class X—it is assumed that this information is obtained, by some means, from the transmitting Bridge that is the source of the frames received by *i*.
c) For input port *i*, calculate $\text{maxBurst}_{X,i}$ using $\max(B_O, B_i)$ for the bandwidth. (In the maxBurst formula, use $W_X = R_0 - \max(B_O, B_i)$.)
d) Add $\max(\text{maxBurst}_{X,i})$ to the total fan-in data.
e) Set $B_O = B_O - B_i$ and repeat from step c) until $B_O = 0$.
f) For each remaining port, add $M_{X,i}$ to the total fan-in data.

The fan-in delay is then equal to the time taken for the total fan-in burst data, computed as shown above, to be output at the line rate of the output port.

NOTE 2—The definition of a measurement interval for stream TSpecs implies a minimum frame transmission rate (8000 frames per second for class A's 125 µs measurement interval). At this frame transmission rate, the frames are smaller and, due to the overhead in small frames, fewer streams are possible (no more than 13 through a 100 Mb port). These constraints should be given due consideration when determining the value to be used for M_X and for determining the maximum number of ports contributing to fan-in delay.

Example calculations of fan-in delay can be found in the paper "Calculating the Delay Added by Qav Stream Queue" [B3].

L.3.1.3 Permanent delay

Permanent delay reflects the fact that, if a path through the network is being used continuously at its full capacity for a particular SR class, interfering traffic can cause "permanent" buffer occupancy at the point of congestion. This is illustrated in Figure L-7 through Figure L-10 and the accompanying text.

In Figure L-7 a Talker station, T, has reserved the highest possible bandwidth, R_X, for an SR class X stream on the path through 3 Bridges to Listener L. For the purposes of the discussion, R_X is the maximum reservable data rate for class X on the outbound Ports of all three Bridges, and Talker T starts transmitting the stream, at the reserved data rate R_X. Assuming that the LANs are short and there is no interfering traffic (i.e., the only traffic being handled is this particular stream), the buffer occupancy in each Bridge will approach zero, as frames can be transmitted onwards as soon as they are received.

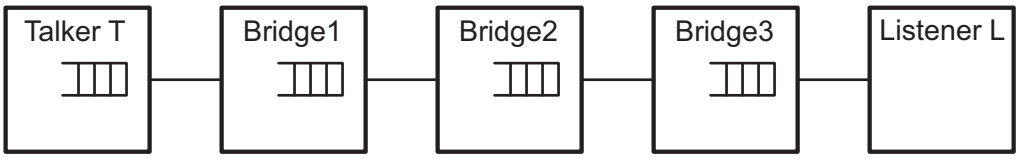


Figure L-7—Permanent delay scenario

In Figure L-8, a second transmission, Q, generates the maximum possible interference to class X (i.e., class X's next frame for transmission is delayed by qDelay_X). Talker T's class X queue fills, and its *credit* increases to $hiCredit_X$ (shown on the figure as $C=C_X$). Because T is no longer transmitting class X frames, the downstream Bridges are starved of frames to transmit, their buffers are empty, and their credit is zero ($C = 0$).

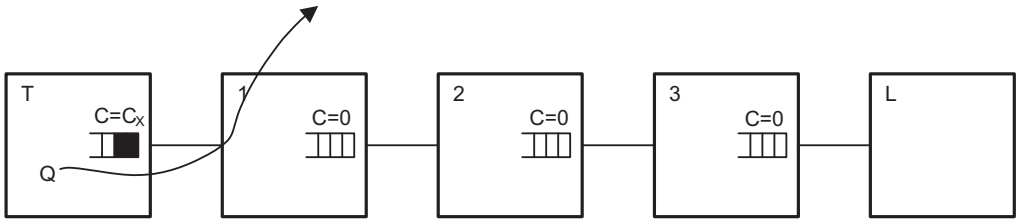


Figure L-8—Building up buffer occupancy—1

In Figure L-9, the interfering traffic goes away, and T is able to transmit a maximum sized class X burst of frames at line rate; once the burst has finished, T reverts to transmitting the stream at the reserved rate R_X. As Bridge 1 has no credit, it will have to buffer most of the burst of frames, and as T is sending frames as fast as Bridge 1 can get rid of them, its buffer occupancy will remain at that level unless something else affects that steady state. Bridge 1 ends up with a credit value that hovers around the *hiCredit* level; the credit in the other Bridges will have *credit* of 0 or some value between 0 and *loCredit* as the Bridges receive and transmit frames.

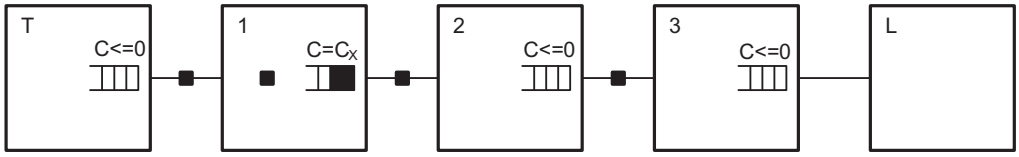


Figure L-9—Building up buffer occupancy—2

If the interfering traffic, Q, starts up again, Talker T's buffer occupancy will build up again; however, as Bridge 1 still has frames buffered, it can continue to transmit, and the downstream Bridges are not starved of frames, and Bridge 1's buffer occupancy and *credit* returns to around 0. When the interference stops, T transmits a burst at line rate, as before, which simply restores Bridge 1's queue to the state shown in Figure L-9.

If a new interfering frame source, S, starts up that affects class X in Bridge 1, then Bridges 2 and 3 could again be starved of traffic, and the buffer occupancy and credit in Bridge 1 could increase temporarily to $2C_X$ (see Figure L-10). When S stops transmitting, then Bridge 2 can create a line rate burst of traffic that will restore its buffer to the previous steady state (Figure L-9), but now Bridge 2 has a permanent buffer loading as shown in Figure L-10.

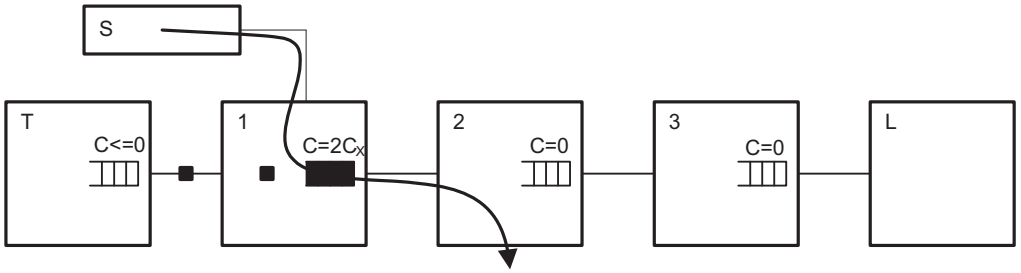


Figure L-10—Building up buffer occupancy—3

This can of course happen for other Bridges in the path, leading eventually to some level of permanent buffer occupancy in each Bridge (Table L-11). The problem does not get any worse from that point on, because no Bridge ever starves (i.e., no Bridge's credit is set to zero because it runs out of frames to send); starvation is a requirement in order for permanent partial occupancy to be created.

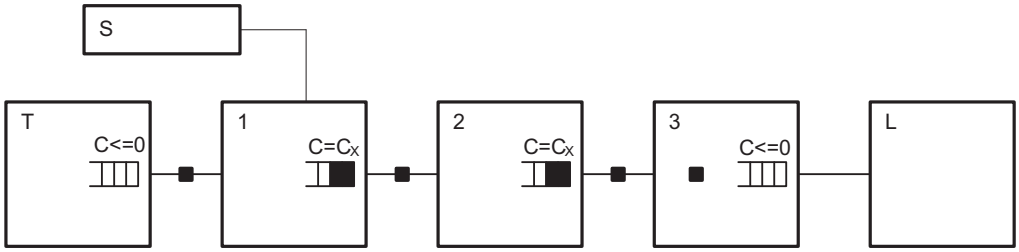


Figure L-11—Building up buffer occupancy—4

It may, therefore, be considered desirable for all Bridges to reserve a little bit more bandwidth than the actual total reserved by the Talkers, so that this "permanent" buffer build-up can drain away. However, this would not make the problem significantly better on the timescales of the output queuing delay, so it does not factor into those calculations, and, of course, this additional capacity would increase the queuing delay at each hop.

NOTE—Many applications have media clocks that are asynchronous to the free-running clock used to determine class measurement intervals. As the two clocks could be operating at the extremes of their permissible variation, it is necessary to reserve more bandwidth than is nominally needed in order to account for the potential difference in clock rate.

Since this kind of event could happen on multiple input ports at the same time, the "permanently buffered" data equals the worst-case fan-in data.

L.3.2 Maximum interference delay and maximum buffer requirement

As discussed in L.3.1, the worst-case interference delay for SR class X on a given Port is the sum of the following three parts:

a) $qDelay_X$ [see Equation (L-35) in L.3.1.1]
b) The fan-in delay (see L.3.1.2)
c) The "permanent" buffer contents contribution (see L.3.1.3), which is equal to the worst-case fan-in delay

The buffering requirements for SR class X consist of the following three components:

d) A contribution from the queuing delay, equal to $maxBurst_X$
e) The fan-in burst data size, computed as described in L.3.1.2
f) The "permanent" buffer contents, which is equal to the fan-in burst data size

The fan-in burst size and the permanent buffer contents do not count twice; if a fan-in burst happens, then it becomes the permanent buffer contents. If it happens a second time, it can only happen after a pause that has allowed the permanent buffer loading to drain. So the worst-case buffering requirement for SR class X is simply the sum of the first two elements, $maxBurst_X$ [Equation (L-42)] and fan-in burst data size; therefore,

$$maxBuffering_X = maxBurst_X + (\text{fan-in burst data size})_X \quad \text{(L-45)}$$

The worst-case total buffering requirement for all of the SR classes on a given Port is the sum of the following two parts:

g) The worst-case buffering requirement for the lowest priority SR class on that Port
h) One max-size frame $M_{i,Z}$ for each class Z of higher priority than Class X for each input port i

Since the worst-case buffer requirement for Class X is when it is taking almost all of the bandwidth from the higher-priority classes, the SR priority levels can share buffering space. The only additional requirement is for the fan-in from higher priorities on other Ports. Thus, the SR classes would do well to share their buffer space on each Port.

L.4 Operation of credit-based shaper in Coordinated Shared Network (CSN)

A CSN is a contention-free, QoS-capable, time division multiplexed access network. One of the nodes of the network acts as the Network Coordinator (NC) node granting transmission opportunities to the other nodes of the network. The NC node also acts as the QoS manager of the network.

From the perspective of the specification of the credit-based shaper, a CSN is equivalent to a distributed Bridge. Rather than shaping the AV traffic in the egress nodes, which could lack the buffering resources to do so, the shaping could instead be performed by the CSN's NC per Class of Service when it schedules transmissions opportunities from the CSN's ingress to the CSN egress nodes. The behavior of CSN's egress to another MAC technology should be consistent with the behavior specified in this standard, regardless of how the shaper is implemented.

Annex M

(normative)

Support for PFC in link layers without MAC Control

M.1 Overview

Priority-based Flow Control (PFC) is a function defined for only point-to-point full-duplex links in terms of the M_CONTROL primitives (11.4 of IEEE Std 802.1AC-2016 [B8]). For IEEE 802.3 link layers the M_CONTROL primitives are mapped into the MAC Control MA_CONTROL primitives (IEEE Std 802.1AC), that use the PDU format defined in IEEE Std 802.3. Other link layers supporting point-to-point full-duplex operations need to define their mapping of the M_CONTROL primitives. This annex describes a PDU format suitable to support PFC.

M.2 PFC PDU format

Figure M-1 shows a PDU format suitable to support PFC.

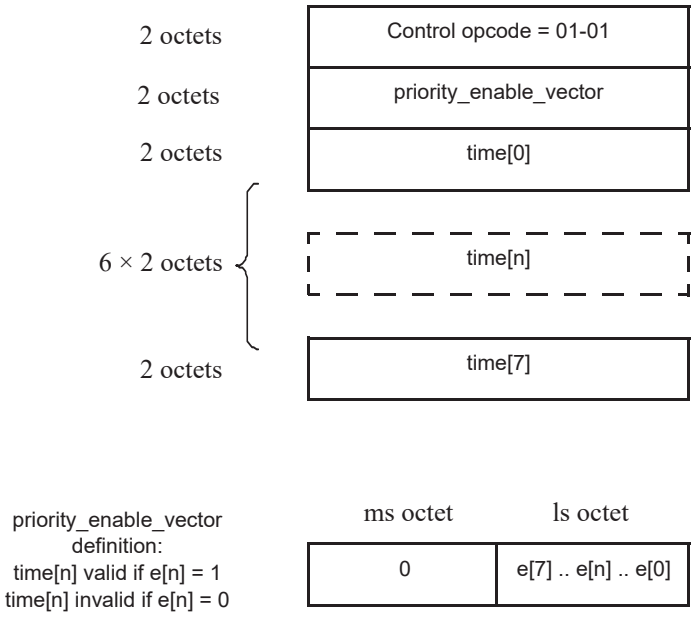


Figure M-1—PFC PDU format

The Control opcode field contains a 2-octet operation code indicating the Control function.

The remaining fields contain the parameters defined in 36.1.2.

Annex N

(informative)

Buffer requirements for PFC

N.1 Overview

To ensure that data frames are not lost due to lack of receive buffer space, receivers must ensure that a PFC M_CONTROL.request primitive is invoked while there is sufficient receive buffer to absorb the data that can continue to be received during the time needed by the remote system to react to the PFC operation. The precise calculation of this buffer requirement is highly implementation dependent. This annex provides an example of how it can be calculated based on a hypothetical delay model. Setting the PFCLinkDelayAllowance (see 12.22.6) to less than the round-trip delay value can result in frames loss.

Figure N-1 provides an high-level view of the various delays to consider:

a) Processing and queuing delay of the PFC request
b) Propagation delay of the PFC frame across the media
c) Response time to the PFC indication at the far end
d) Propagation delay across the media on the return path

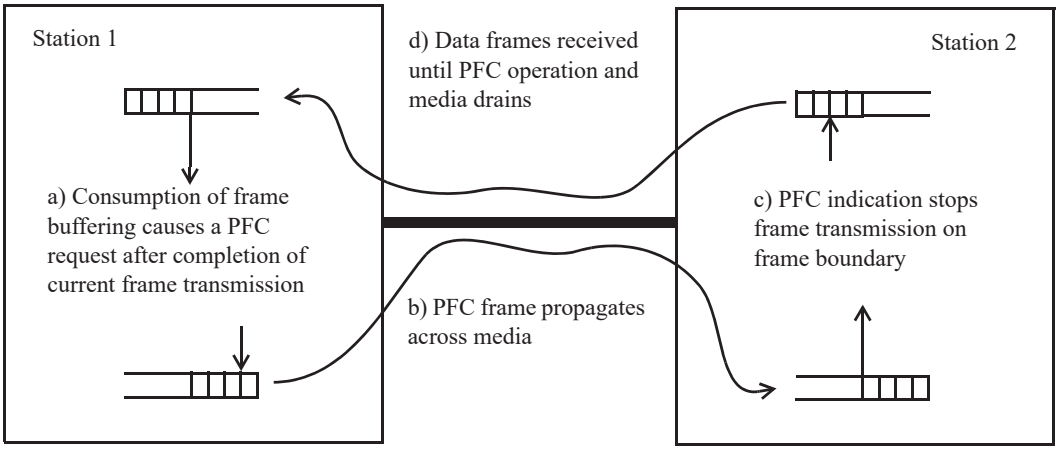


Figure N-1—PFC delays

N.2 Delay model

Figure N-2 shows how to model the various delays between two stations connected by a point-to-point full-duplex IEEE 802.3 link.

The main delay components shown in Figure N-2 are as follows:

a) **PFC transmission delay:** the time needed by a station to request transmission of a PFC frame after a PFC M_CONTROL.request has been invoked (e.g., because a maximum length data frame can be transmitted).
b) **Interface Delay (ID):** the sum of MAC Control, MAC/RS, PCS, PMA, and PMD delays. Interface Delay is dependent on the MAC and physical layer in use.

c) **Cable Delay:** the number of bits in flight stored in the transmission medium. This delay value is dependent on the selected technology and on the medium length.

d) **Higher Layer Delay (HD):** the time needed for a queue to go into paused state after the reception of a PFC M_CONTROL.indication that paused its priority. A substantial portion of this delay component is implementation specific.

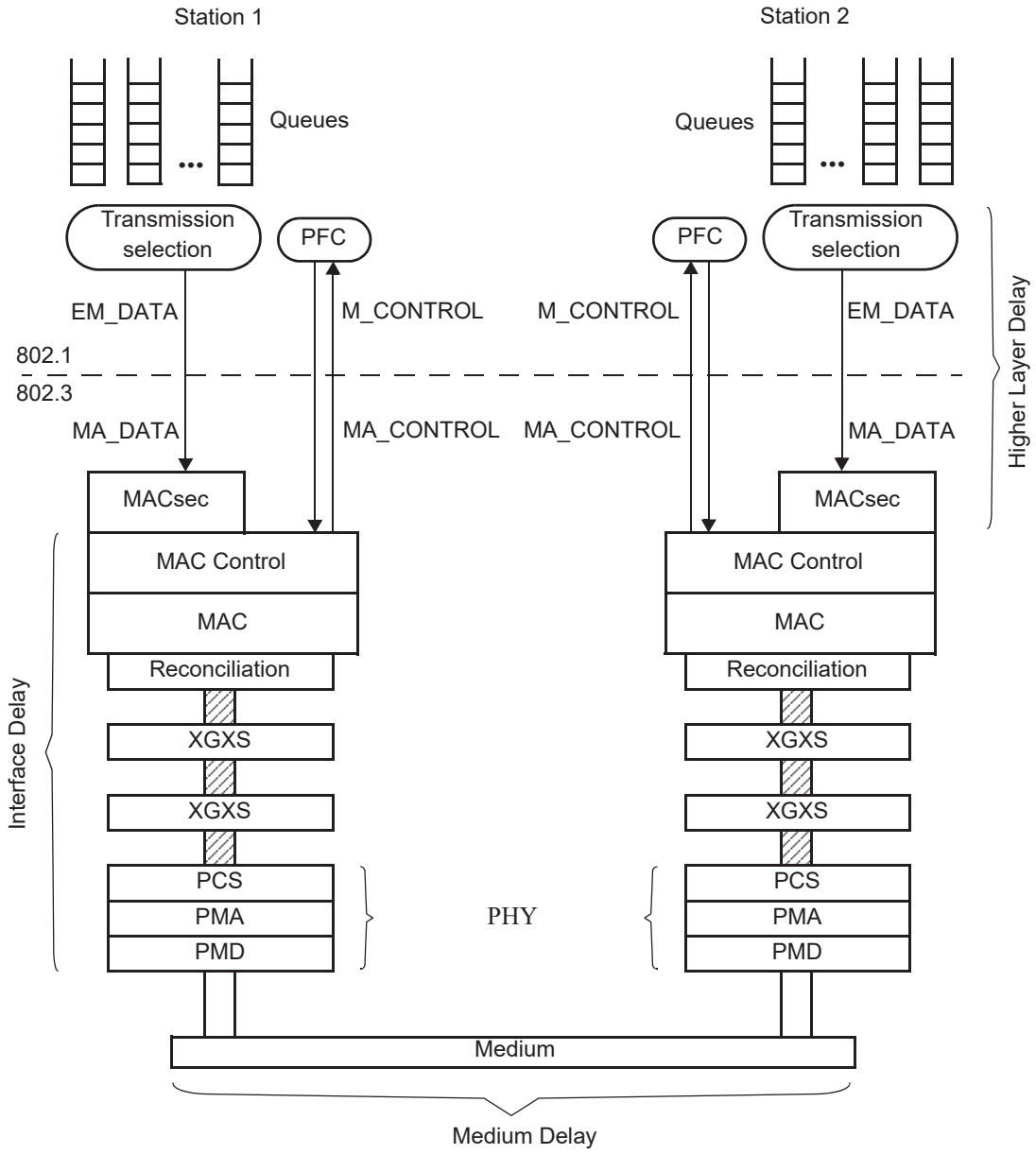


Figure N-2—Delay model

Figure N-3 shows a possible worst-case delay example.

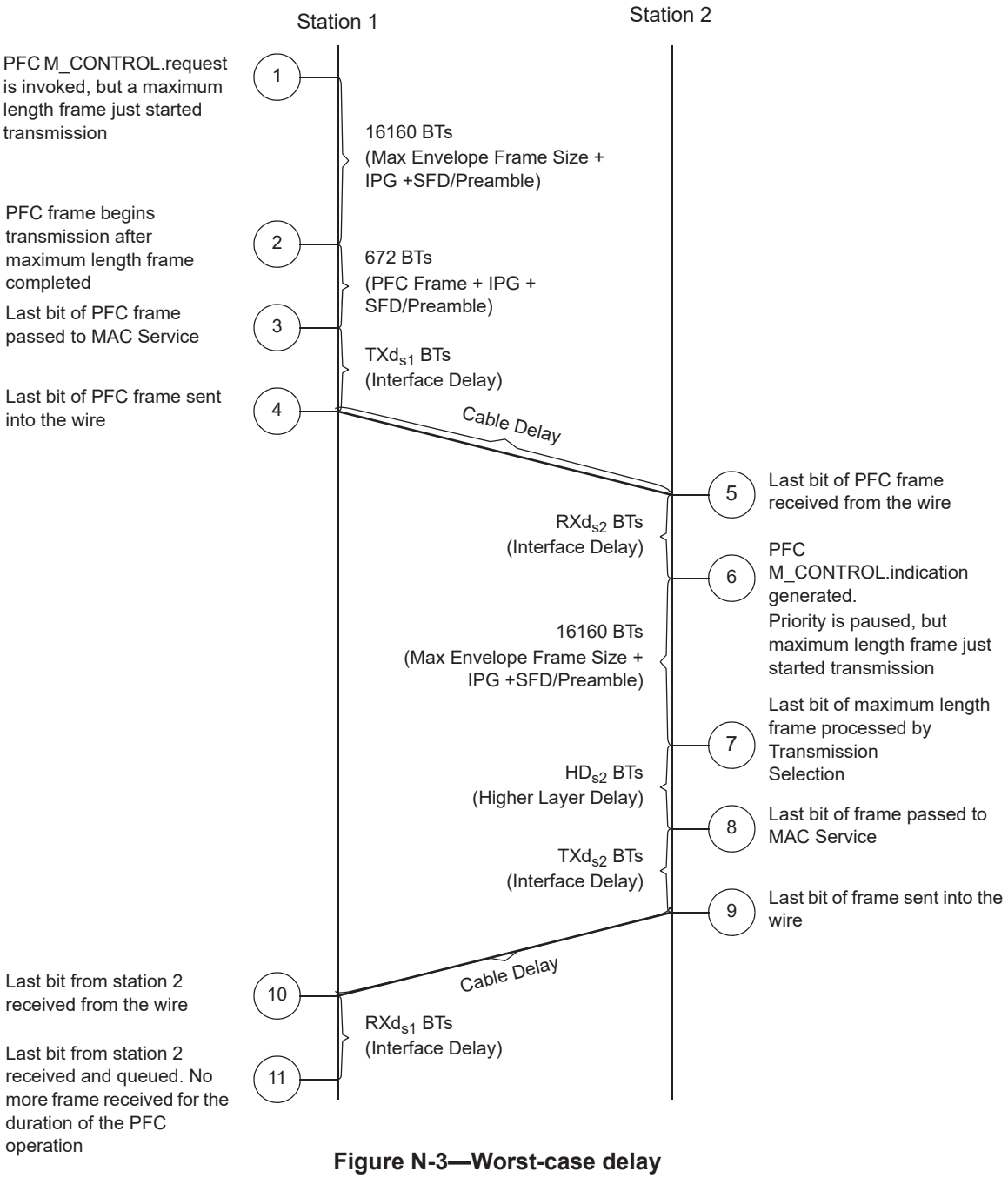


Figure N-3—Worst-case delay

The total Delay Value (DV) is the sum of all delays shown in Figure N-3:

$$DV = 2 \times (\text{Max Frame}) + (\text{PFC Frame}) + 2 \times (\text{Cable Delay}) + TXd_{s1} + RXd_{s2} + HD_{s2} + TXd_{s2} + RXd_{s1}$$

For any given station the Interface Delay includes both transmit and receive paths (i.e., ID = TXd + RXd). Therefore:

$$DV = 2 \times (\text{Max Frame}) + (\text{PFC Frame}) + 2 \times (\text{Cable Delay}) + ID_{s1} + ID_{s2} + HD_{s2}$$

Usually the peer stations connected by a point-to-point link use the same technology, therefore $ID_{s1} = ID_{s2}$:

$$DV = 2 \times (\text{Max Frame}) + (\text{PFC Frame}) + 2 \times (\text{Cable Delay}) + 2 \times ID + HD_{s2}$$

N.3 Interface Delay

The Interface Delay comprises all delay components below the MAC Control Client, excluding the cable delay. Table N-1 shows the Interface Delay constraints for some IEEE 802.3 interfaces.

Table N-1—IEEE 802.3 Interface Delays

Sublayer	Maximum RTT (bit times)	Maximum RTT (pause quanta)	Reference (subclause of IEEE Std 802.3-2018 [B13])
10G MAC Control, MAC, and RS	8192	16	46.1.4
XGXS and XAUI	2048	4	48.5
10GBASE-X PCS	2048	4	49.2.15
10GBASE-R PCS	3584	7	50.3.7
LX4 PMD	512	1	53.2
CX4 PMD	512	1	54.3
Serial PMA and PMD	512	1	52.2
10GBASE-T	25 600	50	55.11

N.4 Cable Delay

The Cable Delay is the propagation delay over the transmission medium and can be approximated by the following equation:

$$\text{Cable Delay} = \text{Medium Length} \times \frac{1}{BT \times \upsilon}$$

where υ is the signal propagation speed in the medium and *BT* is the bit time of the medium.

N.5 Higher Layer Delay

The Higher Layer Delay comprises the delay components between the MAC Control Client and the port Transmission Selection. Example of these delays are MACsec and implementation specific delays.

For link speeds of up to 10Gb/s, MACsec constrains each of the transmit delay and the receive delay to a maximum of 19 360 bit times (see 36.1.3.3).

This standard constrains the implementation specific delays to be less that 614.4 ns (see 36.1.3.3). This delay is equivalent to 6144 bit times at the speed of 10Gb/s.

N.6 Computation example

A station needs to be capable of buffering DV bit times of data to ensure no frame loss due to congestion. The worst case is with a 10GBASE-T PHY. Assuming MACsec is not supported, this results in the following:

— Maximum envelope frame size: 2000 octets, 16 160 bit times;
— PFC frame size: 64 octets, 672 bit times;
— XGMII MAC/RS and XAUI interface: 8192 + 2 × 2048 = 12 288 bit times;
— 10GBASE-T Delay: 25 600 bit times;
— 100 meters Cat6 cable: 5556 bit times (computed assuming $\upsilon = 0.6 \times c$, where c is the speed of the light in meters per second);
— HD = 6144.

The total Delay Value in this scenario results as follows:

$$DV = 2 \times (\text{Max Frame}) + (\text{PFC Frame}) + 2 \times (\text{Cable Delay}) + 2 \times ID + HD_{s2}$$

$$DV = 2 \times (16\,160) + (672) + 2 \times (5556) + 2 \times (25\,600) + 2 \times (12\,288) + 6144 = 126\,024 \text{ bit times}$$

For this case, the amount of buffering needed to ensure no frame loss due to congestion results to be 126 024 bit times, roughly equivalent to 15.5 kB.

If MACsec is used, the High Layer Delay is incremented by 19 360 bit times; therefore, the total Delay Value results as follows:

$$DV = 2 \times (16\,160) + (672) + 2 \times (5556) + 2 \times (25\,600) + 2 \times (12\,288) + 25\,504 = 145\,384 \text{ bit times}$$

For this case, the amount of buffering needed to ensure no frame loss due to congestion results to be 145 384 bit times, roughly equivalent to 18 kB.

Annex O

(informative)

Preserving the integrity of FCS fields in MAC Bridges

O.1 Background

When relaying frames between Ports of a MAC Bridge, one of the functions of the Bridge is to regenerate the FCS field in accordance with the MAC procedures that apply to the medium access method through which the frame will be relayed. One of the requirements of the MAC Bridge standard is that any such regeneration of the FCS shall not increase the level of undetected FCS errors that are experienced on the transmitting MAC over that which would be experienced by preserving the FCS. The point at issue here is only the *undetected* error rate; a conformant Bridge will discard frames that are received with an FCS error; however, there is a finite possibility of undetectable corruption taking place, i.e., the frame is corrupted, but the FCS algorithm does not reveal the error.

This annex looks at the various cases that apply to the operation of the MAC Bridge with respect to FCS regeneration and the alternative approaches that can be taken in order to address the cases. The following cases need to be considered:

a) The source and destination media access methods are identical from the point of view of the operation of the FCS algorithm.

NOTE—This is the case, for example, where the source and destination media access methods are identical. It could also happen with dissimilar media access methods if the FCS coverage, the FCS algorithm, the definitions of the fields covered by the FCS, and the bit/octet ordering are the same in both media access methods.

b) The source and destination media access methods differ from the point of view of the operation of the FCS algorithm.
c) The data covered by the FCS is not modified by the operation of the relay function of the Bridge.
d) The data covered by the FCS is modified by the operation of the relay function of the Bridge.

In each case, it is important to ensure that there is a low probability of additional undetected errors being generated by corruption of the data portion of the frame between removal of the old FCS and computation of the new one, which would result in the transmitted frame carrying invalid data and a valid FCS. Such corruption might occur, for example, as a result of the effect of environmental noise on the operation of the Bridge hardware.

If both item a) and item c) are true, then the FCS carried in the received frame is still valid, and the ideal approach would be to reuse this value as the FCS for the transmitted frame.

If either item b) or item d) are true, then it will be necessary for the Bridge to recalculate the FCS on transmission, and may therefore need to take additional precautions against in-memory corruption causing increased undetected FCS error levels.

O.2 Basic mathematical ideas behind CRC and FCS

The standard CRC algorithm is based on the following ideas:

a) An n-bit message is regarded as a polynomial, M(x), of degree n – 1.
b) In order to generate a CRC value of length r bits, a generator polynomial, G(x), is used, of degree r
c) The value of the last r bits of M(x) are chosen such that M(x) ÷ G(x) has a remainder of 0 [i.e., M(x) = 0 mod G(x)].

Messages can be added, in which each coefficient is 0 or 1:

d) M3(x) = M1(x) + M2(x). Messages are added together by bit-wise addition (XOR) of coefficients with the same bit position (i.e., coefficients with the same exponent).

Subtraction of messages:

e) Addition and subtraction are equivalent operations (as A = A XOR B XOR B); hence, using the messages in item d) above, M1(x) can be regenerated from M3(x) by adding M2(x).

Linearity:

f) If M(x) = 0 mod G(X), then (M(x) + E(x)) = 0 mod G(x) IFF E(x) = 0 mod G(x). In other words, if an error pattern, E(x), is added to a message, M(x), then the resultant message will give no remainder when divided by the generator polynomial if both M(x) and E(x) gave no remainder when divided by the generator polynomial.
g) x^mM(x) = 0 mod G(x) IFF M(x) = 0 mod G(x). A message can be shifted by adding zero padding without affecting the integrity of the CRC.
h) Thus, the CRC algorithm has the property that it will detect any burst error, of length r bits or less, applied to the message, as such an error must result in a nonzero remainder when the message is divided by the generator polynomial. Alternatively, adding two messages together, both of which have valid CRCs, results in a message with a valid CRC.

In Ethernet, the algorithm used differs from the standard CRC, and is known as an FCS. The FCS is based on the CRC but with the following differences:

— The first 32 bits of M(x) are complemented before the FCS value is calculated.
— A CRC value is calculated, as described above, by dividing the first n – 32 bits of M(x) by G(x) and taking the remainder as the CRC value.
— The CRC value is complemented and inserted as the last 32 bits of M(x).

By application of the addition and linearity rules, item d) and item f) above, the Ethernet frame with its FCS can be viewed as consisting of the following component messages, added together:

— An n-bit message, M(x), carrying a standard CRC as the last 32 bits.
— An n-bit “FCS adjustment factor,” An(x), which adjusts the CRC to form an FCS.

Figure O-1 illustrates the conversion of a message with a CRC to the equivalent message with an FCS, by the addition of the adjustment factor. The adjustment factor consists of the following two components:

— The first component, when added to M(x), contributes an adjustment to the CRC, which is equivalent to the effect of complementing the first 32 bits of M(x) before calculating the CRC bits, and complements the first 32 bits of M(x).
— The second component, when added to the partially adjusted M(x), restores the first 32 bits of M(x) to their original value, and complements the (adjusted) CRC to form the final FCS.

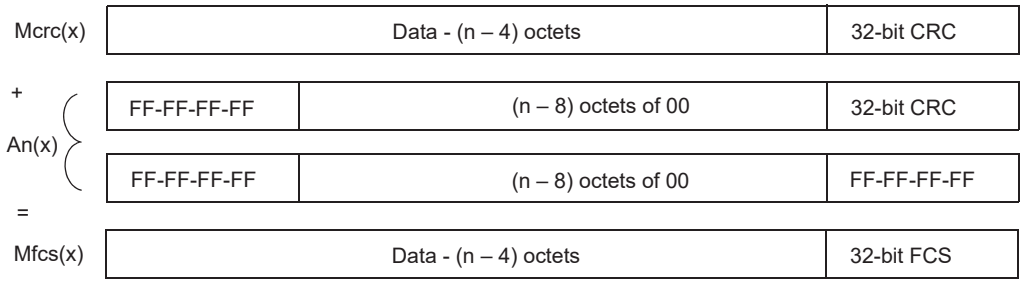


Figure O-1—Converting a CRC to an FCS

O.3 Detection Lossless Circuit approach

This approach is illustrated in Figure O-2. The basis of this approach is that the FCS used in the modified message is always recomputed from scratch using the normal FCS generation algorithm (Check Generator B); however, the original message data and FCS are also used as an input to an FCS checker (Checker A) in order to check that the inputs to the FCS generator were correct. Hence, if errors are introduced into the message while it is in memory in the Bridge in the time period since the message was received and FCS-checked, then Checker A will detect the error at the same time as the new FCS for the modified message is being generated.

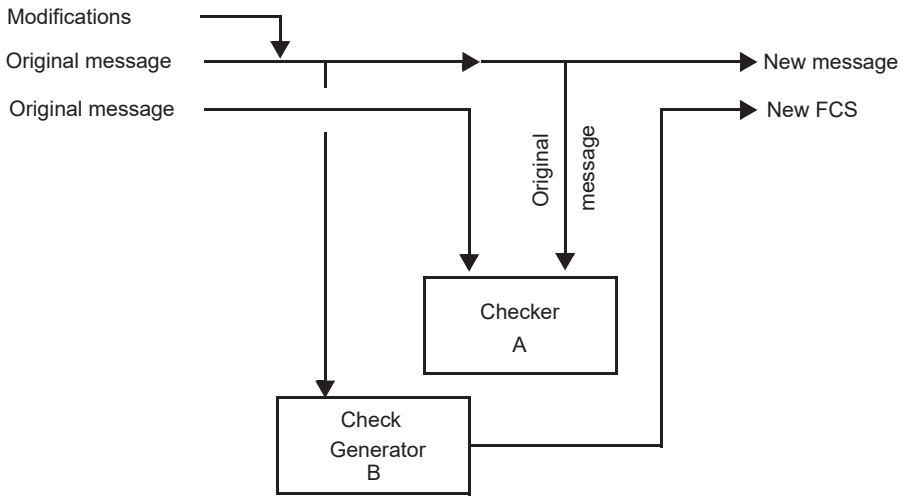


Figure O-2—Detection Lossless Circuit

Checker A is fed both with the original message in its unmodified form, and with the original message as used in the construction of the new message; this occurs after (or simultaneously with) the generation of the new FCS by Check Generator B. Any discrepancies detected by Checker A indicate that the information used to generate the new message and its FCS are suspect, and that the message should therefore be discarded.

O.4 Algorithmic modification of an FCS

In cases where the need to recalculate the FCS comes about as a result of changes to the data rather than by changes in the operation of the FCS algorithm, one option, rather than recalculating an FCS from scratch for a given message, is to examine the changes that have been made to the message and to calculate an FCS adjustment factor that reflects those changes. There are two cases, as follows:

a) The overall length of the message is unchanged, but the contents of one or more octets of data covered by the FCS have changed.
b) The overall length of the message has increased or decreased, as a result of the addition or removal of octets covered by the FCS, but the contents of the original octets is unchanged (although some may have been shifted in position as a result of the insertion/deletion).

O.4.1 Data changed, length unchanged

Adjustment of a message, $MF_1(x)$, in order to change the value of a field F from current value F_1 to new value F_2 consists of the following steps:

— Remove the FCS adjustment factor for a message of length n, An(x).
— Remove the contribution to the message and its FCS provided by the current value of the field, $F_1(x)$.
— Add the contribution to the message and its FCS provided by the new value of the field, $F_2(x)$.
— Add the FCS adjustment factor for a message of length n, An(x).

In other words,

$$MF_2(x) = MF_1(x) – An(x) – F_1(x) + F_2(x) + An(x)$$

The addition and subtraction of An(x) cancel each other out, so,

$$MF_2(x) = MF_1(x) – F_1(x) + F_2(x)$$

Also, the correction factors $F_1(x)$ and $F_2(x)$ can be replaced by a single factor, $F_3(x)$, which is the contribution to M(x) and its FCS that would be provided by the value of Field F that would be produced by F_1 XOR F_2. So,

$$MF_2(x) = MF_1(x) + F_3(x)$$

This is shown in Figure O-3.

Alternatively,

$$\text{FCS of } MF_2(x) = (\text{FCS of } MF_1(x)) + \text{adjustment}$$

where

$$\text{Adjustment} = (\text{FCS of } F_1(x)) + (\text{FCS of } F_2(x))$$

or equivalently,

$$\text{FCS of } MF_2(x) = (\text{FCS of } MF_1(x)) + (\text{FCS of } F_3(x))$$

The adjustment factor (FCS of $F_3(x)$) is incidentally the same factor that would be used if the value of F were to be changed back from F_2 to F_1.

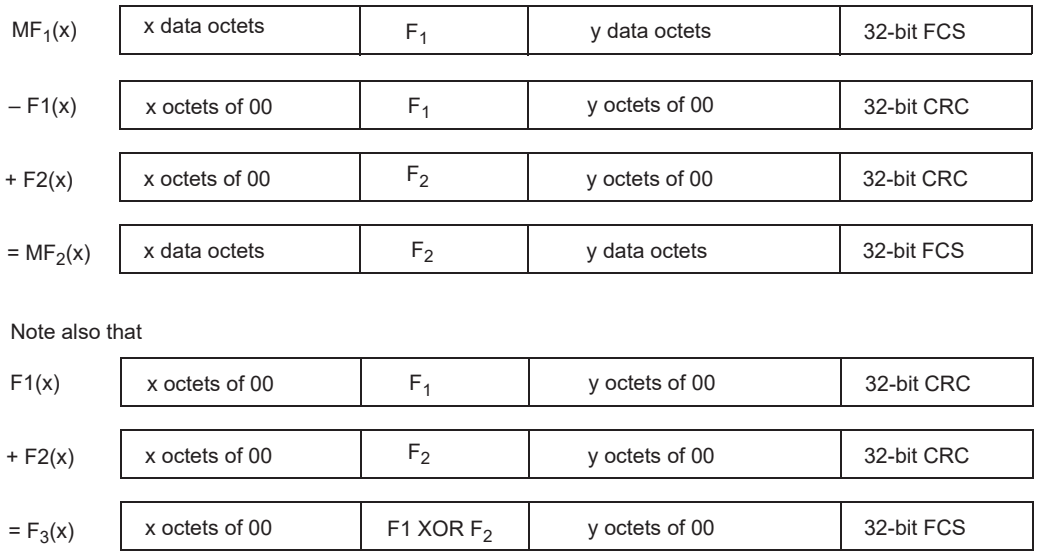


Figure O-3—Field change adjustment

The relative simplicity of this case (relative to the case where the length changes) is a consequence of linearity and the fact that the FCS adjustment factor, An(x), is constant for any given message length n, not a function of the data carried in the message.

O.4.2 Length changed, original data unchanged

Adjustment of a message M(x) of length n to cater for an inserted field, I, of length i involves the following steps:

- Remove the FCS adjustment factor for a message of length n, An(x);
- Remove the contribution to the message and FCS that is provided by the header portion of the message (the portion before the inserted field), H(x);
- Add the contribution to the message and FCS that is provided by the header plus the inserted field I, HI(x);
- Add the FCS adjustment factor for a message of length n+i, An+i(x).

So,

$$MI(x) = M(x) – An(x) – H(x) + HI(x) + An+i(x)$$

This is shown in Figure O-4.

Alternatively,

$$\text{FCS of } MI(x) = (\text{FCS of } M(x)) + \text{adjustment}$$

where

$$\text{adjustment} = (\text{CRC of } An(x)) + (\text{CRC of } H(x)) + (\text{CRC of } HI(x)) + (\text{CRC of } (An+i(x))$$

As with the field change example, the value of *adjustment* is the same adjustment factor that would be used to adjust the FCS of MI(x) if field I were to be removed from the message.

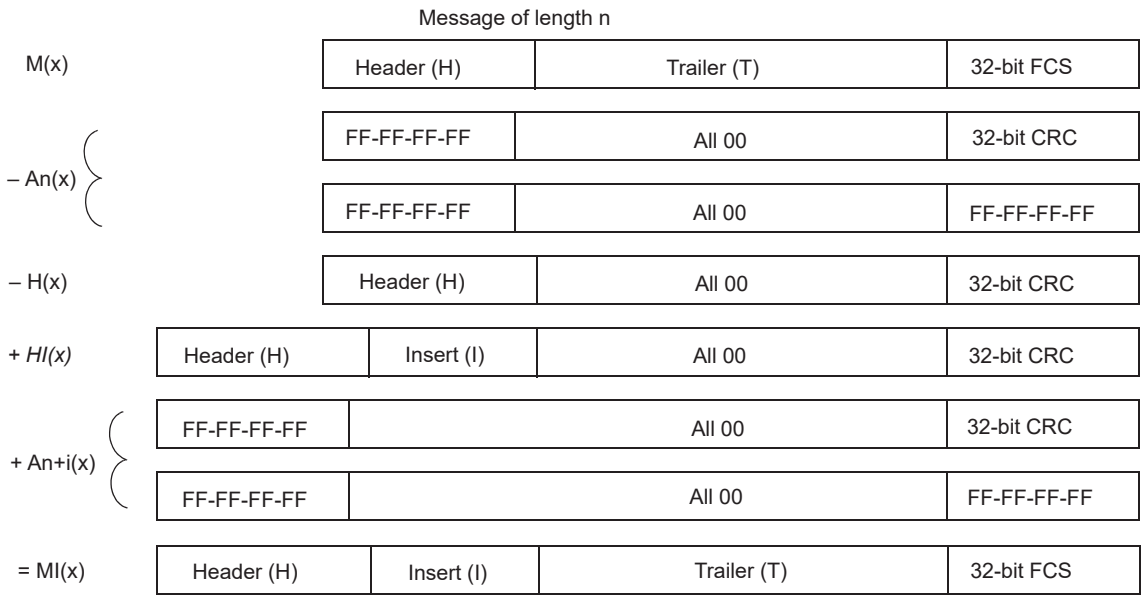


Figure O-4—Field insertion adjustment

O.4.3 Preservation of detectability

With either of the algorithmic adjustment methods described here, the important question is whether the ability of the FCS to detect errors in the message is preserved across these transformations; in other words, if a detectable error pattern, E(x), is added to the message M(x) before the modification, addition, or removal of a field, is that error still detectable after the message has been adjusted.

NOTE—The following analysis assumes that E(x) is a detectable error pattern, of length 32 bits or less. Analysis of the performance of this method with longer error patterns has not been attempted here.

In the cases where the error component is in those parts of the message that are not affected (changed or shifted) by the transformation, it is reasonably apparent that, as the transformation takes no account of the portion of the message that is in error, the detectability of that error is unchanged.

In the case of a field change, where field F_1 is to be replaced with F_2, and E(x) had been applied in some part of the message before changing the field, the new FCS value would be calculated as follows:

$$\text{FCS of } MF_2(x) = (\text{FCS of } MF_1(x)) + (\text{FCS of } F_1(x)) + (\text{FCS of } F_2(x))$$

However, the correction factor that is applied to the FCS contains components based only on F_1 and F_2, and no contribution related to the error pattern E(x). Therefore, after the value of the field has been changed to F_2, the new FCS value as calculated above will still be capable of detecting error pattern E(x), regardless of where the error pattern appears in the message.

In the case of a field insertion (or removal, as insertion and removal have already been shown to be equivalent), where E(x) has been applied to H(x), the correction factor that is applied to the FCS will contain two components related to E(x); the first based on E(x) in its original position, and the second based on E(x) shifted by i, the length of the inserted field, as follows:

$$\text{FCS of } MI(x) = (\text{FCS of } M(x)) + \text{adjustment}$$

where

adjustment = (CRC of An(x)) + (CRC of H(x)) + (CRC of HI(x)) + (CRC of (An+i(x))
+ (CRC of E(x)) + (CRC of (E(x) shifted by i))

The presence of the (CRC of E(x)) component ensures that the final message will still indicate an FCS error. (Note that, even if (CRC of E(x)) and (CRC of (E(x) shifted by i)) turn out to be the same value, the final message will still indicate an FCS error, as its FCS is now correct for the value of MI(x) without the error component.)

The above does not exhaustively analyze all the cases of field insertion and removal, and in particular, does not analyze the cases where the error pattern crosses the insertion/removal boundaries; however, it can be shown that the error detection characteristics of the FCS are preserved in these cases as well.

The conclusion from the above examples is that, as long as the field values used in the calculation of these FCS correction factors are the same as the field values present in the original and final messages (e.g., that the same value of H+E is used both in its original and shifted forms), then the properties of the FCS are preserved. However, if different values are used for calculation of the correction factor from those present in the messages (as could happen, for example, as a result of in-memory corruption), then the properties of the FCS are no longer preserved. Hence, if these algorithmic approaches are used, it is necessary to design the implementation in a manner that ensures that these conditions are met.

O.5 Conclusions

Where it is necessary to recalculate the FCS before transmission, then either the algorithmic FCS modification approaches or the Detection Lossless Circuit approach offer a basis for this to be achieved while still preserving the error detection coverage that was provided by the original FCS.

The Detection Lossless Circuit approach requires access to the entire contents of the original message, to compute the necessary FCS adjustments or to check the integrity of the data that is being used to create the new message and its FCS. In contrast, the algorithmic approach requires access only to the header, insert, and FCS of the original message.

With the algorithmic approach, care needs to be taken in the implementation in order to ensure that the inputs to the correction algorithms are consistent with the contents of the original and modified messages, whereas in the Detection Lossless Circuit, such consistency checking is inherent in the way that the original FCS is used to check the generation of the new FCS.

Annex P

(informative)

Frame duplication and misordering

Although RSTP provides a single loop-free path between communicating stations at any instant, RSTP can reconfigure the active topology of the Bridged Network in less time than it can take a frame to transit from its source to its destination(s). This annex explains how this can result in user data frame duplication and misordering and examines the possible QoS impact.

NOTE—The ForceVersion parameter provided by RSTP allows network administrators to choose slower reconfiguration, thereby trading off service availability against the risk of duplication and misordering.

P.1 Background

In a network of Bridges implementing STP, specified in the 1998 and earlier editions of IEEE Std 802.1D [B11], delays in transitioning Ports to Forwarding ensure that frames in transit prior to a network reconfiguration are delivered or discarded before being forwarded on the new active topology. In such a network, the only source of misordered or duplicated frames is a “magically healed” LAN between two Bridges, for example, as a result of accidental interconnections between shared media hubs.

RSTP, by design, can transition a Port to Forwarding very rapidly. A Root Port transition can occur as rapidly as the hardware can manage it, and a Designated Port transition in the time it takes to transmit two frames from separate stations on a single LAN. It is conceivable that a reconfiguration can take place, and a Port be made Forwarding as a result, while frames forwarded on the prior active topology are still in transit.

P.2 Frame duplication

A unicast frame whose destination address has been learned by the Bridges that can forward it, can only be buffered for transmission on one Port of one Bridge at any one time, and cannot be duplicated.

A unicast frame whose destination address has not been learned, can be flooded by some Bridges, and therefore buffered on multiple outbound Ports at the same time, and can be duplicated during network reconfiguration. Figure P-1 provides an example. In this network fragment, the Root Bridge is assumed to be somewhere to the left of Bridge A’s Port A1, and the Port Path Costs of the three Bridges result in the active topology shown, with Port B3 Discarding and the remaining Ports all Forwarding.

If the configuration is stable, a unicast frame arriving at A1 and destined for an unlearned unicast destination reachable through B2 is flooded by Bridge A to its Ports A2 and A3, and by Bridge C to its Ports C2 and C3. As B3 is Discarding, only the frame reaching B1 is transmitted through B2, and the destination receives a single copy of the frame.

During reconfiguration the following sequence of events can occur:

a) A receives the frame through A1 and transmits copies of it through A2 and A3.
b) B and C each receive a copy and queue them for transmission through B2, C2, and C3.
c) B2 transmits its copy of the frame to its destination.
d) B detects that LAN A2-B1 has failed, and immediately makes B3 Forwarding as its new Root Port.
e) C2 transmits its copy of the frame, B receives and transmits this second copy through B2.

The destination station, reachable through B2, receives the same frame twice. However, any subsequent response from the destination station would cause the address to be learned. While this reconfiguration will itself cause addresses to be flushed from the Bridge's FDBs of Bridges, the flushing commences after the Port becomes Forwarding, and will not increase frame duplication unless there are further changes in the active topology.

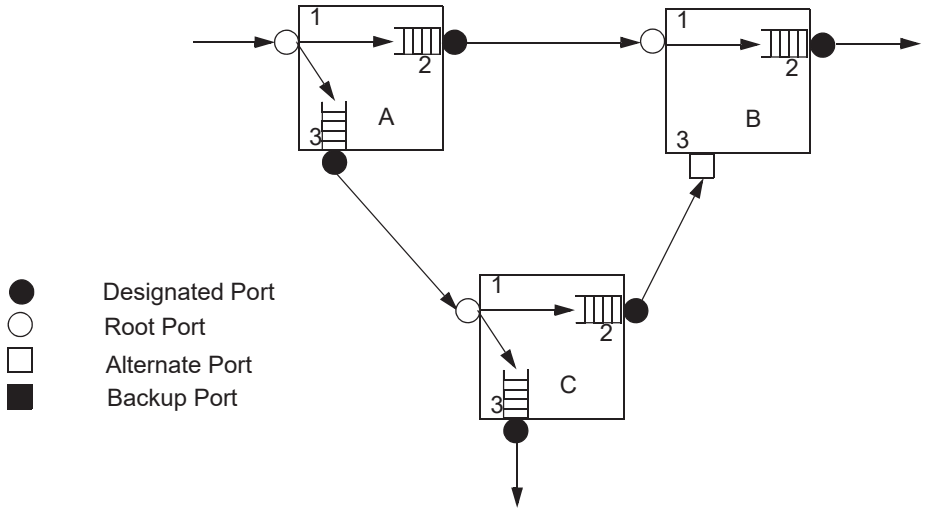


Figure P-1—Frame duplication scenario

Multicast frames are all potentially subject to duplication on reconfiguration events, as they can be buffered at multiple outbound Ports. Frame duplication does not cause problems in known multicast LAN protocols.

The risk of frame duplication depends upon network configuration, frequency of reconfiguration, equipment implementation details, and the characteristics of the network traffic that determine how long each frame is likely to be buffered in each Bridge, and therefore cannot be quantified without reference to the a particular network.

P.3 Frame misordering

A change in the active topology between two communicating end stations can result in frame misordering, as a frame sent after reconfiguration can experience a lower transit delay, being queued at fewer Bridge Ports or for less time. Figure P-2 provides an example. In this network fragment a station connected to A1 is communicating with a station connected to B2. Prior to reconfiguration, A2 is an Alternate Port and is Discarding; all traffic between the two stations is relayed by Bridge C. During reconfiguration the following sequence of events can occur:

a) Frame F1 is received through A1, buffered and transmitted through A3, received through C1 and buffered awaiting transmission through C2.
b) A detects that LAN A3-C1 has failed, and immediately makes A2 Forwarding as its new Root Port.
c) Frame F2 is received through A1, transmitted through A2 to B1, and then transmitted through B2.
d) F1 is transmitted through C2 to B3, and then transmitted through B2.

Clearly, the receiving station connected to B2 sees the frames in the reverse of the order in which the originating station transmitted them.

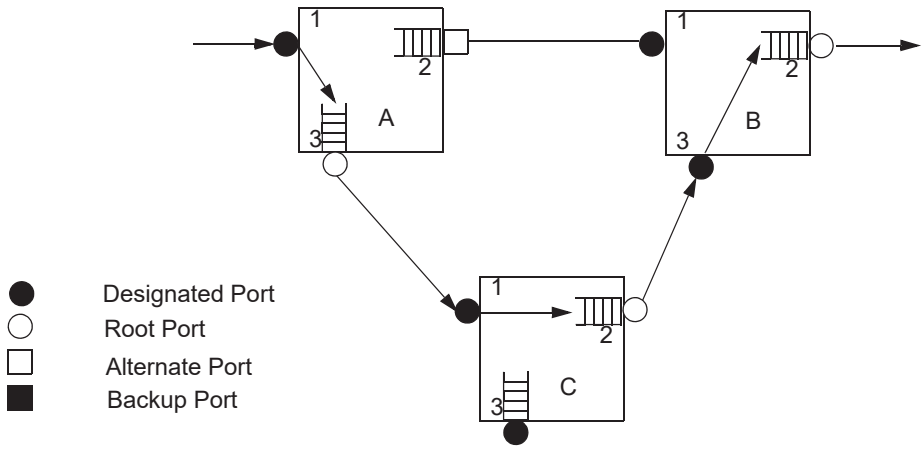


Figure P-2—Frame misordering scenario

As with frame duplication, the overall risk of frame misordering depends upon network configuration, frequency of reconfiguration, equipment implementation details, and the characteristics of the network traffic that determine how long each frame is likely to be buffered in each Bridge, and therefore cannot be quantified without reference to the a particular network.

Some LAN protocols, for example LAT, LLC2, and NETBEUI, are sensitive to misordering, so even a low incidence of misordering could result in perceived problems in networks that support these protocols.

P.4 Other considerations

The possibility that frames may be stored “in transit” on old routes after a reconfiguration has completed means that there is also a possibility that addresses will be mis-learned, leading to a risk of denial of service for the addresses concerned. Hence, it is necessary to run short aging timers for a period after a reconfiguration to allow such frames to be delivered or discarded.

The Bridge model described in this standard does not include the concept of queuing on input to a Port; however, practical Bridge designs generally include some input queuing. While this is not a solution to the effects described above, a Bridge should flush any input queue associated with a Port that becomes Disabled. This behavior is consistent with the Bridge model; if a frame is in an input queue, it has not been received as far as the Bridge Port is concerned, and therefore should not be received after the Port becomes Disabled.

Annex Q

(informative)

Traffic scheduling

This annex provides some background to the mechanisms provided in this standard for traffic scheduling, with the intent of providing some insight into the motivation for the provision of mechanisms for traffic scheduling and some of the ways that the mechanisms might be used.

Q.1 Motivation

Some applications have a need for frame delivery that is highly predictable in terms of the time at which frame transmission will occur, and the overall latency and jitter that will be experienced as the frame is propagated to its destination. Examples include industrial and automotive control applications, where data transmitted over the network is used to feed the parameters of control loops that are critical to the operation of the plant or machinery involved, and where frames carrying control data are transmitted on a repeating time schedule; late delivery of such frames can result in instability, inaccuracy, or failure of the operation of the control loops concerned. In some implementations, this need has been met by the provision of dedicated, highly engineered networks that are used solely for the transmission of time-critical control traffic; however, as the bandwidth occupied by such traffic is often low, and the cost of providing a dedicated control network can be high, it can be desirable to mix time-critical traffic with other classes of traffic in the same network, as long as such mixing can be achieved while still meeting the timing requirements of the time-critical traffic.

Prioritization alone is insufficient to address the needs of this kind of traffic; if a low priority frame is already being transmitted, then that transmission will complete before a higher priority frame can access the transmission medium, so there could be a delay of up to a maximum-sized frame before a high priority transmission can start. If such delays occur at every hop, then the accumulated latency could be unacceptably large.

Interfering traffic can itself be time-critical; for example, there could be multiple time-critical traffic streams related to different control systems. The ability to coordinate different time-critical traffic streams in such a way that they do not interfere with each other is also important.

One approach to meeting these objectives is to ensure that, at specific times, only one traffic class (or set of traffic classes) has access to the network; in effect to create a protected “channel” that is used by that traffic class alone. However, in order to ensure that the remaining unprotected traffic cannot affect the transmission of protected traffic, it is necessary to stop the transmission of unprotected traffic sufficiently far in advance of the protected time slot to be certain that the last unprotected transmission has completed before protected transmission starts. In the worst case, this would mean that the last unprotected transmission would start a maximum-sized frame transmission time before the start of the protected traffic “window.” In effect, a guard band is created before the time that the protected traffic transmission is due to start; transmission of unprotected traffic is not permitted between the start of the guard band and the start of the protected traffic window. The simplest approach is for the guard band to be as long as a maximum-sized frame transmission; however, the start of the guard band need not be fixed if the implementation is able to determine, from the size of the frames that it has queued, that there is sufficient time for a frame to be transmitted in its entirety before the start of the protected traffic window. This approach is illustrated in Figure Q-1. If the simple approach were taken, then the time difference between T0 and T1 would be equal to the transmission time of a maximum-sized frame on that port (Figure Q-1, part A); if the implementation is able to determine frame transmission times on the fly, then T0 could vary between a maximum frame transmission time before T1 and a minimum frame transmission time before T1, depending upon what unprotected frames were available for transmission on the Port (Figure Q-1, part B).

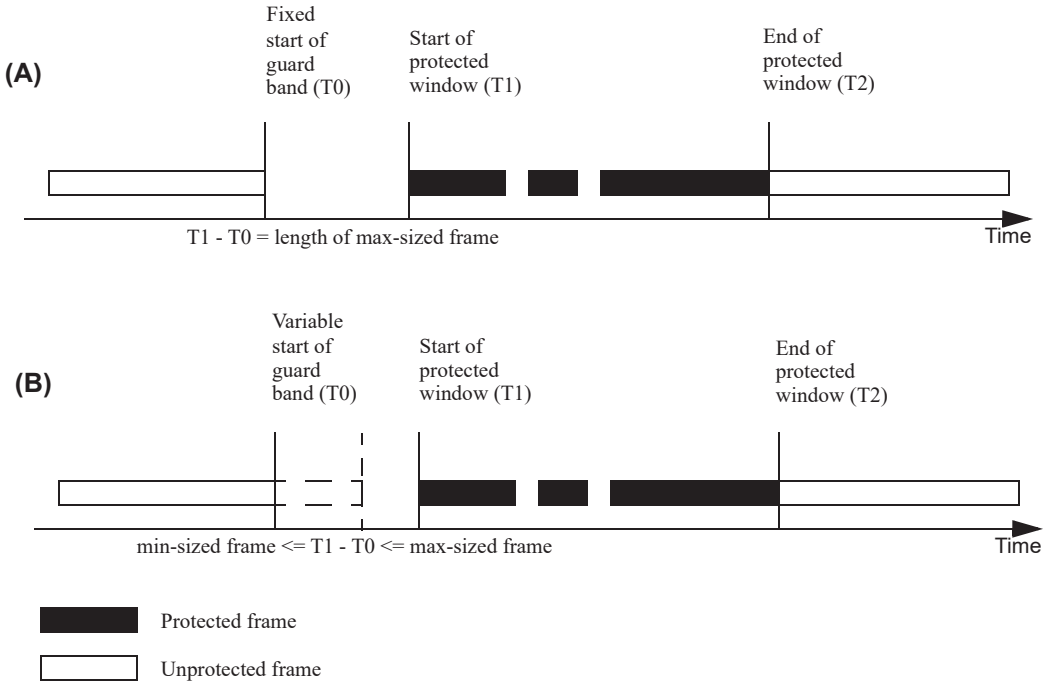


Figure Q-1—Establishing a guard band

Q.2 Using gate operations to create protected windows

The enhancements for scheduled traffic described in 8.6.8.4 allow transmission to be switched on and off on a timed basis for each traffic class that is implemented on a port. This switching is achieved by means of individual on/off transmission gates associated with each traffic class and a list of gate operations that control the gates; an individual SetGateStates operation has a time delay parameter that indicates the delay after the gate operation is executed until the next operation is to occur, and a GateState parameter that defines a vector of up to eight state values (open or closed) that is to be applied to each gate when the operation is executed. The gate operations allow any combination of open/closed states to be defined, and the mechanism makes no assumptions about which traffic classes are being "protected" and which are "unprotected"; any such assumptions are left to the designer of the sequence of gate operations. The sequence of gate operations terminates at the end of the list, and restarts when OperCycleTime (8.6.9.4.19) nanoseconds have elapsed since the start of the sequence, thus providing a repeating cycle of gate state changes. If OperCycleTime is shorter than the total execution time of the sequence of operations, the sequence is truncated and restarted at OperCycleTime.

There is no necessity to explicitly define the start of a guard band, as the specification of how the gates operate states that a frame for a given traffic class can only be transmitted if the gate associated with that traffic class is open and there is sufficient time for the whole of the frame to be transmitted before the gate is due to close. Figure Q-2 illustrates how gate operations could be used to create a protected window for traffic class 3 in order to achieve the result illustrated in Figure Q-1. A SetGateStates operation at time T1 sets the state of the gates for traffic classes 7, 6, 5, 4, 2, 1, and 0 to closed (C) and sets the state of the gate for traffic class 3 to open (o), so only traffic class 3 can transmit after T1. At time T2, the SetGateStates operation reverses the state for all eight traffic classes, so traffic class 3 can no longer transmit after T1, but all other traffic classes can.

There is no need to explicitly define the position of T0, because the "guard band" behavior is inherent in the defined behavior of the gates, as previously stated.

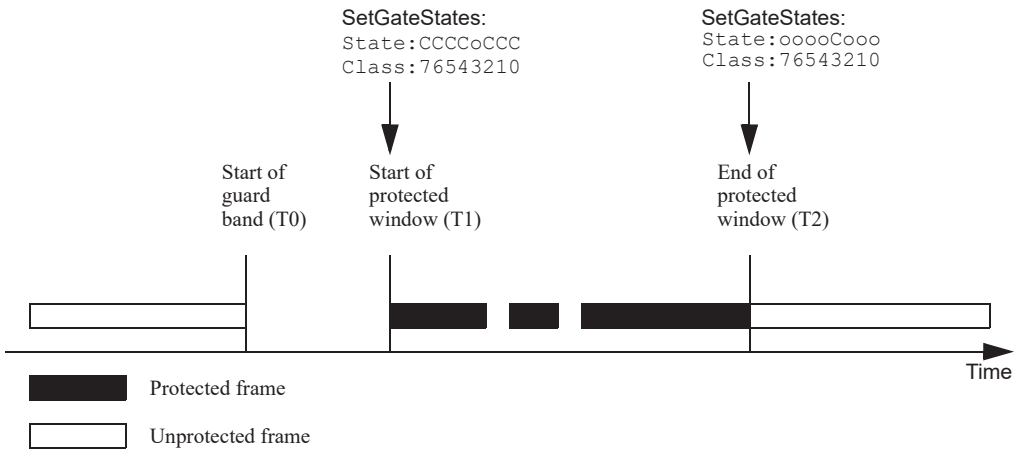


Figure Q-2—Using gate operations

Q.3 Availability of PTP

The timing of gate operations as specified in 8.6.8.4 assumes that PTP is operating and therefore PTP time is available to the Bridge or end station. However, that is clearly not the case on initial startup or when PTP communication is interrupted for some reason; particular implementations could also choose to use alternative (non-PTP) mechanisms for ensuring that a common view of time is available across a number of systems. The approach adopted in these circumstances will be heavily dependent on the application, and so is an implementation choice; the mechanisms described in 8.6.8.4 are not themselves affected by that choice.

Q.4 Scheduled traffic and end stations

It is possible for Bridges to support the enhancements for scheduled traffic while end stations connected to those Bridges do not. In general, the scheduling mechanism is not needed in end stations that are only recipients of scheduled traffic.

Q.5 CycleTimeExtension variables

The AdminCycleTimeExtension (8.6.9.4.4) and OperCycleTimeExtension (8.6.9.4.20) state machine variables provide a means for an operator to control how a new gating cycle is configured into a system that is already running an existing gating cycle.

If the choice of cycle time for the new gating cycle (AdminCycleTime) is unchanged from the cycle time for the old gating cycle (OperCycleTime), and if the base time chosen for the new gating cycle (AdminBaseTime) is an integer multiple of the OperCycleTime different to OperBaseTime, then the new gating cycle will exactly “line up” with the old gating cycle, i.e., the cycle start times for the new gating cycle will be the same as they would have been for the old configuration. This could be considered to be the ideal case and allows the new gating cycle to be installed and executed with no timing issues.

However, if AdminCycleTime differs from OperCycleTime, and/or AdminBaseTime is in the future and is not an integer multiple of OperCycleTime different to OperBaseTime, then the old and new cycles do not line up, and when AdminBaseTime is reached (i.e., when the new configuration is installed and starts to execute), the last old cycle would normally be truncated in order to start the first new cycle. This could be undesirable if it results in a very short last old cycle; arguably it would be better to simply extend the penultimate old cycle by that small amount, rather than starting a very short cycle. The CycleTimeExtension variables allow this extension of the last old cycle to be done in a defined way; if the last complete old cycle would normally end less than OperCycleTimeExtension nanoseconds before the new base time, then the last complete cycle before AdminBaseTime is reached is extended so that it ends at AdminBaseTime.

Annex R

(informative)

Preemption and IEEE 802.1AE MAC Security

This annex answers questions about the use of MAC Security (MACsec) that arose in the development of the IEEE Std 802.1Qbu (Frame Preemption) amendment to this standard. It provides background for readers not familiar with MACsec. For the normative specification of MACsec and its supporting authentication and key management framework refer to IEEE Std 802.1AE and IEEE Std 802.1X.

NOTE—While these issues arose during development of preemption, they can also apply to other situations, such as a customer link running MACsec over a provider bridged network.

Preemption allows one or more higher priority (express) frames to interrupt the transmission of a lower priority (preemptible) frame, the preemptible frame transmission being resumed and completed once the express frame(s) have been transmitted. A preemptible frame can thus be broken into two or more fragments. A MACsec Cipher Suite implementation can protect each frame in its entirety before requesting its transmission, or can transmit the octets of the protected frame as soon as they are made available by the operation of the block by block symmetric cryptography. The latter is often preferred as it reduces the delay due to protection, and some implementations impose a constant delay in support of time-sensitive networking objectives. Similarly validation of a received frame can be delayed until its reception is complete, or can proceed as each block of octets becomes available. These implementation details lie outside the normative scope of IEEE Std 802.1AE, but naturally give rise to questions as to how frames should be protected when they are fragmented, particularly when the symmetric keys used to protect frames are being changed.

Each time a Cipher Suite's symmetric cryptography is used to protect a frame with a given key, a unique value, known as a 'nonce' or IV (initial value), has to be included in the computation. A PN (packet number) that is incremented for each frame transmitted forms part of the MACsec IV. A replayProtect control with a configurable replay window allows the receiver to use the PN to protect against misordered, replayed, and much delayed frames. A frame whose PN value is less than the highest received with a successfully validated frame (from the same source, protected by the same key) minus the replay window size is discarded. Setting the replay window size to zero and enabling replayProtect enforces strict replay protection, no out of order or replayed frames are accepted. The transmitter of each MACsec frame is identified by a Secure Channel Identifier (SCI), and the Secure Channel (SC) that allows it to communicate securely with its peers in a secure Connectivity Association (CA) is supported by a sequence of Secure Associations (SAs). Each SA is replaced by its successor when its associated secret Secure Association Key (SAK) can no longer be used, either because all or most of the PN space has been used with one of the SAs in the CA, or because the network administrator has a security policy that mandates regular key changes (often once a week). New SAs and SAKs are also required after reauthentication and reauthorization, when the (possibly changed) members of a CA acquire a fresh secure Connectivity Association Key (CAK), the shared secret key whose possession permits participation in the CA and that is used by the MAC Security Key Agreement protocol (MKA) to identify the CA members to each other and to distribute SAKs.

MACsec connectivity is not interrupted or delayed by SA and SAK changes. The SCI and the Association Number (AN), a two-bit circular sequence number that identifies the SA within the SC, are communicated by the MAC Security TAG (SecTAG) and form part of the IV. Their values thus have to be decided and encoded in the frame to be transmitted prior to encipherment. The MACsec operational and management models reflect the fact that, at any instant, the frame whose SecTAG is currently being encoded can be using a different SA and SAK than the frame currently being cryptographically processed. This accommodates implementations that buffer user transmit requests for performance or implementation reasons (e.g., to allow parallel processing). A transmit SA/SAK is not deleted until sometime after it has ceased to be used. Similarly an implementation that is enciphering a preemptible frame block by block can suspend its

cryptographic operation, encipher an express frame that has been assigned to a subsequent SA, and resume processing the preempted frame using the IV already encoded, the SAK identified by the SCI and AN for that IV, and the intermediate results produced by the Cipher Suite up to the point that the frame was preempted. The Integrity Check Value (ICV) generated, and appended to the MACsec protected frame, protects the entire frame. An attacker cannot omit a fragment or substitute one for another. The ICV also has exactly the same value that would be obtained by protecting the entire frame prior to transmitting any of its octets, which is important for reasons that go beyond facilitating interoperability between different styles of implementation. While MACsec protects communication between neighboring peer users of the MAC Service, those service instances can be supported by bridging at a lower layer. Communication between two C-VLAN Bridges can be supported by individual LANs connected by TPMRs, or by S-VLAN Bridges, for example. The receiving MAC Security Entity (SecY) that validates a preemptible frame can receive it in fragments that differ from those transmitted by the port and SecY that originally protected the frame, and is not necessarily aware that the received frame was fragmented en-route. The first of two TPMRs supporting a link between two C-VLAN Bridges (for example) might reassemble all received frames prior to forwarding, thus allowing express frames to overtake preemptible frames on the link connecting the TPMRs without fragmenting the latter.

Just as the use of an SA can be overlapped with the use of its successor on transmission, each receive SA and its successor are enabled for reception for 3 seconds after an MKA Key Server tells the other member(s) of the CA to start transmitting using a new SAK and SA(s). Thus the receipt of an express frame protected with a new SAK does not preclude the receipt and validation of a preempted frame, protected with the prior SAK, after its final fragment (including the protected frame's ICV) has been received.

IEEE Std 802.1AE describes the use of MACsec in a number of different systems, interface stacks, and interworking scenarios. When MACsec is used to secure connectivity across a provider network, the protected frame can be priority-tagged (6.13) so the provider can forward frames of different priorities appropriately, even if the contents of those frames is otherwise confidential, and they can be received and validated out of order just as they might be if some frames had been preempted en-route. The receiving SecY's replay window size can be managed to accommodate these frames, though it is not always easy to determine or predict an optimal value for the size of replay window that is needed. MACsec's strict replay protection can also be retained by assigning transmitted frames for different service access priorities (or for express and preemptible frames) to different SCs, each supported by its own sequence of SAs. From the point of view of a receiving SecY, the separate SCs behave just as if they had been transmitted by separate SecYs. IEEE Std 802.1AE allows the choice of SCI and access priority[64] to be determined by the frame's user priority.[65] (See Seaman [B59].)

[64] The priority value accompanying the service request made at the SecY's lower Common Port to transmit the protected frame.
[65] The priority value provided by the service request, to protect and transmit the frame, made at the SecY's upper Controlled Port.

Annex S

(informative)

Preemption and scheduled traffic

The enhancements for scheduled traffic specified in 8.6.8.4 and the support for frame preemption specified in 6.7.2 and 8.6.8 can be used individually or in combination in order to provide different degrees of protection to "time-sensitive traffic" from interference caused by traffic with less stringent timing requirements. The choice of which features to use, and in what combination, will depend upon the latency and jitter requirements of the application concerned. There are four permutations of interest. They are as follows:

a) Scheduling used in isolation (S.1)
b) Preemption used in isolation (S.2)
c) Scheduling and preemption used in combination, but without use of HOLD and RELEASE (S.3)
d) Scheduling and preemption used in combination, with use of HOLD and RELEASE (S.4)

NOTE—As the only MAC standard for preemption at the time this annex was developed was IEEE Std 802.3, it reflects constraints that exist in that particular approach to preemption.

S.1 Scheduling used in isolation

This subject is dealt with in Annex Q.

S.2 Preemption used in isolation

Preemption allows one or more higher priority (express) frames to interrupt the transmission of a lower priority (preemptable) frame, the preemptable frame transmission being resumed and completed once the express frame(s) have been transmitted.

The ability to designate one or more priority as express (and the remaining priorities as preemptable) means that, when an express frame is ready for transmission and a preemptable frame is already in the process of being transmitted, the delay before the express frame transmission starts is at worst 123 octet times and will often be 64 octet times or less. Preemption, used without scheduling, is therefore a useful tool for reducing the jitter experienced by time-sensitive frames. These frames could be transmitted using any of the available transmission selection algorithms (Table 8-6), but the likely choice would be an algorithm that is intended for use with time-sensitive data, such as the credit-based shaper (8.6.8.2). In common use cases, it would be expected that express traffic would have a higher priority than preemptable traffic.

NOTE 1—IEEE Std 802.3 defines a minimum final fragment size of 64 octets and allows the receiver to request that any non-final fragments are larger than this by 0, 64, 128, or 192 octets. Therefore, the minimum non-final fragment size is 64, 128, 192, or 256 octets, depending upon the non-final fragment size stipulated by the receiving MAC. For the purposes of the discussion in this annex, it is assumed that the minimum non-final fragment size selected is 64 octets.

NOTE 2—The 123 octet times worst-case delay is because non-final fragments have to be 64 octets in length, including the mCRC that is added by the MAC Merge sublayer, so a fragment that is 124 (60 + 64) octets in length can be preempted, but a fragment that is 123 or fewer octets in length cannot be preempted. This occurs when transmission has just started for a fragment of a frame with less than 124 octets left to transmit, or for a preemptable frame of less than 124 octets in total. The more likely case is that the delay would be between 0 and 64 octet times. The actual delay experienced also has to take account of the extra overheads imposed by the need for preamble, start of frame delimiter (SFD), inter-frame gap (IFG), and the latency of the MAC itself.

It should be noted that, other things being equal, designating a priority as "express" effectively increases its priority above that of any priority designated as "preemptable". Also, in cases where the number of traffic

classes supported on a port is less than 8, all priority values that map to the same traffic class should have the same designation (all express or all preemptable).

If preemptable and express priorities are assigned to the same traffic class, an express frame might not be able to preempt a preemptable frame that is ahead of it in the queue.

S.3 Scheduling and preemption used in combination, no HOLD/RELEASE

The discussion of scheduling in Annex Q points out that there is no need for an explicitly scheduled "guard band" when using the scheduling mechanism in isolation, because the specification of the operation of the transmission gates is such that, in a conformant implementation, a frame cannot start transmission if the transmission gate for its traffic class is due to close before transmission of the frame would complete. However, the requirement not to transmit a frame if transmission cannot complete before the gate closes means that, depending upon the size of frames in the queue, there would be a significant length of time during which frames cannot be transmitted.

If the schedule that applies to the preemptable traffic classes was designed to allow preemptable traffic to be transmitted at any time (i.e., there is no "gate close" event for the preemptable traffic), then preemptable frame transmission can occur at any time up to the start of an express transmission, and depending upon the timings, can continue up to 123 octet times after the express traffic gate opens. This dramatically reduces the delay experienced by preemptable traffic, at the expense of increasing the delay experienced by express traffic. While that may be acceptable for some applications, it is clearly not acceptable for applications where it is desired to reduce or remove any delay experienced by express frames.

S.4 Scheduling and preemption used in combination with HOLD/RELEASE

The HOLD and RELEASE mechanism provided by preemption (6.7.2, 12.30.1) allows an explicit "guard band" to be implemented around a protected transmission window, but one that is rather smaller than would otherwise be needed. As with S.3, this scenario assumes that the preemptable traffic's gate is scheduled to be open at all times. If an MM_CTL.request(hold_req) primitive is scheduled 124 octet times before the express traffic window opens, then preemptable frame transmission can start up to 124 octet times before the start of the protected window, and can potentially continue up to (but not beyond) the start of the window.

The result of using scheduling, HOLD/RELEASE and preemption in combination is that the express traffic's protected window can be completely protected from interference from preemptable traffic, while at the same time reducing the impact of the protected window on the amount of bandwidth that is available to preemptable traffic.

A further reason to use HOLD and RELEASE is that a schedule will often be intended for a string of express frames to be sent within an open window. If HOLD/RELEASE is not used and there is a greater than IPG gap between transmitting express frames (e.g., because of minor jitter in there arrival time), a preemptable frame or fragment could be started between express frames and cause up to 124 octets of latency in the middle of the string of express frames. Using HOLD ensures that this will not happen.

S.5 Bandwidth allocation and express traffic

The implementation of preemption in an IEEE 802.3 MAC (see IEEE Std 802.3) does not enforce a limit on how long a preemptable frame can be preempted by express traffic. This is at odds with the following:

a) Transit delay requirements of a bridge, if there is any preempted traffic present.
b) The impossibility, as shown by queuing theory, of arranging express traffic to occupy exactly 100% of the available bandwidth in the absence of unbounded queues.

For effective use of preemption, system-wide mechanisms, such as bandwidth allocation, must operate so as to keep the bandwidth allocated to express traffic below 100% as judged on timescales comparable to the delays tolerated by time-sensitive traffic.

The fact that preemption can add delay that is invisible to transit delay protection could be addressed by schedules being set such that express traffic windows are short enough and gaps between them are short enough that the worst case time to send a preemptable frame is much less than transit delay requirements. For example, if transit delay is one second, the time between express windows is greater than the maximum transmission time for a single frame, and express window size is small compared to one second (e.g., <50 ms), then preemption will not add significantly to worst-case transit delay.

For preemption without scheduling, there is no guarantee on the added latency, but that alternative should be used when the volume of express traffic is expected to be small. If the express traffic is using a shaper, such as the credit-based shaper, that could put a similar reasonable bound on transit delay.

Annex T

(informative)

Cyclic queuing and forwarding[66]

T.1 Overview of CQF

Cyclic queuing and forwarding (CQF) is a method of traffic shaping that can deliver deterministic, and easily calculated, latency for time-sensitive traffic streams. As the name implies, the principle underlying CQF is that stream traffic is transmitted and queued for transmission along a network path in a cyclic manner. Time is divided into numbered time intervals *i*, *i*+1, *i*+2, ... *i*+*N*, each of duration *d*. Frames transmitted by a Bridge, *Alice*, during time interval *i* are received by a downstream Bridge, *Bob*, during time interval *i* and are transmitted onwards by *Bob* towards Bridge *Charlie* during time interval *i*+1, and so on. A starting assumption is that, for a given traffic class, all Bridges and all end stations connected to a given bridge have a common understanding (to a known accuracy) of the start time of cycle *i*, and the cycle duration, *d*.

Frames transmitted by *Alice* during interval *i* are transmitted by *Bob* in interval *i*+1; the maximum possible delay experienced by a given frame is from the beginning of *i* to the end of *i*+1, or twice *d*. Similarly, the minimum possible delay experienced is from the end of *i* to the beginning of *i*+1, which is zero. More generally, the maximum delay experienced by a given frame is:

$$(h+1) \times d$$

and the minimum delay experienced by a given frame is:

$$(h-1) \times d$$

where *h* is the number of hops.

This illustrates the attraction of CQF as a technique for handling time-sensitive traffic; the latency introduced as a frame transits the network is completely described by the cycle time and the number of hops, and is unaffected by any other topology considerations, including interference from other non time-sensitive traffic. This only holds, however, if frames are kept to their allotted cycles; if, for example, some of the frames that were expected to be received by *Bob* during cycle *i* do not appear until cycle *i*+1 has started, then the stated assumptions about maximum latency calculation no longer hold. Careful choice of cycle times, alignment of cycle times among the Bridges in the network, and the timing of first and last transmissions within a cycle are required in order to ensure that the desired latency bounds are achieved.

Any delays through a particular intermediate relay (for example, *Bob*) do not affect the end-to-end delay so long as *Bob's* performance does not affect the correct assignment of frames to time intervals.

Since one of the goals for the handling of time-sensitive streams is zero frame loss (assuming that no unrecognizable non-conformant traffic is present), it is prudent to assume that reception is continuous—a frame received by a downstream system will always be assigned to one interval or another. This places most of the burden of correct interval assignment on the transmitting system; frames should not be transmitted if incorrect interval assignment is possible upon reception. It is therefore necessary to define the anticipated (and accommodated) errors in reception assignment with respect to the point in interval time, *t,* where interval *i*–1 becomes interval *i*. A relay (such as *Bob*) can of course choose when to start reception assignment to *i* in relation to *t*; it is assumed that *Bob's* intent is that the earliest frame to be assigned to *i* is the first whose very last octet (or other frame transmission encoding symbol) is still on the transmission medium (or other definable external event to what is considered to be *Bob* reference point) at *t*, thus placing any accommodation of known implementation dependent delays within *Bob* under *Bob's* control.

[66] In early discussions, CQF was known as the "Peristaltic Shaper" [B64].

While *Bob* attempts to start *i* reception with a frame coming off the medium at *i*, and may factor known and repeatable internal delays into the way he goes about that intent, his actual start time depends on:

a) The error in *Bob's* time sync (i.e., the error in his determination as to when *t* actually occurs).
b) The maximum deviation (jitter) in *Bob's* use of that time.
c) Additional delays that *Bob* does not account for, such as delays in selecting the output queue to be used for *i.*

Alice has to stop transmitting frames for *i*–1 before *t*, by a time that is the sum of *Bob's* possible early start of *i* as a consequence of a) through c), and the following:

d) The error in *Alice's* time sync (i.e., the error in her determination as to when *t* occurs).
e) The maximum deviation (jitter) in *Alice's* use of that time.
f) The time between *Alice* deciding to commit a frame for transmission and the appearance of the last octet/symbol "on the medium" at *Alice's* end.
g) The length of "the medium" in transmission time, i.e., the time for the last octet/symbol to leave *Alice* and reach *Bob*, including any consideration of the effect of interfering frames or fragments.

The description of CQF in terms of a number of consecutive intervals (as opposed to their support by "odd/even" queues, as discussed in T.2 onwards) gives easy answers to what to do with traffic still queued when its selected transmission interval has expired—discard it, or mark it down (discard eligible or priority change) and generate an alarm. In an environment where the stream bandwidth is allocated appropriately (i.e., the bandwidth allocated per time interval is less than can be received/transmitted in the chosen interval duration), this will be a rare occurrence, the traffic that follows will be conformant, and the overall system performance will be recoverable.

The discussion so far has assumed that all link speeds are the same; however, the situation becomes more complicated when links of different speeds are considered. One typical arrangement might comprise low speed links at the start and end of the path (network periphery to periphery), another with the high speed towards one end (periphery to core or vice versa). Taking the first of these, and placing *Alice* at the first transition from slow to fast, *Bob* as her fast neighbor, *Charlie* as his fast neighbor, and *Donald* at the transition from fast to slow, the important thing (treating the fast core of the network as a CQF black box) is that all conformant traffic received by *Alice* in interval *i* (say) is transmitted by *Donald* in a later interval *i*+*n*. A number of internal arrangements might be made between *Alice*, *Bob*, *Charlie*, and *Donald* to make this happen and would be valid from an external CQF perspective. It is also possible to consider fractional *n*, where *n* is still > 1, as *Alice* may need to collect the entirety of any slow cycle before transmitting that in a more compressed burst into the rest of the fast network. More complex possibilities are equivalent to redefining the slow cycle time. Some of the less elaborate possibilities for the use of links of different speeds are discussed in T.5.

T.2 An approach to CQF implementation

In essence, the approach involves the use of two transmission queues and a cycle timer. During even numbered cycles (intervals), queue 1 accumulates received frames from the Bridge's reception Ports (and does not transmit them), while queue 2 transmits any queued frames from the previous odd-numbered cycle (and does not receive any frames). During odd-numbered cycles, queue 2 accumulates received frames from the Bridge's reception Ports (and does not transmit them), while queue 1 transmits any queued frames from the previous even-numbered cycle (and does not receive any frames). With appropriate choice of receive and transmit cycle times (see T.5), such that, for any given stream, the cycle is at least long enough to accommodate all of the time-sensitive traffic that will need to be transmitted on the Bridge Port during the class measurement interval for that stream (see 34.6.1.1, also known as the observation interval in IEEE Std 802.1BA™ [B9]), plus a maximum-sized interfering frame (or frame fragment, if preemption is supported), then all of the stream's traffic will be accumulated during the cycle time in queues that are in receive mode, and it will all be transmitted during the cycle time when the queues switch to transmit mode.

CQF is implemented by configuring a combination of the stream gate control mechanisms defined in 8.6.5.4 and the traffic scheduling mechanisms defined in 8.6.8.4 and 8.6.9. Per-stream filtering is used to direct received frames to one of a pair of outbound queues on a timed basis, determined by the cycle time of the per-stream filter, and traffic scheduling is used to ensure that frames are transmitted from the appropriate queue using the same cycle time, as described in the rest of this annex.

T.3 Use of Per-Stream Filtering and Policing for CQF

The first step in establishing the filtering and queuing structures needed for CQF is to set up one or more stream filters (8.6.5.3) and a stream gate instance (8.6.5.4) that will be receiving incoming time-sensitive frames. The stream filter(s) are configured so that all time-sensitive frames received on a given Port are directed to the same stream gate instance; in turn, the stream gate instance is configured so that the internal priority value (IPV) associated with the time-sensitive frames will direct them to one of two outbound queues on a timed basis. The use of the IPV allows this direction of frames to outbound queues to be independent of the received priority, and also does not affect the priority associated with the frame on transmission.

T.3.1 Stream filter configuration

The simplest stream filter configuration would be achieved where the same priority is used for all time-sensitive frames (and this priority is not used for any other frames); for example, the default priority assigned to SR class A (see Clause 34) could be used, in which case, the priority associated with the time-sensitive frames would be 3. The parameters that would define the stream filter for the time-sensitive frames would then be as follows:

a) The *stream_handle specification* would take the wild-card value.
b) The *priority specification* would take the priority value 3.
c) The *stream gate instance identifier* would take the value of the instance identifier for the stream gate (T.3.2).
d) In the simplest case, there would be no further per-stream classification and metering operations (8.6.5.2); however, these could be added as appropriate, for example if the maximum SDU size (8.6.5.3.1) for the time-sensitive traffic is bounded at a value less than the maximum SDU size for the medium.

This stream filter configuration results in all frames that carry a priority value of 3 being submitted to the stream gate. As the operation of stream filters is such that received frames that do not match a stream filter are handled as if subsequent per-stream classification and metering operations were not implemented, there is no need for further stream filter configuration to handle frames that carry priorities other than 3 unless there are other filtering or gating decisions that need to be taken for such frames.

T.3.2 Stream gate configuration

The *stream gate instance* (8.6.5.4) needed to support the stream filter described in T.3.1 has a *stream gate control list* that contains two entries, each containing a SetGateAndIPV operation, with parameters as follows:

1) StreamGateState = *open*, IPV = 7, TimeInterval = T
2) StreamGateState = *open*, IPV = 6, TimeInterval = T

This control list has the effect of directing any traffic that passes the stream filter specified in T.3.1 to one of two different outbound queues (assuming that the outbound Ports support 8 queues, and that the default assignments for priorities to traffic classes follows the recommendation shown in Table 34-1); in the first time interval T, traffic is directed to queue 7, in the second time interval T, to queue 6, in the third time

interval to queue 7, in the fourth time interval, to queue 6, and so on. The choice of time interval T is discussed in T.5; the cycle time (OperCycleTime, see 8.6.9.4.19) for the stream gate state machines would need to be set to 2T in order to accommodate the sum of the time intervals for the two gate operations. See Figure T-1.

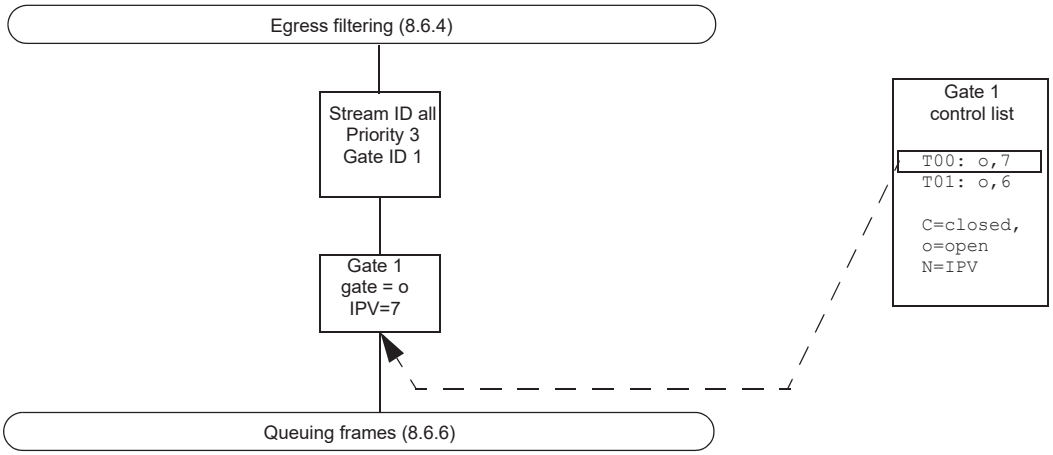


Figure T-1—Example Stream Filer and Stream Gate configuration for CQF

T.4 Use of traffic scheduling for CQF

The traffic scheduling support needed on each outbound Port in order to support the PSFP configuration described in T.3 is to execute a gate control list that will set the GateState to *open* for queue 6 and *closed* for queue 7 for a TimeInterval of T, and then set the GateState to *open* for queue 7 and *closed* for queue 6 for a TimeInterval of T, repeating ad infinitum. If there are no other traffic scheduling considerations, this can be achieved with a gate control list that contains just two SetGateStates gate operations, with parameters as follows:

1) GateState: 0, 1, 2, 3, 4, 5, 6 *open*, 7 *closed*, TimeInterval = T
2) GateState: 0, 1, 2, 3, 4, 5, 7 *open*, 6 *closed*, TimeInterval = T

This sequence of gate operations has the effect that during the initial time period T, the GateState for queue 7 is closed while queue 7 is being filled, and queue 6 is open to allow any queued frames to be transmitted; during the second time period T, the GateState for queue 6 is closed while queue 6 is being filled, and queue 7 is open to allow any queued frames to be transmitted. The gates for all other queues are open. The choice of time interval T is discussed in T.5; the cycle time (OperCycleTime; see 8.6.9.4.19) for the scheduled traffic state machines would be set to 2T in order to accommodate the sum of the time intervals for the two gate operations.

If there are traffic scheduling requirements for any of the other queues, then the gate control list could be extended to accommodate those requirements; however, the time interval between the changes of state of the gates for queues 6 and 7 has to be T, and consequently, OperCycleTime has to be a multiple of 2T, in order for the CQF requirements to be met. Figure T-2 illustrates the simplest possible traffic scheduling configuration for the case that traffic scheduling is only needed to support CQF.

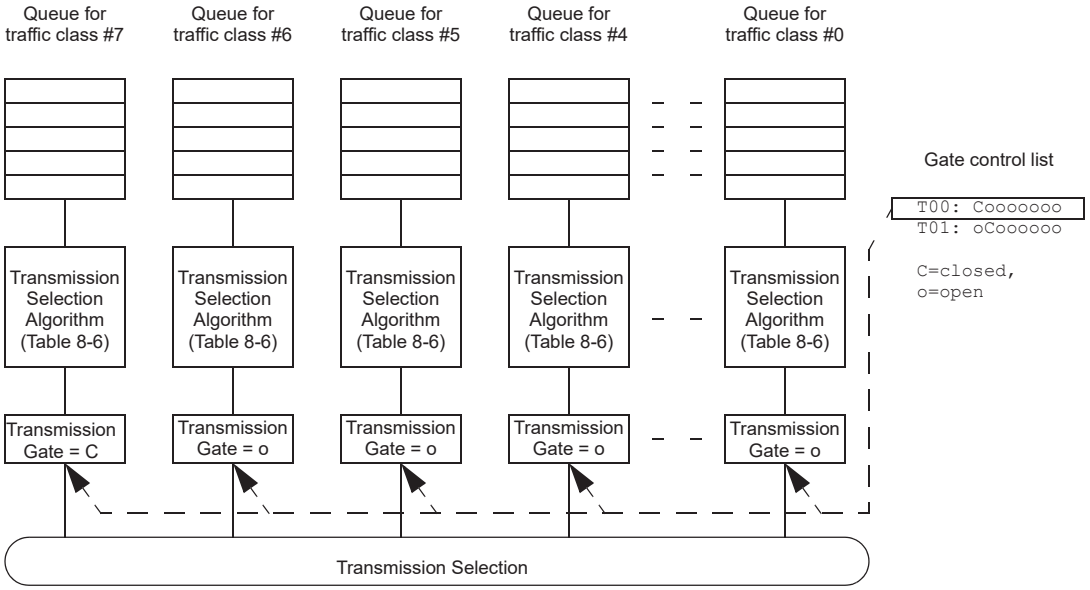


Figure T-2—Traffic scheduling example for CQF

T.5 Timing considerations

T.5.1 Choice of T

T should be chosen such that it is large enough to accommodate the stream data that can be received during the class measurement interval for the stream(s) concerned, plus at least one maximal interfering frame or frame fragment. This is important in order to ensure the key performance aspect associated with the class measurement interval; namely, that if a stream or set of streams is observed over time, the reserved data rate for that stream or set of streams will not be exceeded during any observed time period equal to the class measurement interval associated with those streams. This effectively places a lower bound on the choice of T, that it should not be smaller than the class measurement interval, and also places a restriction on larger values of T, that they should be integer multiples of the class measurement interval.

If streams associated with two different observation intervals are being handled, for example if streams that use SR classes A and B pass through the Bridge, then the OperCycleTime used for the transmit traffic scheduling has to be a common multiple of the two class measurement intervals that are in use in order to make it possible for the transmission cycles to properly match the two values of T that are chosen. Figure T-3 and Figure T-4 illustrate how the Stream Filters, Stream Gates, and traffic scheduling could be configured in the case where SR classes A and B are active; in Figure T-3, incoming frames that carry SR Class A (priority 3) are handled using Gate 1, and the cycle time for the stream gate control list is twice the class measurement interval for SR Class A, which is 2 × 125 μs. Gate 1 alternately tags these frames with an IPV of 7 or 6. Incoming frames that carry SR Class B (priority 2) are handled using Gate 2, and the cycle time for the stream gate control list is twice the class measurement interval for SR Class B, which is 2 × 250 μs. Gate 2 alternately tags these frames with an IPV of 5 or 4.

The traffic schedule is based on the smaller of the two class measurement intervals, 125 μs, but now has four entries in the gate control list (as opposed to 2 entries in Figure T-2), giving an overall cycle time of 500 μs. The gate control list switches the gate states for traffic classes 7 and 6 every 125 μs, and switches the gate states for traffic classes 5 and 4 every 250 μs.

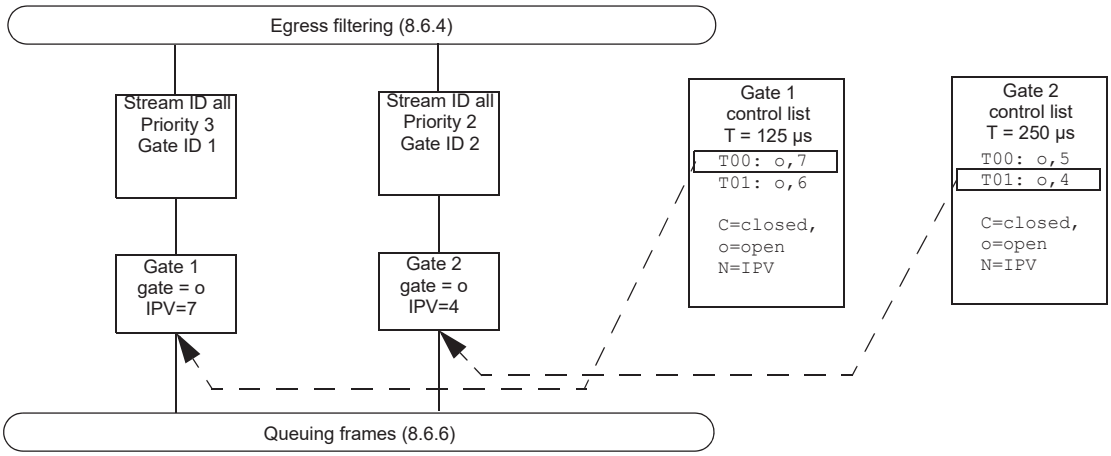


Figure T-3—Example Stream Filter and Stream Gate configuration with two values of T

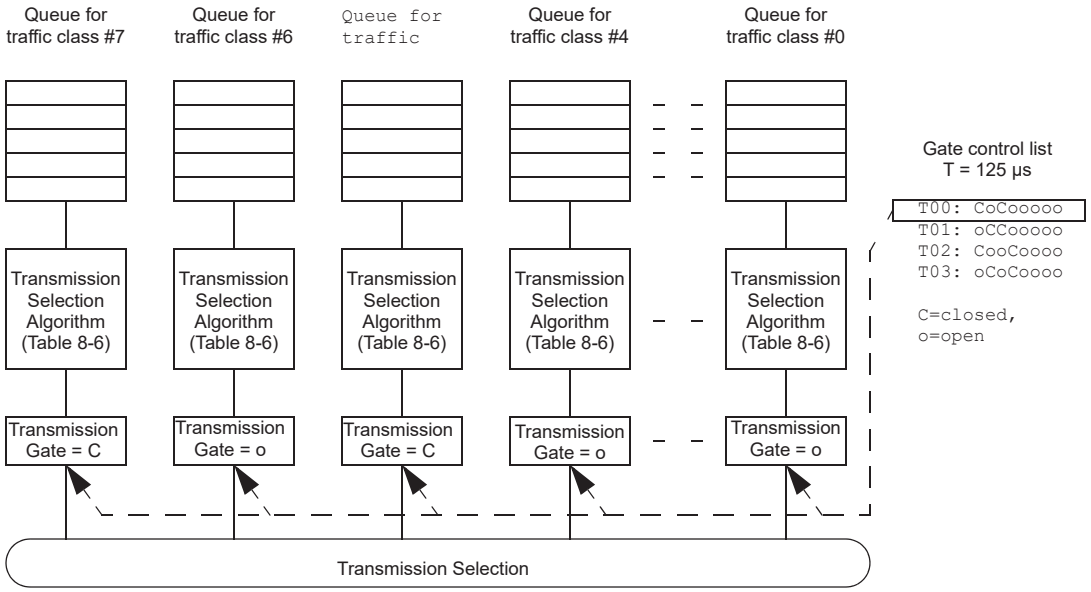


Figure T-4—Traffic scheduling example with two values of T

T.5.2 Cycle interleaving

In some circumstances, particularly where the data rates differ between reception and transmission Ports, it can be desirable to interleave cycles on the faster Port so that the best use is made of the higher bandwidth available, and also to reduce the latency that is added as a stream passes through faster parts of the transmission path. Because there is a delay imposed on the transmission of received frames, caused by the cyclic switching of reception and transmission between a pair of queues, when a queue is allowed to transmit, all of its received frames will have been enqueued, and all of them will therefore be transmitted in a burst, assuming that priorities permit, and that the transmission queue uses the strict priority transmission selection algorithm (8.6.8.1). Hence, if the received traffic from a given Port was spread out over the time interval T, and it is all sent to the same queue, the transmitted traffic will be compressed into a burst. If

the transmission data rate is, say, ten times the reception data rate, then the maximum length of that burst is T/10, so there is the potential to fit 9 more such bursts into the bandwidth available on that transmission Port. With appropriate timing on reception Ports and transmission Ports, the reception and transmission cycles can be interleaved such that those additional transmission bursts can occur. In the example illustrated in Figure T-5, it is assumed that:

a) There are two Ports on which stream data is being received, Rx1 and Rx2.
b) There is a single Port on which stream data is being transmitted, Tx1.
c) Rx1 and Rx2 operate at half of the data rate of Tx1 (or less).
d) All stream traffic is SR Class A, and is received with priority 3.

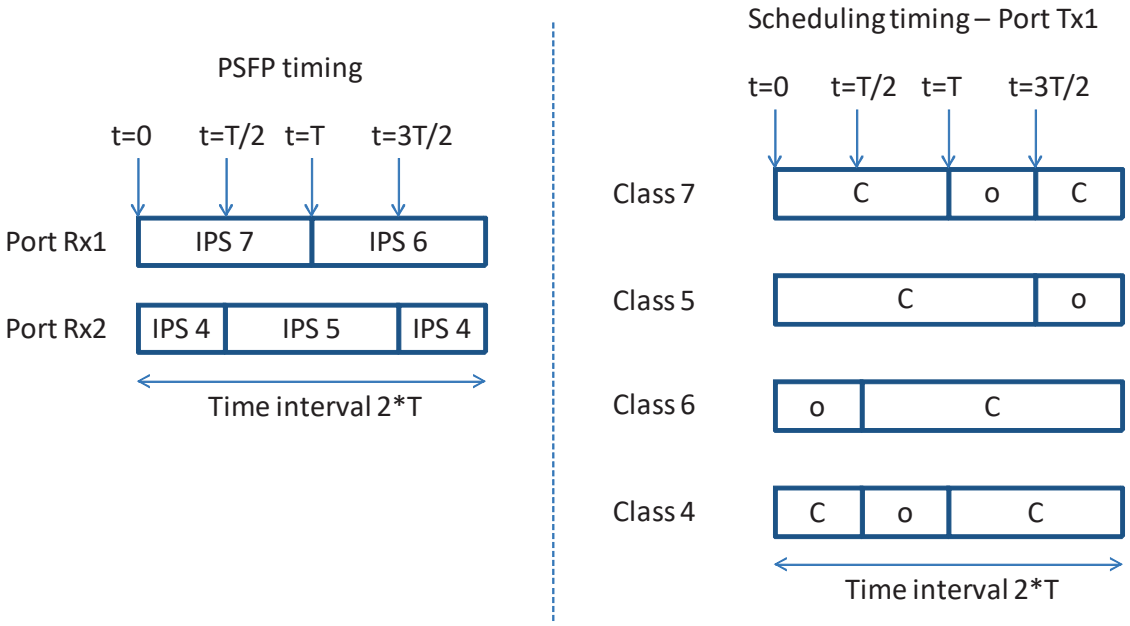


Figure T-5—Interleaving example—factor of 2

On the reception side, traffic received on Rx1 with priority 3 is sent to traffic class queue 7 during the odd cycles and to traffic class queue 6 during the even cycles. Similarly, traffic received on Rx2 with priority 3 is sent to traffic class queue 5 during the odd cycles and to traffic class queue 4 during the even cycles; however, these cycles are offset with respect to the cycles for Rx1 by T/2.

On the transmission side, each queue is in the open (transmitting) state for T/2, and in the closed (receiving) state for 3T/2. The timings of the gate open/gate closed events are arranged so that only one queue is transmitting at any one time.

It should be noted that with a scheme like this, although the transmit side appears to be operating on the basis of a value of T that is half that used on the Rx side, the effect from the point of view of the streams originating from a given reception Port is that the Rx and Tx timing is the same, as frames received on that Port are transmitted once in every time period T, and as assumed in the preceding point c), the transmit rate is twice the receive rate (or more), so the available transmit bandwidth is the same as or more than the receive bandwidth. The interleaving therefore meets the requirements stated in T.5.1. The reception Port of the Bridge downstream of Tx1 can operate using T/2, and if it is possible to carry this through to the transmission Ports as well, the contribution to the latency for streams passing through this Bridge will be T/2, rather than the T contributed by the first Bridge.

More complex schemes can be envisaged; for example, using more than two Rx Ports, and these can be made to work as long as the received bandwidth can be shared equally between the pairs of traffic classes that are used. Interleaving of this kind can also be defined for larger interleave factors; the only limitation is the number of available outbound queues. It is also possible to define interleaving schemes where the received bandwidth is not shared equally among the pairs of traffic classes, as long as the bandwidth allocated to a given pair of traffic classes does not exceed the bandwidth available during the time intervals when those traffic classes are able to transmit.

NOTE—Although the number of traffic classes described in this standard is limited to 8, the value of the IPV does not have such a limitation placed upon it. If a system supported more than 8 traffic classes, it would therefore be possible to define interleaving factors greater than 4.

T.5.3 Cycle alignment between adjacent Ports

The examples so far assume a perfect world where the transmission from transmission Port to reception Port is instantaneous and the internal timings of the transmitting and receiving systems are perfectly synchronized. In reality, transmission takes time, and synchronization is not perfect; therefore, it would be possible that a transmission Port launches the last frame(s) of one transmission burst just after the reception Port downstream has switched reception and transmission queues, which would mean that those last frames are placed in the wrong queue. Similarly, if the timing misalignment worked the other way, it would be possible for the transmission Port to finish transmitting its burst early, and switch to transmitting the next burst before the downstream Port had changed state.

In order to avoid this problem, the timings must be adjusted such that there is a very high degree of probability that when a reception Port changes the state of the stream filters to direct incoming frames to a different outbound queue, there are no frames still to be transmitted, or in flight, from the upstream transmission Port. This can be achieved by slightly delaying the start of the transmission window, and slightly advancing the end of the transmission window. The value of “slightly” depends on a number of factors, including the following:

a) Any error in the time synchronization between the adjacent systems.
b) Jitter in the propagation time of a frame from starting to leave the transmit queue in the upstream system to being presented to the downstream policing function.
c) Jitter in the propagation time of a frame between the downstream policing function and the appropriate transmission queue in the downstream system.
d) The size of any potential interfering frame or frame fragment.
e) Difference in the resolution of the clocks that are maintained by adjacent systems.

The effect of this adjustment factor, S, on the timings shown on the transmission Port in the earlier examples would be that the time slots where the gate is in the “open” state would be shorter by a factor of 2S, and would start S later. Hence, the transmission phase for traffic class 7 in Figure T-5 would start at T+S, and would end at (3T/2)–S. S should be set to the sum of the errors or jitter values from all sources given in the preceding list.

Annex U

(informative)

TSN configuration examples

This annex provides implementation examples for Time-Sensitive Networking (TSN) configuration (Clause 46).

The examples in this annex are not intended to be comprehensive, but to serve as informative background to assist in understanding of Clause 46.

U.1 Examples for time-aware talker

One of the goals of TSN configuration is avoid forcing the user's application to be subservient to the network's configuration. The user describes what it does (e.g., TrafficSpecification) and what it needs from the network (e.g., UserToNetworkRequirements). The user also describes the configuration that it is willing to accept from the network (e.g., InterfaceCapabilities), but the goals are to keep that configuration to a minimum and to avoid topics that change aspects of the user's application, such as the timing of the application's execution and interaction with the physical world (e.g., sensors, actuators).

Aligned with these goals, it is possible for the Talker to transmit frames in a manner that is not aware of time synchronization protocols like IEEE Std 802.1AS. Using the time-aware features of TrafficSpecification and InterfaceConfiguration, it is also possible for a Talker to use awareness of time synchronization for transmission of frames. Nevertheless, TSN configuration avoids assumptions of a specific implementation of time-aware transmit, and TSN configuration avoids changes to application timing.

In order to demonstrate these concepts, consider an example in which Talkers and Listeners use IEEE Std 802.1AS to execute synchronized application loops at an interval of 500 µs. The code for the application consists of two stages: a 250 µs computation stage that generates data and a 250 µs stage to transmit that data in TSN frames. The MaxLatency requirements can span one or more iterations of the application loop.

This example uses IEEE Std 802.1AS for time synchronization. The application begins execution on September 13, 2020, at 12:26:40 pm TAI, which corresponds to 1 600 000 000 000 000 µs in IEEE 802.1AS time.

The application loops begin in alignment with IEEE 802.1AS time; in other words, the 250 µs transmit stage begins at a base offset of 250 µs in IEEE 802.1AS time. For example, after the application has been running for 6 s, a sequence of transmit stages can execute at 1 600 000 006 000 750 µs, 1 600 000 006 001 250 µs, 1 600 000 006 001 750 µs, and so on.

This example focuses on a single Talker that transmits two Streams, J and K. The application generates a single frame of data for J and/or K at arbitrary times in the computation. In other words, during a single iteration data for K can follow J, and in the next iteration data for J can follow K, and in the next iteration data can be J only.

The frame for Stream J uses 120 µs in time. The frame for Stream K uses 80 µs in time. This implies a 100 Mb/s LAN technology.

U.1.1 Using enhancements for scheduled traffic

One option for implementation of this time-aware Talker is the enhancements for scheduled traffic (8.6.8.4). The Talker has two queues for transmit: one for TSN frames and another for non-TSN frames (e.g., best effort). The scheduled traffic enhancements use IEEE 802.1AS time to open and close gates for each queue (traffic class).

The enhancements of 8.6.8.4 schedule traffic per queue, and not per stream. Given the preceding application assumptions, therefore, the frame for Stream J can precede the frame for Stream K, and in the next cycle K can precede J.

For a time-aware Talker, the Jitter of TrafficSpecification (46.2.3.5) represents the variance in time for the single Stream. Since the enhancements of 8.6.8.4 are per queue, the Jitter must include the variance that is introduced by other Streams from this Talker.

Using the scheduled traffic enhancements of 8.6.8.4, the time-aware Talker needs an open TSN window of 120+80=200 µs for both J and K. The network (CNC) can locate that TSN window from 250 µs to 450 µs through 300 µs to 500 µs. The Talker uses the TimeAwareOffset returned in InterfaceConfiguration (46.2.5.3) to determine where to locate the TSN window.

For this implementation, the TrafficSpecifications are as follows:

- Stream J
  - MaxFrameSize = (120 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = 40 µs (Stream K can occur before J, such that J is 80 µs in window.
    Stream K can occur after J, such that J is 0 µs in window.
    Jitter represents the midpoint of this variance.
    Use the returned TimeAwareOffset-Jitter as the start of
    the TSN window.)
  - EarliestTransmitOffset = 250 µs + Jitter = 290 µs
  - LatestTransmitOffset = 500 µs – <MaxFrameSize in time> – Jitter = 340 µs
- Stream K
  - MaxFrameSize = (80 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = 60 µs (Stream J can occur before or after K)
    EarliestTransmitOffset = 250 µs + Jitter = 310 µs
  - LatestTransmitOffset = 500 µs – <MaxFrameSize in time> – Jitter = 360 µs

Assume that the CNC decides to use EarliestTransmitOffset, presumably because that can be aligned with the schedules in Bridges. This results in InterfaceConfigurations of:

- Stream J
  - TimeAwareOffset = 290 µs
- Stream K
  - TimeAwareOffset = 310 µs

The Talker subtracts the Jitter from these TimeAwareOffset values and uses the lower of the results to configure AdminBaseTime and OperBaseTime of 8.6.8.4. The resulting configuration of the scheduled traffic enhancements of 8.6.8.4 is shown in Figure U-1 along with example traffic.

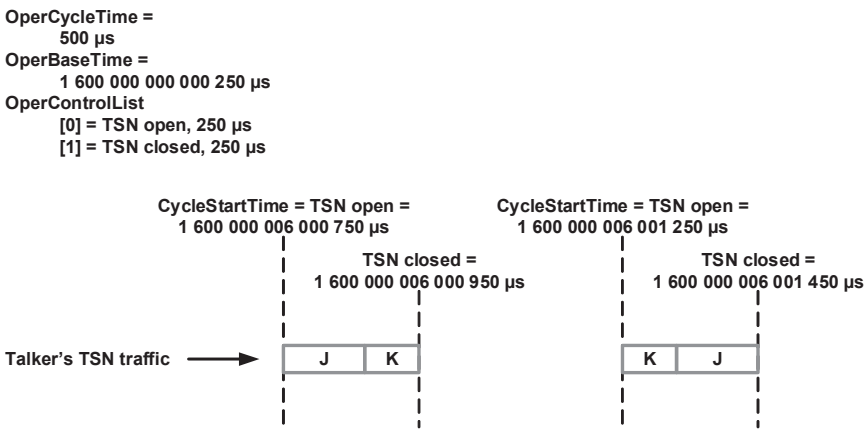


Figure U-1—Example of enhancements for scheduled traffic

NOTE—For this example, the Talker could also decide to use OperBaseTime of 0 µs and swap OperControlList elements 0 and 1 (i.e., 250 µs TSN closed followed by 250 µs TSN open). That configuration is equivalent from the network perspective.

U.1.2 Using strict priority

If the Talker has no hardware to assist in scheduling of traffic, it can take advantage of its application timing for TSN configuration of its Streams. This implementation assumes that the Talker has two queues for transmit, but each queue uses strict priority alone for transmission selection (8.6.8.1). The TSN queue uses a higher priority traffic class than the non-TSN queue.

For this implementation, assume that the Talker disables the TSN queue during its computation stage, but continues to place frames for J and K into the TSN queue. When the Talker transitions to its transmit stage (i.e., 250 µs base offset in IEEE 802.1AS time), it enables the TSN queue for transmit.

When the TSN queue is enabled, a non-TSN frame (e.g., best effort) can interfere such that it has just begun its transmit. For 100 Mb/s full-duplex IEEE Std 802.3 and a maximum frame size of 1522, this interference is 123.36 µs. This interference must be incorporated into the Jitter of TrafficSpecification, much like the Jitter of Streams J and K in U.1.1.

This implementation has no flexibility in the location of its TSN window, which always starts at a 250 µs offset.

For this implementation, the TrafficSpecifications are as follows:

- Stream J
  - MaxFrameSize = (120 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = (80 µs + 123.36 µs) / 2 = 101.68 µs
    (Stream K and max non-TSN can occur before J.)
  - EarliestTransmitOffset = 250 µs + Jitter = 351.68 µs
  - LatestTransmitOffset = 250 µs + Jitter = 351.68 µs
    (No flexibility. TSN window always starts at 250 µs.)

- Stream K
  - MaxFrameSize = (80 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = (120 µs + 123.36 µs) / 2 = 121.68 µs)
    EarliestTransmitOffset = 250 µs + Jitter = 371.68 µs
  - LatestTransmitOffset = 250 µs + Jitter = 371.68 µs

This results in the following InterfaceConfigurations (or a failure):

- Stream J
  - TimeAwareOffset = 351.68 µs
- Stream K
  - TimeAwareOffset = 371.68 µs

Due to the high Jitter and inflexibility of the scheduling window, this implementation has the potential for more Stream configuration failures as compared to the implementation described in U.1.1.

U.1.3 Using per-stream scheduling

Some Talker implementations provide additional hardware assistance for time-aware transmission, such that each individual Stream has its own scheduled gating (i.e., per stream).

One such implementation is similar to the scheduled traffic enhancements of 8.6.8.4, but each Stream has a dedicated transmit queue and gate control list. An alternative implementation has a single transmit queue for TSN traffic, but each frame has an associated timestamp to specify its time for transmit. A variety of implementations are possible. For this example, assume that scheduled transmit is per stream, but do not assume a specific hardware implementation.

Assume that the per-stream scheduling hardware uses IEEE 802.1AS time directly. Therefore, the time-aware transmit has no additional variance beyond what IEEE Std 802.1AS provides, and the Jitter of TrafficSpecification is zero.

Given the application requirements, the CNC can locate Stream J anywhere in the window from 250 µs to 500 µs. The CNC can also locate Stream K anywhere in the window from 250 µs to 500 µs, but it cannot overlap with Stream J.

For this implementation, the TrafficSpecifications are as follows:

- Stream J
  - MaxFrameSize = (120 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = 0 µs
  - EarliestTransmitOffset = 250 µs + Jitter = 250 µs
  - LatestTransmitOffset = 500 µs – <MaxFrameSize in time> – Jitter = 380 µs
- Stream K
  - MaxFrameSize = (80 µs in time)
  - MaxFramesPerInterval = 1
  - Interval = 500 µs
  - Jitter = 0 µs
    EarliestTransmitOffset = 250 µs + Jitter = 250 µs
  - LatestTransmitOffset = 500 µs – <MaxFrameSize in time> – Jitter = 420 µs

Assuming that the CNC can locate Stream J at 250 µs and Stream K immediately after, this results in the following InterfaceConfigurations:

- Stream J
  - TimeAwareOffset = 250 µs
- Stream K
  - TimeAwareOffset = 370 µs

Due to the zero Jitter and improved flexibility of the scheduling window, this implementation has the potential for more Stream configuration success as compared to the implementation described in U.1.1. In addition, given that each Stream has a distinct offset in time, this implementation enables the CNC to configure the scheduled traffic enhancements of 8.6.8.4 in Bridges such that multiple Streams do not overlap upon ingress from multiple Ports. In turn, the overall variance in latency is reduced.

U.2 Example of workflow for fully centralized models

This subclause provides an example workflow for the centralized TSN configuration models of Clause 46. The example is not intended to be comprehensive, but to help the reader understand how aspects of the configuration can be addressed (e.g., TSN domain detection and enforcement).

The example assumes the fully centralized model (46.1.3.3) with a single Centralized User Configuration (CUC) entity and a single Centralized Network Configuration (CNC) entity.

Many user-level protocol standards exist for the purpose of discovering and configuring end stations in order to design a distributed application. The application is usually specific to a particular market segment (e.g., industrial automation, professional audio/video). A centralized software entity is used for the application's design, possibly including programming of software in end stations (e.g., industrial Programmable Logic Controller). The centralized entity uses the user-level protocol to communicate with the relevant end stations for its application. When TSN configuration is applied to these existing standards, the goal is to integrate TSN functionality without significant changes. The existing application design software is represented by the CUC concept, and the end stations are represented by the Talker and Listener concepts. This example does not designate a specific user-level protocol, but it does assume the existence of a single CUC.

The CNC discovers capabilities of network infrastructure (e.g., Bridges) and configures those features.

The example provides a workflow as a framework for describing each step in the TSN configuration procedure. The steps do not necessarily need to occur sequentially. Although the example assumes a single CUC, its CNC workflow (i.e., step 4 through step 8 below) can be applied to other examples that assume multiple CUCs, such as the following:

a) Multiple application design tools are used (i.e., multiple user-level protocols), and therefore multiple CUCs are used with a single CNC.
b) No application design tool is used, and instead each CUC represents a single Talker or Listener that communicates directly with the CNC.
c) Each CUC represents a single Talker or Listener that uses the Nearest Bridge as a proxy to the CNC (i.e., centralized network/distributed user model).

The workflow for this example consists of the following steps:

1) **CUC discovers Talker and Listener end stations.**

   The protocol used by the CUC is outside the scope of this standard. When the communication between CUC and end stations uses IP, protocols such as mDNS (IETF RFC 6762 [B42]) are sometimes used.

2) CUC reads the capabilities of each end station.

This step includes TSN capabilities, but also many other capabilities that are not related to network technology. For example, if the end station is a sensor, the CUC reads the capabilities of the sensor as it applies to the physical world. The CUC also reads the frame size that is needed to transfer the sensor's measured value and associated diagnostics.

Although the communication between CUC and end station is not directly related to Clause 46, the CUC needs to obtain the following information:

— Number of Ports and MAC address of each Port
— InterfaceCapabilities: IEEE 802.1 capabilities of each Port
— TrafficSpecification.MaxFrameSize and MaxFramesPerInterval: Size of end station's data

The user-level protocol used by the CUC is outside the scope of this standard.

3) End-user designs the distributed application using the CUC.

The end user of the CUC decides which end stations communicate with one another as part of the distributed application. In other words, in terms of this standard, the CUC is used to design the Streams, including selection of the Talker and Listeners for each Stream. The CUC is also used to design the application's timing requirements.

The CUC creates the following information for each Stream, and its end stations are not directly aware of this information:

— StreamID: This identifier is primarily used between CUC and CNC.
— StreamRank: The importance of each Stream is related to its use in the application.
— UserToNetworkRequirements: MaxLatency is tied to application timing requirements.

The periodic execution of application code is designed using the CUC. This translates to the interval (i.e., period, rate) at which a Talker transmits its data. The CUC sends this interval to its end stations using the user-level protocol.

4) CNC discovers the physical network topology.

To discover the physical links between end stations and Bridges, the CNC uses IEEE Std 802.1AB (LLDP) along with a remote management protocol.

5) CNC reads the TSN capabilities of each Bridge.

The CNC uses a remote management protocol to read the TSN capabilities of each Bridge.

Whereas the previous step used the MIB/YANG of IEEE Std 802.1AB, this step uses the MIB/YANG of standards for TSN, such as IEEE Std 802.1Q, IEEE Std 802.1AS, and IEEE Std 802.1CB. The CNC uses the Chassis (Bridge) and Port identifications from the IEEE 802.1AB MIB/YANG to find the corresponding Port capabilities in the MIB/YANG of other IEEE 802.1 standards.

For example, the CNC will read the Bridge Delay (12.32.1) and Propagation Delay (12.32.2) from each Bridge in order to compute AccumulatedLatency (for step 9).

The CNC of this fully centralized model coexists with the fully distributed model (46.1.3.1). If the CNC finds a Bridge with msrpEnabledStatus TRUE (12.22.1) and MRP externalControl FALSE (12.32.4.1), the CNC avoids use of MSRP's VLAN ID (12.22.2, 12.22.4) for Streams configured by the CNC. The CNC also avoids use of MSRP's Priority (12.20.4) and associated traffic class. Although there might be methodologies for sharing the same resources (VLANs and traffic classes) between both models, this CNC takes the simpler approach of keeping the resources separate.

6) CUC sends Talker/Listener groups to the CNC.

The CUC requests configuration of Streams by sending Join requests (46.2.2) that specify the Talker group and Listener groups for each Stream.

The EndStationInterfaces group of each Talker and Listener identifies the associated end station in the physical topology, using the end station's MAC address. The MAC address is persistent (i.e., does not change due to software or protocols) and is assumed to be unique within the network, which serves as excellent identification in the physical topology. For this example, assume that end

stations use MAC address as their LLDP Chassis ID, such that the CNC can associate each Talker/Listener group to its neighboring Bridge Port.

7) CNC configures TSN domain(s).

Using the information learned in step 4 through step 6, the CNC knows the Bridges in the path(s) between each Talker and its Listeners. The CNC also knows the Bridge Ports that do not transmit frames for a Stream. This effectively defines the TSN domain for the collection of Streams.

The CNC uses destination MAC address and VLAN ID as tools to configure TSN features within the TSN domain. The InterfaceConfiguration group provides a mechanism for the CNC to allocate destination MAC addresses and VLAN IDs from its own pool and to provide the allocated values to the CUC (and the end stations). If end stations do not support InterfaceConfiguration, the CNC learns the destination MAC addresses and VLAN IDs from the DataFrameSpecification of each Stream.

i) Inside the TSN domain

When Bridges in the TSN domain are using spanning tree protocols (e.g., MSTP, ISIS-SPB) to forward Streams, the CNC uses management of the Static Filtering Entries (12.7) in order to avoid spanning tree protocols updating the active topology of the VLAN used by Streams.

When the CNC uses IEEE Std 802.1CB for redundant paths for Streams, the CNC uses management of Static Trees (12.32.3) and the associated TE-MSTID in order to avoid spanning tree operation on the VLAN ID used by Streams. The CNC uses management of IEEE Std 802.1CB to configure the redundant paths in Bridges between each Talker and its Listeners.

ii) Outside the TSN domain

The CNC uses management of Static Filtering Entries (12.7) to prevent transmit of TSN frames to Bridge Ports outside the TSN domain.

The CNC uses management of the Priority Regeneration Table (12.6) to prevent interference by non-TSN frames received on Bridge Ports outside the TSN domain, in that the priority of the non-TSN frame can be downgraded to zero. This is similar to the use of the Priority Regeneration Override Table (12.20.3) by SRP (6.9.4).

The accuracy/precision of IEEE Std 802.1AS degrades slightly for each Bridge that transfers time, so it makes sense for the CNC to limit the size of the IEEE 802.1AS domain as much as possible. As its default mode of operation, the CNC of this example uses management of IEEE Std 802.1AS to disable operation on Ports outside of the TSN domain. For example, assume that the CNC detects two distinct TSN domains G and H with respect to Talkers and Listeners (i.e., no Stream from G to H or vice versa). There is a Bridge between TSN domains G and H, and that Bridge supports IEEE Std 802.1AS. Rather than use a single IEEE 802.1AS domain that spans G and H, the CNC disables IEEE Std 802.1AS on the Ports between G and H; this action effectively creates two distinct IEEE 802.1AS domains, one for each TSN domain.

8) CNC configures TSN features for Streams.

The CNC uses the management of IEEE Std 802.1Q to configure TSN features in the path(s) from Talker to Listeners. Examples include enhancements for scheduled traffic (8.6.8.4), frame preemption (6.7.2), and the credit-based shaper (8.6.8.2).

9) CNC returns the Status of each Stream to the CUC.

This step includes the success/failure of each Stream's configuration, the AccumulatedLatency, and the InterfaceConfiguration for each end station.

10) CUC configures each end station.

If one or more Streams fail configuration, the CUC might decide to adjust its requirements and try again (i.e., return to step 3).

Assuming that the Stream status is sufficient to proceed, the CUC configures each end station to prepare it for application execution. Although the communication between CUC and end station is not directly related to Clause 46, the CUC provides the following information for each Stream:

— InterfaceConfiguration: Provides the destination MAC address and/or VLAN ID (if needed).

11) CUC executes the distributed application.

If there are other CUCs for other applications, the CNC can continue to configure Bridge resources for those while this application runs.

12) CUC stops the distributed application.

The CUC can send Leave requests (46.2.2) for Streams that are no longer needed.

If the application is changed, this workflow can return to step 1, step 2, or step 3.

Annex V

(informative)

Asynchronous Traffic Shaping delay analysis framework

The framework in this annex provides methods for worst-case delay analysis in static networks with static configurations. General assumptions of this framework are listed in V.1. The end-to-end delay modeling approach is described in V.2. An upper bound on buffering delays is described in V.3. Subsequent clauses (V.4 through V.8) cover additional sources of delays. The combined delay bounds are shown in V.9.

V.1 General assumptions

The following assumptions are made throughout the remainder of this framework:

a) The Transmission Selection Table (8.6.8) of all transmission Ports under consideration assigns the ATS Transmission Selection Algorithm (Table 8-6, 8.6.8.5) to one or more numerically highest traffic classes (i.e., no other algorithm than the ATS Transmission Selection Algorithm is assigned to a numerically higher traffic class than the traffic classes to which the ATS Transmission Selection Algorithm is assigned).
b) The transmission gates (8.6.8.4) associated with all traffic classes using the ATS Transmission Selection Algorithm of all transmission Ports under consideration reside permanently in state Open.
c) All streams are associated with ATS traffic classes in all transmission Ports.
d) If frame preemption (6.7.2) is supported by a transmission Port under consideration, it is assumed that the frame preemption status in the frame preemption status table associated with the transmission Port in the network is either express, or preemptable for all traffic classes using the ATS Transmission Selection Algorithm.
e) The underlying MAC Service of all transmission Ports under consideration transmits at a constant data rate.
f) The committed information rate parameters in Bridges under consideration are set consistently with the constraints in V.8.
g) The data rate of a Port under consideration is greater than the sum of associated committed information rates.
h) Frames at all transmission Ports have the same media-dependent overhead (12.4.2.2). Likewise, there is no variation in frame lengths (i.e., tag addition or removal along a path is not considered).

V.2 End-to-end delay modeling approach

The path from the Talker station to a single Listener station is subdivided into the contained *n* hops, where the *1*st hop is the hop from the Talker to the first Bridge on the path, and the *n*th hop is the hop from the last Bridge on the path to the Listener.

The end-to-end delay bound $d_{max}(f)$ of a stream of interest is given by per hop delay bounds $d_{max}(k, f)$ of the *n* subsequent hops along the path of stream *f* as shown in Equation (V-1).

$$d_{max}(f) = \sum_{k=1}^{n} d_{max}(k, f) \quad \text{(V-1)}$$

where

f	is the stream of interest
k	is the hop index at the path from the Talker to the Listener ($1 \le k \le n$)
$d_{max}(k, f)$	is the per hop delay bound of stream *f* at the *k*th hop

Figure V-1 illustrates the path of stream *f* across the relevant mechanisms and interfaces of two subsequent bridges along the path, and the associated delay bounds [e.g., $d_{AT, max}(k)$, introduced in V.5] described in the following subclauses.

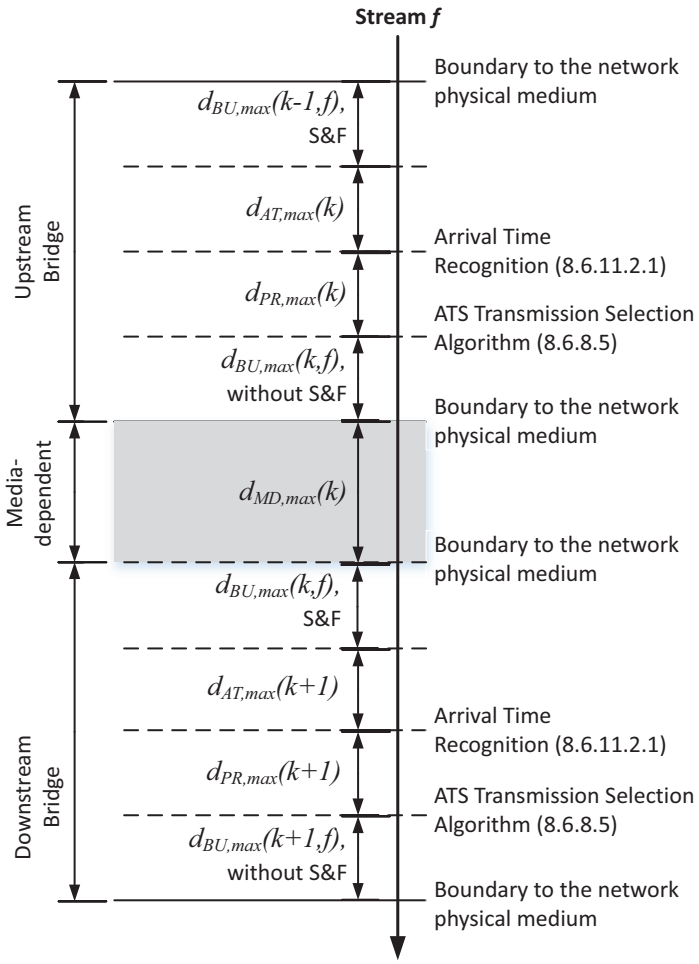


Figure V-1—Path of frames along a single hop with index *k* with two Bridges

V.3 Buffering delays

The buffering delays comprise all delays on frames of a stream *f* resulting from their residence in queues of associated traffic classes in the transmission Ports along the path. For a transmission Port on the path, these delays are caused by:

a) Competing frames in queues of traffic classes different than the traffic class of stream *f*.
b) Competing frames in the queue of the traffic class of stream *f* competing for transmission.
c) The enforcement of traffic envelopes by the operation of the ATS scheduler state machines (8.6.11).
d) Store and forward operation in reception Ports.

A delay bound $d_{BU,\,max}(k, f)$ on the buffering delay for a single hop in absence of the effects covered in subsequent clauses is known (see Specht and Samii [B63]). For $k < n$ (i.e., all but the last hop to the Listener), the delay bound $d_{BU,\,max}(k, f)$ is given by Equation (V-2).

$$d_{BU,\,max}(k, f) = \max_{h \in F_S(k, f)} \left\{ \frac{\sum_{g \in F_H(k, h) \cup F_S(k, h)} b_{max}(k, g) - l_{min}(h) + l_{LP,\,max}(k, h)}{R(k) - \sum_{g \in F_H(k, h)} r_{max}(k, g)} + \frac{l_{min}(h)}{R(k)} \right\} \quad \text{(V-2)}$$

For $k = n$ (i.e., the last hop to the Listener), this bound is given by Equation (V-3).

$$d_{BU,\,max}(n, f) = \frac{\sum_{g \in F_H(n, f) \cup F_S(n, f)} b_{max}(n, g) - l_{min}(f) + l_{LP,\,max}(n, f)}{R(n) - \sum_{g \in F_H(n, f)} r_{max}(n, g)} + \frac{l_{min}(f)}{R(n)} \quad \text{(V-3)}$$

where

$F_H(k, f)$ and $F_H(k, h)$	denote the set of streams transmitted in a numerically higher traffic class (8.6.8) than stream *f* and a stream *h*, respectively, at the upstream transmission Port of the *k*th hop
$F_S(k, f)$ and $F_S(k, h)$	denote the set of streams transmitted in the same traffic class as stream *f*, including stream *f* and stream *h*, respectively, at the upstream transmission Port of the *k*th hop
$l_{LP,\,max}(k, f)$ and $l_{LP,\,max}(k, h)$	denote the maximum interference length, in bits, by any numerically lower traffic class than the class of stream *f* and a stream *h*, respectively, at the upstream transmission Port of the *k*th hop
$l_{min}(f)$ and $l_{min}(h)$	denote the minimum frame length of stream *f* and a stream *h*, respectively, in bits, including all media-dependent overhead (8.6.11.3.11, 12.4.2.2)
$b_{max}(k, g)$	is the maximum burst size associated with a stream *g* at the *k*th hop, in bits
$r_{max}(k, g)$	is the committed information rate of stream *g* at the upstream device of the *k*th hop, in bits per second
$R(k)$	is the transmission rate, in bits per second, that the underlying MAC Service that supports transmission through the upstream transmission Port of the *k*th hop provides

NOTE 1—The relationship between $b_{max}(k, g)$ and the committed burst size at the Talker station is further discussed in V.7.

NOTE 2—The relationship between $r_{max}(k, g)$ and the committed information rate at the Talker station (47.2) is further discussed in V.8.

NOTE 3—If frame preemption is not supported, $l_{LP,\,max}(k, f)$ is at most one maximum frame length, including all media-dependent overhead, supported by the upstream transmission Port of the *k*th hop. If frame preemption is supported, and all classes with the ATS transmission selection algorithm can preempt all numerically lower traffic classes, $l_{LP,\,max}(k, f)$ is at most a maximum fragment length (S.2), including all media-dependent overhead.

V.4 Media-dependent delays

Frames of stream *f* experience a media-dependent delay between the upstream transmission Port of this hop and the downstream reception Port of a hop. This delay is measured between:

a) The time at which a particular octet of a frame passed the boundary from the upstream transmission Port to the network physical medium and
b) The time at which this particular octet passed the boundary from the network physical medium to the downstream Port.

The maximum media-dependent delay of the *k*th hop is denoted as $d_{MD,\,max}(k)$ and assumed to be known for analysis.

Variations in media-dependent delays do not affect the combined delay bounds in V.9. Such variations happen before the arrival time recognition by the associated ATS scheduler clock and the processing by the associated ATS scheduler instance. A frame that experiences a lower media-dependent delay than an earlier frame processed by the same scheduler instance would be delayed by scheduler, if required by envelope enforcement.

V.5 Bridge—Internal arrival time recognition delays

The maximum arrival time recognition delay in the upstream Bridge of the *k*th hop ($k > 1$) for any frame of a stream is given by the associated ArrivalRecognitionDelayMax parameter (8.6.11.3.1, 12.31.8.5). For compact representation and notational consistency, ArrivalRecognitionDelayMax is subsequently denoted as $d_{AT,\,max}(k)$.

Variations in arrival time recognition delays do not affect the combined delay bounds in V.9, similar to variations in media-dependent delays (V.4).

V.6 Bridge—Internal processing delays

The bounds on the processing delays in the upstream Bridge of the *k*th hop ($k > 1$) for any frame of a stream are given by the associated ProcessingDelayMin and ProcessingDelayMax parameters (8.6.11.3.2, 12.31.8.6, 12.31.8.7). The associated ProcessingDelayMin and ProcessingDelayMax parameters are subsequently denoted as $d_{PR,\,min}(k)$ and $d_{PR,\,max}(k)$, respectively.

Variations in Bridge-internal processing delays can increase the burst sizes in buffering delays (V.3). Based on the specified computation of the assigned eligibility time (8.6.11.3.2), these variations reside within the associated clock offset variations (V.7).

NOTE—The total of the maximum arrival time recognition delay and the maximum processing delay is different from the associated maximum independent delay found in the Bridge Delay attributes (12.32.1.1). This total can be larger.

V.7 Bridge—Internal clock offset variations

The maximum clock offset variation in the upstream Bridge of the *k*th hop ($k > 1$) for any frame of a stream is given by the associated ClockOffsetVariationMax parameter (8.6.11.2, 12.31.8.3). The associated ClockOffsetVariationMax is subsequently denoted as $\Delta_{CO,\,max}(k, g)$.

Clock offset variations of up to $d_{AT,\,max}(k)$ between ATS scheduler clock and transmission selection clock instances (8.6.11.2) associated with a stream *g* can increase the burst size of streams subsequently competing in the transmission Port.

This impact can be taken into account by definition of $b_{max}(k, g)$ for $k > 1$, as shown in Equation (V-4).

$$b_{max}(k, g) = r_{max}(k, g)\Delta_{CO,\,max}(k, g) + b_{max}(1, g) \tag{V-4}$$

where $b_{max}(1, g)$ is the committed burst size of stream *g* at the Talker station (47.2).

V.8 Inter-device clock rate deviations

The clock constraints in 8.6.11 limit ATS scheduler clock instances and transmission selection clock instances in a Bridge to effectively operate at the same rate, although differences within [ClockOffsetMin,ClockOffsetMax] are permitted (8.6.11.2). As a basic property of asynchronous mechanisms such as ATS, no such limitation exists between different devices (i.e., clocks in different devices are not synchronized).

Deviations of clocks from their nominal rates (e.g., within oscillator tolerances) affect the spacing between successive frames according to the assigned eligibility times (8.6.11.3.2, 8.6.8.5). If the upstream device at a hop runs faster than nominal (e.g., +100 ppm), and a connected downstream Bridge at this hop runs slower than nominal (e.g., –100 ppm), the backlog as well as the per hop delay in the downstream Bridge could grow under peak load conditions.

The situation can be prevented by management constraints (12.31.5) on $r_{max}(k, g)$ for $1 < k < n$, such that Equation (V-5) holds for any stream *g*.

$$r_{max}(k, g) \geq \frac{1 + 10^{-6}\Delta_{CR,\,max}(k-1)}{1 - 10^{-6}\Delta_{CR,\,max}(k)} r_{max}(k-1, g) \tag{V-5}$$

where

$\Delta_{CR,\,max}(k)$ is the upper bound over all absolute rate deviations of all ATS scheduler clocks and transmission selection clocks from their nominal rate in the upstream device of the *k*th hop available via the associated ClockRateDeviationMax parameter (12.31.8.4), in ppm (e.g., $\Delta_{CR,\,max}(k) = 100$)

$r_{max}(1, g)$ is the committed information rate of stream *g* at the Talker station (47.2)

V.9 Combined delay bounds

For a path from a Talker station to a Listener station with at least one Bridge ($n > 1$), a combined end-to-end delay bound $d_{max}(f)$ of a stream of interest *f* can be summarized by Equation (V-6)

$$d_{max}(f) = \sum_{k=1}^{n} d_{BU,\,max}(k, f) + \sum_{k=1}^{n} d_{MD,\,max}(k) + \sum_{k=2}^{n} d_{AT,\,max}(k) + \sum_{k=2}^{n} d_{PR,\,max}(k) \tag{V-6}$$

with Equation (V-7), Equation (V-8), and Equation (V-9) for $1 < k < n$.

$$d_{BU,\,max}(1, f) = \max_{h \in F_S(1,f)} \left\{ \frac{\sum_{g \in F_H(1,h) \cup F_S(1,h)} b_{max}(1, g) - l_{min}(h) + l_{LP,\,max}(1, h)}{R(1) - \sum_{g \in F_H(1,h)} r_{max}(1, g)} + \frac{l_{min}(h)}{R(1)} \right\} \tag{V-7}$$

$$d_{BU,\,max}(n, f) = \frac{\sum_{g \in F_H(n,f) \cup F_S(n,f)} (r_{max}(n, g)\Delta_{CO,\,max}(n, g) + b_{max}(1, g)) - l_{min}(f) + l_{LP,\,max}(n, f)}{R(n) - \sum_{g \in F_H(n,f)} r_{max}(n, g)} + \frac{l_{min}(f)}{R(n)} \tag{V-8}$$

$$d_{BU,\,max}(k, f) = \max_{h \in F_S(k,f)} \left\{ \frac{\sum_{g \in F_H(k,h) \cup F_S(k,h)} (r_{max}(k, g)\Delta_{CO,\,max}(k, g) + b_{max}(1, g)) - l_{min}(h) + l_{LP,\,max}(k, h)}{R(k) - \sum_{g \in F_H(k,h)} r_{max}(k, g)} + \frac{l_{min}(h)}{R(k)} \right\} \tag{V-9}$$

In absence of Bridges on the path from the Talker station to the Listener station (i.e., $n = 1$), the end-to-end delay bound can be summarized by Equation (V-10).

$$d_{max}(1, f) = \frac{\sum_{g \in F_H(1,f) \cup F_S(1,f)} b_{max}(1, g) - l_{min}(f) + l_{LP,\,max}(1, f)}{R(1) - \sum_{g \in F_H(1,f)} r_{max}(1, g)} + \frac{l_{min}(f)}{R(1)} + d_{MD,\,max}(1) \tag{V-10}$$

Annex W

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] Alizadeh, M., B. Atikoglu, A. Kabbani, A. Lakshmikantha, R. Pan, B. Prabhakar, and M. Seaman, "Data Center Transport Mechanisms: Congestion Control Theory and IEEE Standardization," *Proceedings of the 46th Annual Allerton Conference on Communication, Control and Computing*, Urbana-Champaign, Sept. 2008.

[B2] Asynchronous Transfer Mode (ATM): A collection of equipment and standards used for telecommunications and data transfer, https://www.itu.int/ITU-T/ and https://www.broadband-forum.org.

[B3] Calculating the Delay Added by Qav Stream Queue, https://www.ieee802.org/1/files/public/docs2009/av-fuller-queue-delay-calculation-0809-v02.pdf.

[B4] IEC 62439-3:2016, Industrial communications networks—High availability automation networks—Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR).[67]

[B5] IEEE Std 802™-2014, IEEE Standard for Local and Metropolitan Area Networks—Overview and Architecture.[68, 69]

[B6] IEEE Std 802.1AB™-2005, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

[B7] IEEE Std 802.1AB™-2009, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

[B8] IEEE Std 802.1AC™-2016, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

[B9] IEEE Std 802.1BA™, IEEE Standard for Local and Metropolitan Area Networks—Audio Video Bridging (AVB) Systems.

[B10] IEEE Std 802.1D™, 1993 Edition [ISO/IEC 10038:1993], IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local area networks—Media Access Control (MAC) bridges.

[B11] IEEE Std 802.1D™, 1998 Edition [ISO/IEC 15802-3:1998], IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Common specifications—Part 3: Media Access Control (MAC) Bridges.

[B12] IEEE Std 802.1D™-2004, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Bridges.

[67] IEC publications are available from the International Electrotechnical Commission (https://www.iec.ch) and the American National Standards Institute (https://www.ansi.org/).

[68] The IEEE standards or products referred to in Annex W are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

[69] IEEE publications are available from The Institute of Electrical and Electronics Engineers (https://standards.ieee.org/).

[B13] IEEE Std 802.3™-2018, IEEE Standard for Ethernet.

[B14] IEEE Std 802.11™-2016, IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

[B15] IEEE Std 1588-2019, IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurements and Control Systems.

[B16] IEEE Std 1722™, IEEE Standard for a Transport Protocol for Time-Sensitive Applications in Bridged Local Area Networks.

NOTE—See also IEC 61883-6:2005, Consumer audio/video equipment—Digital Interface—Part 6: Audio and music data transmission protocol and IEC 61883-4:2004, Consumer audio/video equipment—Digital Interface—Part 4: MPEG2-TS data transmission.

[B17] IETF RFC 768 (STD0006), User Datagram Protocol, August 1980.[70]

[B18] IETF RFC 791, Internet Protocol—DARPA Internet Program Protocol Specification, September 1981.

[B19] IETF RFC 793 (STD0007), Transmission Control Protocol, September 1981.

[B20] IETF RFC 1321, The MD5 Message-Digest Algorithm, April 1992.

[B21] IETF RFC 1633, Integrated Services in the Internet Architecture: an Overview, June 1994.

[B22] IETF RFC 2210, The Use of RSVP with IETF Integrated Services, September 1997.

[B23] IETF RFC 2211, Specification of the Controlled-Load Network Element Service, September 1997.

[B24] IETF RFC 2212, Specification of Guaranteed Quality of Service, September 1997.

[B25] IETF RFC 2215, General Characterization Parameters for Integrated Service Network Elements, September 1997.

[B26] IETF RFC 2475, An Architecture for Differentiated Services, December 1998.

[B27] IETF RFC 2597, Assured Forwarding PHB Group, June 1999.

[B28] IETF RFC 2814, SBM (Subnet Bandwidth Manager): A Protocol for RSVP-based Admission Control over IEEE 802-style Networks, May 2000.

[B29] IETF RFC 2815, Integrated Service Mappings on IEEE 802 Networks, May 2000.

[B30] IETF RFC 2816, A Framework for Integrated Services Over Shared and Switched IEEE 802 LAN Technologies, May 2000.

[B31] IETF RFC 3031, Multiprotocol Label Switching Architecture, January 2001.

[B32] IETF RFC 3246, An Expedited Forwarding PHB (Per-Hop Behavior), March 2002.

[B33] IETF RFC 3270, Multi-Protocol Label Switching (MPLS) Support of Differentiated Services, May 2002.

[B34] IETF RFC 4655, A Path Computation Element (PCE)-Based Architecture, August 2006.

[70] IETF RFCs are available from the Internet Engineering Task Force (https://www.ietf.org/).

[B35] IETF RFC 4663, Transferring MIB Work from IETF Bridge MIB WG to IEEE 802.1 WG, September 2006.

[B36] IETF RFC 4960, Stream Control Transmission Protocol, September 2007.

[B37] IETF RFC 5306, Restart Signaling for IS-IS, October 2008.

[B38] IETF RFC 6087, Guidelines for Authors and Reviewers of YANG Data Model Documents, January 2011.

[B39] IETF RFC 6241, Network Configuration Protocol (NETCONF), June 2011.

[B40] IETF RFC 6242, Using the NETCONF Protocol over Secure Shell (SSH), June 2011.

[B41] IETF RFC 6536, Network Configuration Protocol (NETCONF) Access Control Model, March 2012.

[B42] IETF RFC 6762, Multicast DNS, February 2013.

[B43] IETF RFC 7223, A YANG Data Model for Interface Management, May 2014.

[B44] IETF RFC 7319, IANA Considerations for Connectivity Fault Management (CFM) Code Points, July 2014.

[B45] IETF RFC 8040, RESTCONF Protocol, January 2017.

[B46] IETF RFC 8200 (STD0086), Internet Protocol, Version 6 (IPv6) Specification, July 2017.

[B47] ITU-T Recommendation G.806, Characteristics of transport equipment—Description methodology and generic functionality.[71]

[B48] ITU-T Recommendation G.8031/Y.1342, Ethernet linear protection switching.

[B49] ITU-T Recommendation I.610 (02/1999), B-ISDN operation and maintenance principles and functions.

[B50] ITU-T Recommendation X.25 (10/1996), Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.

[B51] MEF Technical Specification 4 (MEF 4), Metro Ethernet Network Architecture Framework—Part 1: Generic Framework, May 2004.[72]

[B52] MEF Technical Specification 16 (MEF 16), Ethernet Local Management Interface (E-LMI), January 2006.

[B53] MEF Technical Specification 26 (MEF 26), External Network Network Interface (ENNI)—Phase 1, January 2010.

[B54] MEF 35.1, Service OAM Performance Monitoring Implementation Agreement.

[B55] MoCA MAC/PHY Specification Extensions v1.1, MoCA-M/P-SPEC-V1.1-06162009, June 2009.[73]

[B56] MoCA MAC/PHY Specification v2.0, MoCA_Specification_v2-131121, November 2013.

[71] ITU-T publications are available from the International Telecommunications Union (https://www.itu.int/).
[72] MEF publications are available from the MEF Forum (https://www.mef.net/).
[73] MoCa publications are available from the Multimedia over Coax Alliance (https://mocalliance.org).

[B57] Multiprotocol Label Switching (MPLS): A standard for label-based forwarding in an IP network. The standard is specified in several RFCs, (see https://datatracker.ietf.org/doc/charter-ietf-mpls/) and ITU-T recommendations (see https://www.itu.int/ITU-T/).

[B58] OMG Unified Modeling Language (OMG UML), Version 2.5.1, December 2017.

[B59] Seaman, M., "Preemption and MACsec replay protection," available at https://www.ieee802.org/1/files/public/docs2014/ae-seaman-preemption-1114-v04.pdf, November 2014.

[B60] SMPTE 259M-2008, SMPTE Standard for Television—SDTV Digital Signal/Data—Serial Digital Interface, 2008. See section 8.[74]

[B61] SMPTE 292M-2008, SMPTE Standard 1.5 Gb/s Signal/Data Serial Interface, 2008.

[B62] SMPTE 424M-2012, SMPTE Standard for Television—3 Gb/s Signal/Data Serial Interface.

[B63] Specht, J., and S. Samii, "Urgency-Based Scheduler for Time-Sensitive Switched Ethernet Networks," *28th Euromicro Conference on Real-Time Systems (ECRTS)*, pp. 75–85, 2016.

[B64] Teener, M. J., "Peristaltic Shaper: updates, multiple speeds," available at https://www.ieee802.org/1/files/public/docs2014/new-tsn-mjt-peristaltic-shaper-0114.pdf, January 2014.

[B65] Xu, L., K. Harfoush, and I. Rhee, "Binary increase congestion control (BIC) for fast long-distance networks," *IEEE INFOCOM 2004*, vol. 4, pp. 2514-2524, Mar. 2004.

[74] SMPTE publications are available from the Society of Motion Picture and Television Engineers (https://www.smpte.org).

IEEE SA
STANDARDS ASSOCIATION

RAISING THE WORLD'S STANDARDS

Connect with us on:

Twitter: twitter.com/ieeesa
Facebook: facebook.com/ieeesa
LinkedIn: linkedin.com/groups/1791118
Beyond Standards blog: beyondstandards.ieee.org
YouTube: youtube.com/ieeesa

standards.ieee.org
Phone: +1 732 981 0060

IEEE