



GLINT Gamma

A 3D Geometry and Lighting Processor for the PC

Neil Trevett
Vice President, Marketing
NASDAQ:TDDDF
www.3dlabs.com



3D*labs*



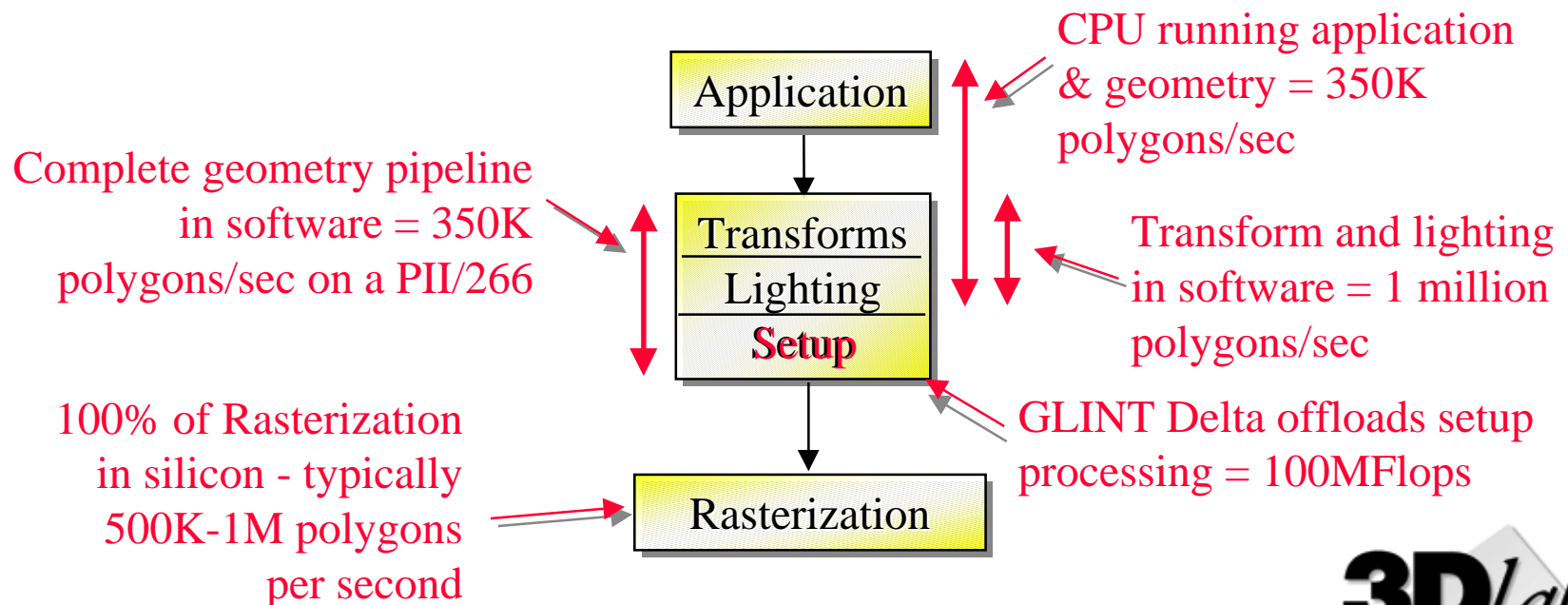
Agenda

- A backgrounder to the 3D geometry pipeline
- System considerations for 3D geometry acceleration
- GLINT Gamma architecture overview
- GLINT Gamma detailed architecture
- Board design examples using GLINT Gamma

Geometry is the PC's 3D Bottleneck

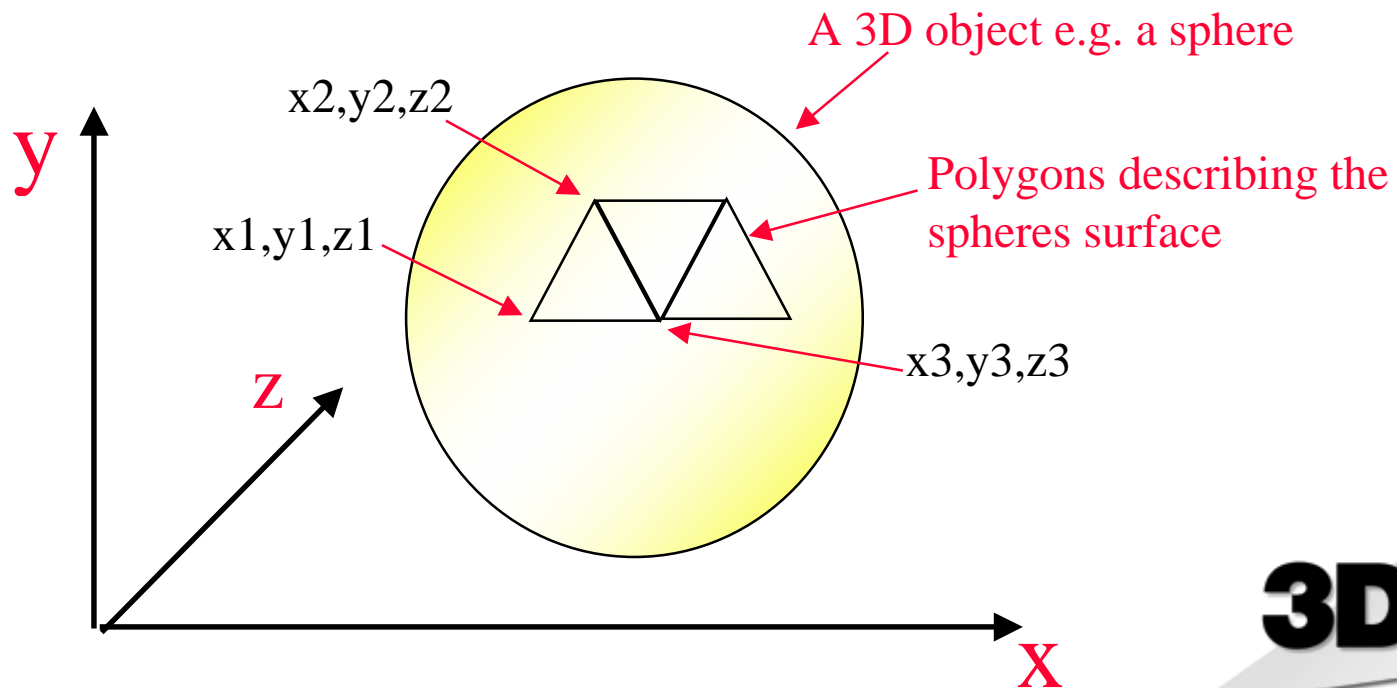
The last difference between 3D workstations and PCs

- The fastest CPU *cannot* keep today's rasterization silicon saturated if running the geometry in software
- Professional 3D is particularly demanding
 - Many small polygons used for precise modeling of surfaces
 - Viewperf uses polygons less than 1 pixel in size



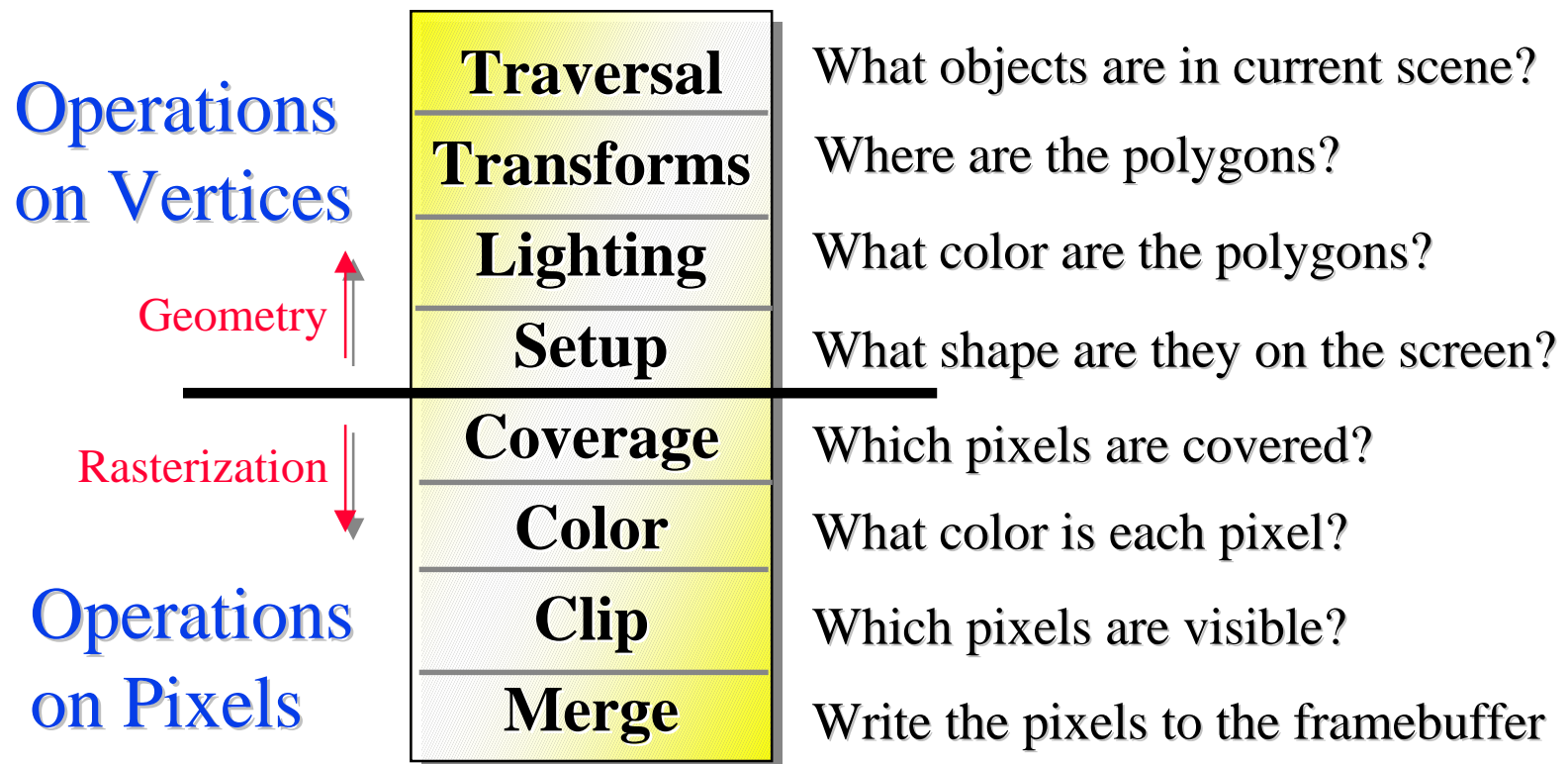
What is a 3D Object?

- Surfaces of objects are described as a grid of polygons
- The vertices of the polygons are located in 3D coordinate space - x, y, z
- The objects making up a scene are held in a database



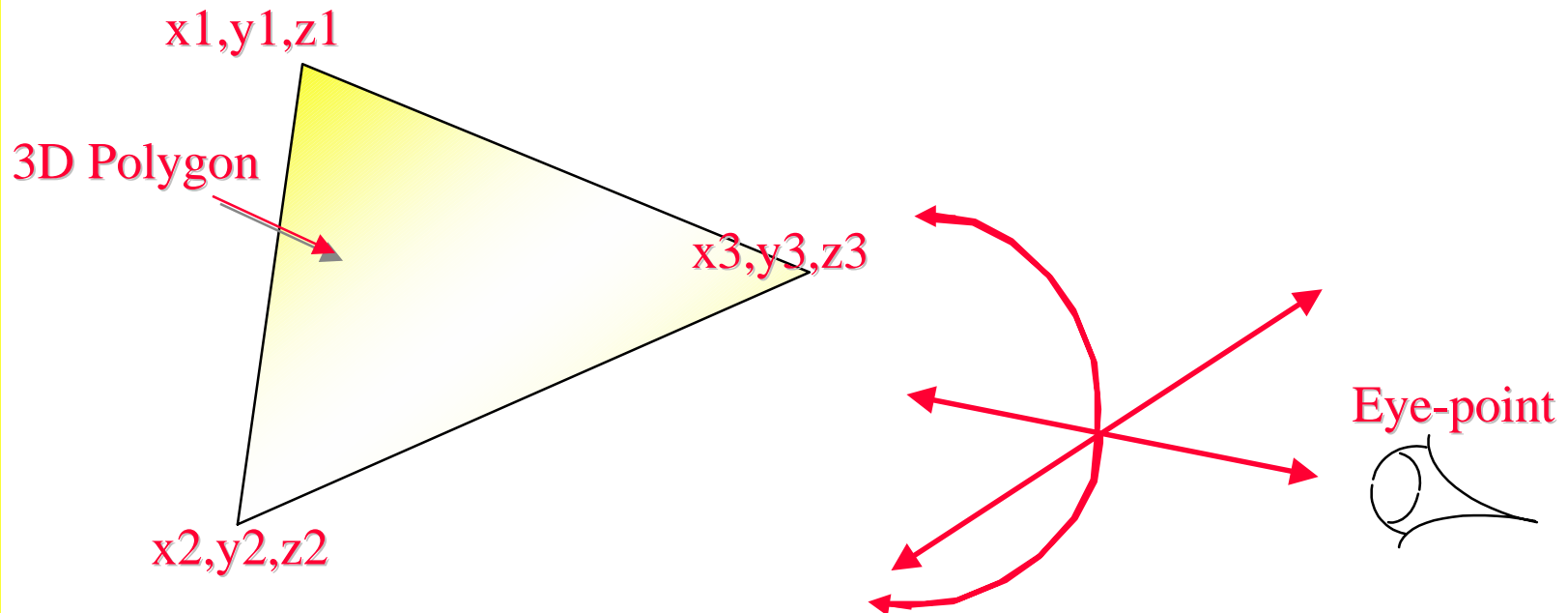
3D Processing Stages

The journey from database to screen



Transform Processing

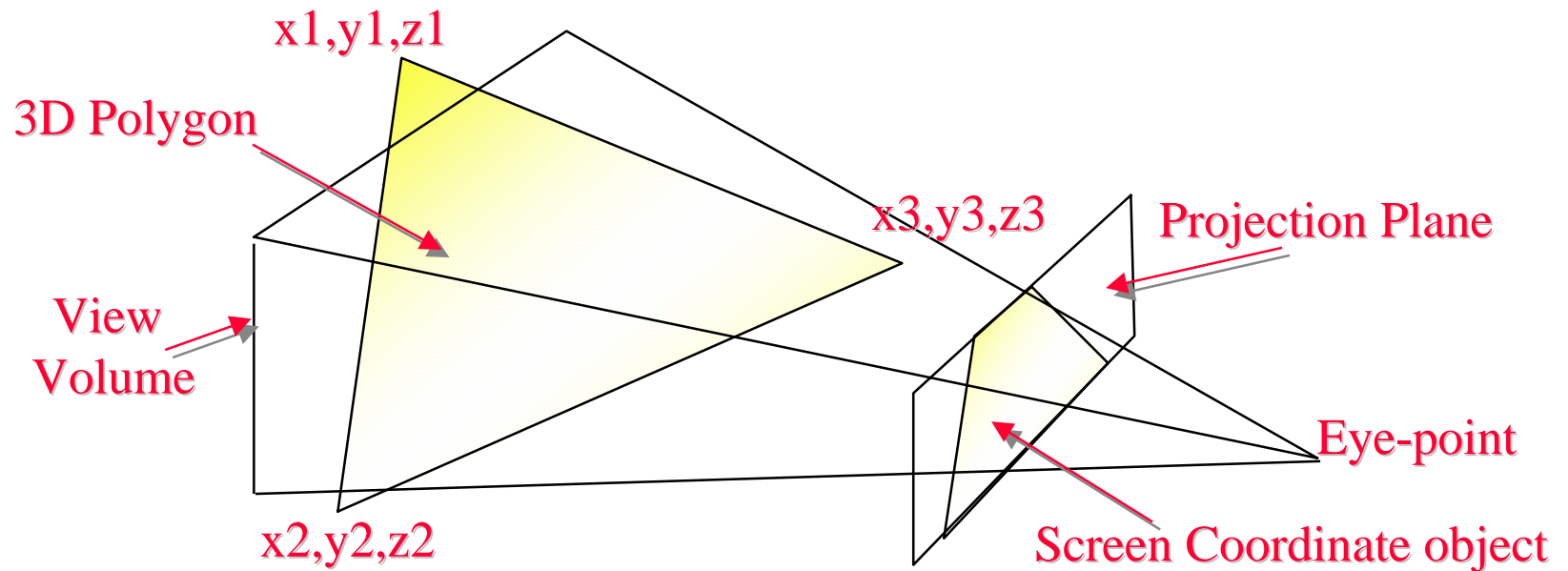
Positioning objects in a scene



- Input = the vertices of all objects in the scene in a database
- Output = list of visible vertices, correctly positioned
- Transform for eye-point - 4x4 Matrix Multiplications
 - Allows positioning with six degrees of freedom
- Lots of floating point operations!

Transform Processing

View Volume clipping and the Projection Plane

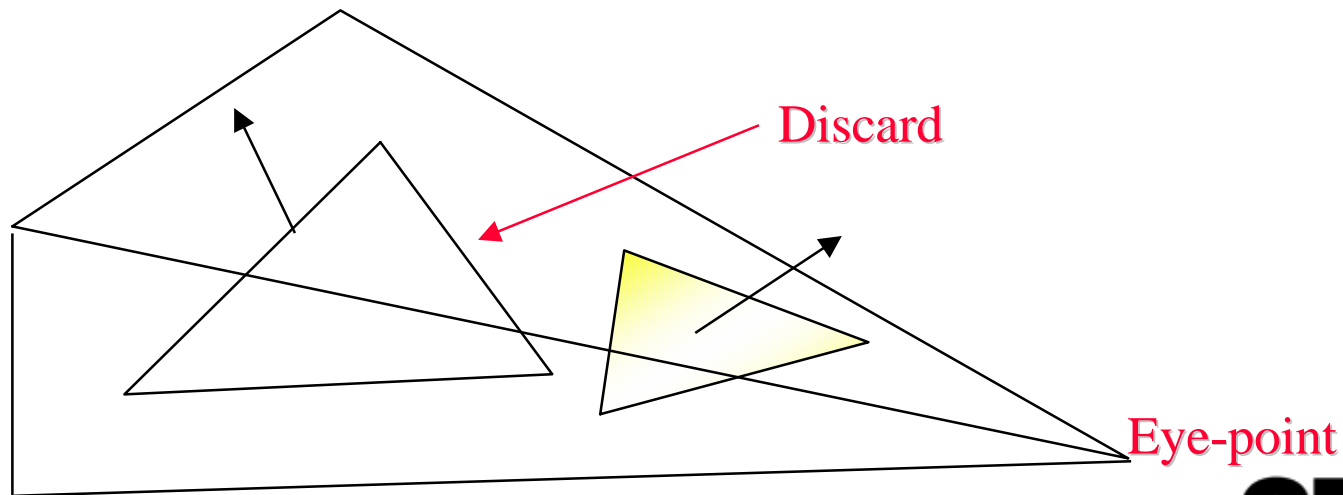


- Project onto Projection Plane - Trigonometry
- Clip against view volume - More Trigonometry

Geometry Efficiencies

View Volume Culling and Backface Culling

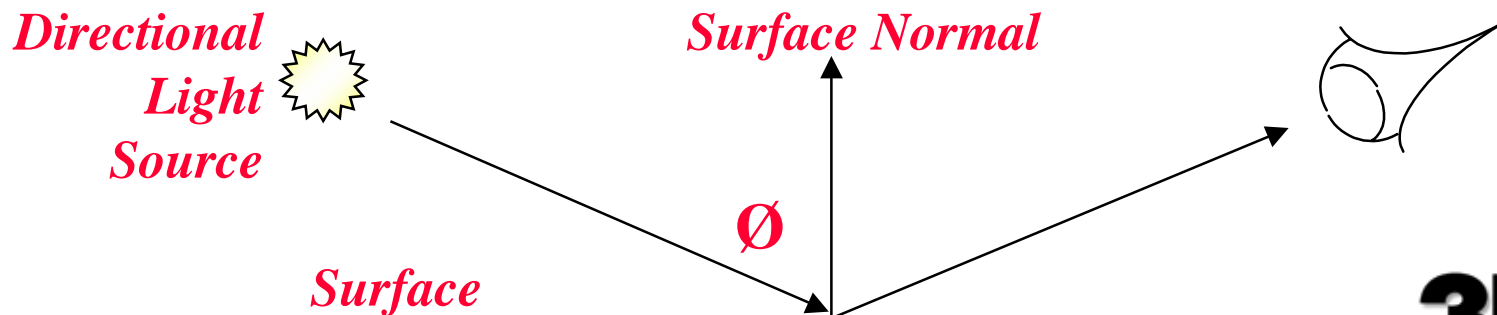
- View Volume culling can eliminate the majority of polygons in a scene trivially - it's behind you!
- The other big win is: Backface Culling
 - Normally polygons are “one-sided”
 - Polygons with normals pointing away from the eyepoint are invisible
 - The geometry pipeline can discard backfacing polygons
 - About 50% of the polygons in most real models are backfacing



Lighting Equation

Calculating the color of each vertex

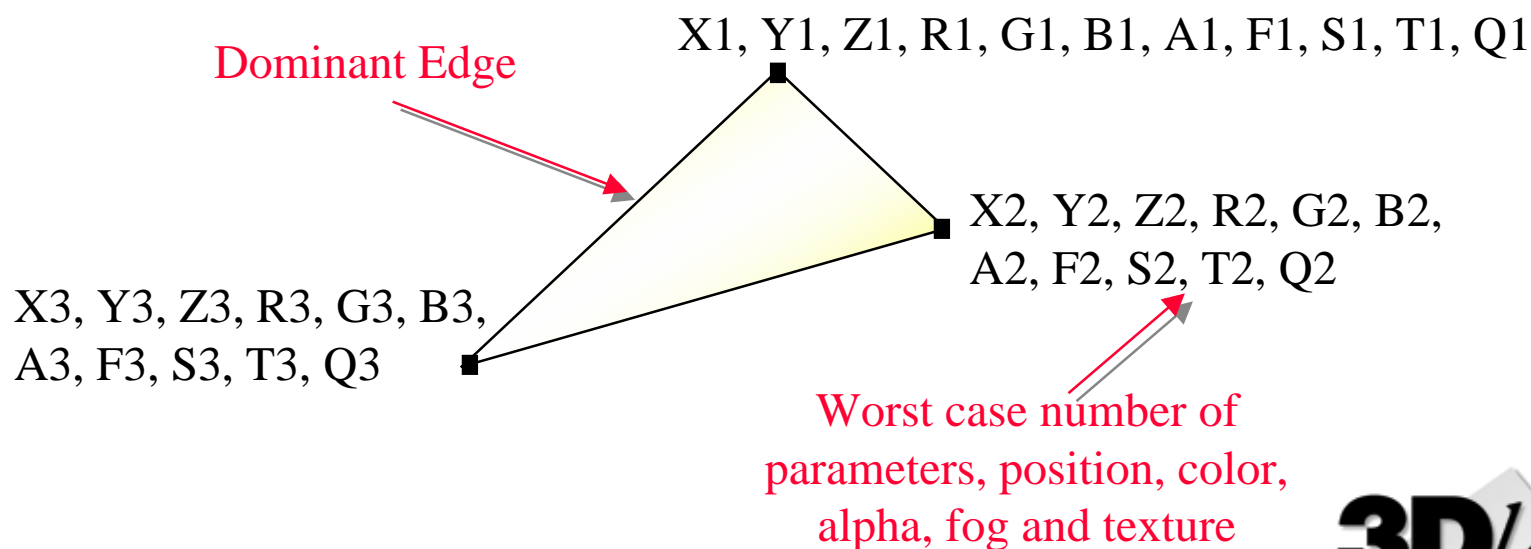
- Objects are lit by one or more light sources
 - Ambient light: non-directional, has a color
 - Directional lights: with position, direction and color
- Surfaces have reflective properties
 - Diffuse reflection coefficient: independent of angle
 - Specular reflection coefficient: depends on angle, gives glinting highlights
- Color - $I_a.K_a + I_d.K_f + I_d.K_s.\cos\theta$



Setup Calculations

Preparing for rasterization

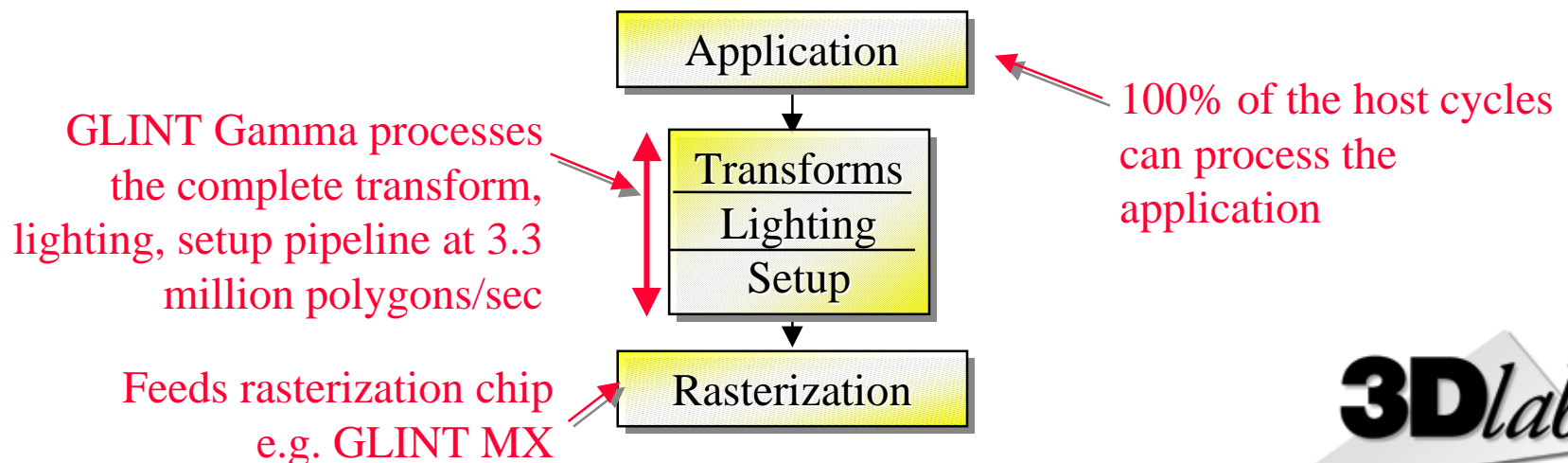
- Take screen coordinates of vertices
 - In floating point format
- Calculate slope and delta information
 - For each interpolant need to calculate StartI, dIdx, dIdyDom
- Converts to sub-pixel accurate fixed point format



GLINT Gamma

Complete Geometry Processing in a chip

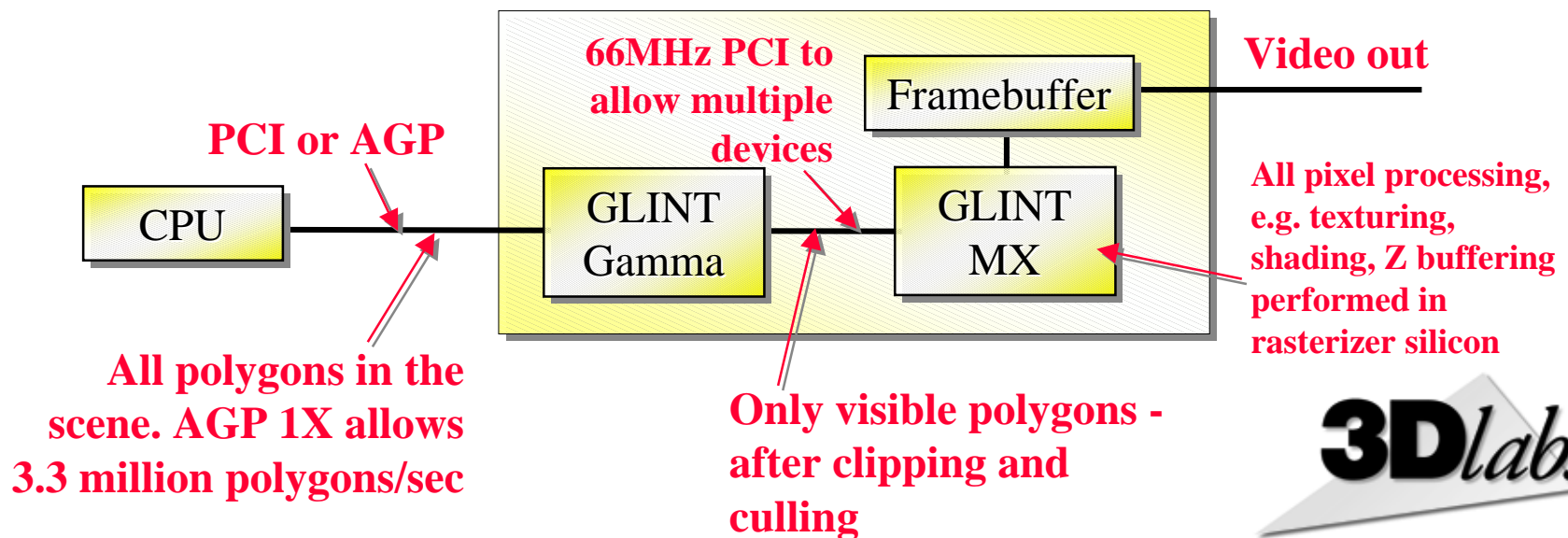
- GLINT Gamma integrates 100% of the geometry pipeline
 - At a price point suitable for PCs
- 3.3 million polygons/sec needs *2,000MFlops*
 - With full transformations and lighting enabled
 - 50% backface culled
- Host is free to process the application
 - GLINT Gamma will have a bigger effect on typical application performance than faster pixel fill-rates



System Design Using GLINT Gamma

Hardware preprocessing for rasterization silicon

- GLINT Gamma reads and processes polygon command stream
 - Outputs command stream for a rasterizer processor e.g. GLINT MX
- 33MHz PCI is not fast enough for host connection
 - Full 33MHz PCI bandwidth only supports 1.5 million polygons/sec
 - AGP enables the full 3.3 million polygons/sec performance
 - Need AGP's sideband addressing for optimized vertex fetching
- Use 66MHz PCI Connection to rasterizer
 - Can guarantee 66MHz on-board operation, and allows multiple devices



GLINT Gamma Functional Pipeline

Parameter fetch to fog

- Input DMA controller fetches parameters
 - Performs address translation
- OpenGL Begin/End paradigm
 - Points, Lines, Line loop, Line strip, Triangles, Triangle strip, Triangle fan, Quads, Quad strips
- Full geometry transformation processing
 - Vertex (View Model and Projection matrix)
- Texture Coordinate Generation
 - Spherical, Object linear, Eye linear
- Fog calculations
 - Linear, Exponential and Exponential Squared

Parameter Fetch
Primitive Processing
Transforms
Texture
Coordinates
Fog Calculations
Clipping
Lighting
Setup

GLINT Gamma Functional Pipeline

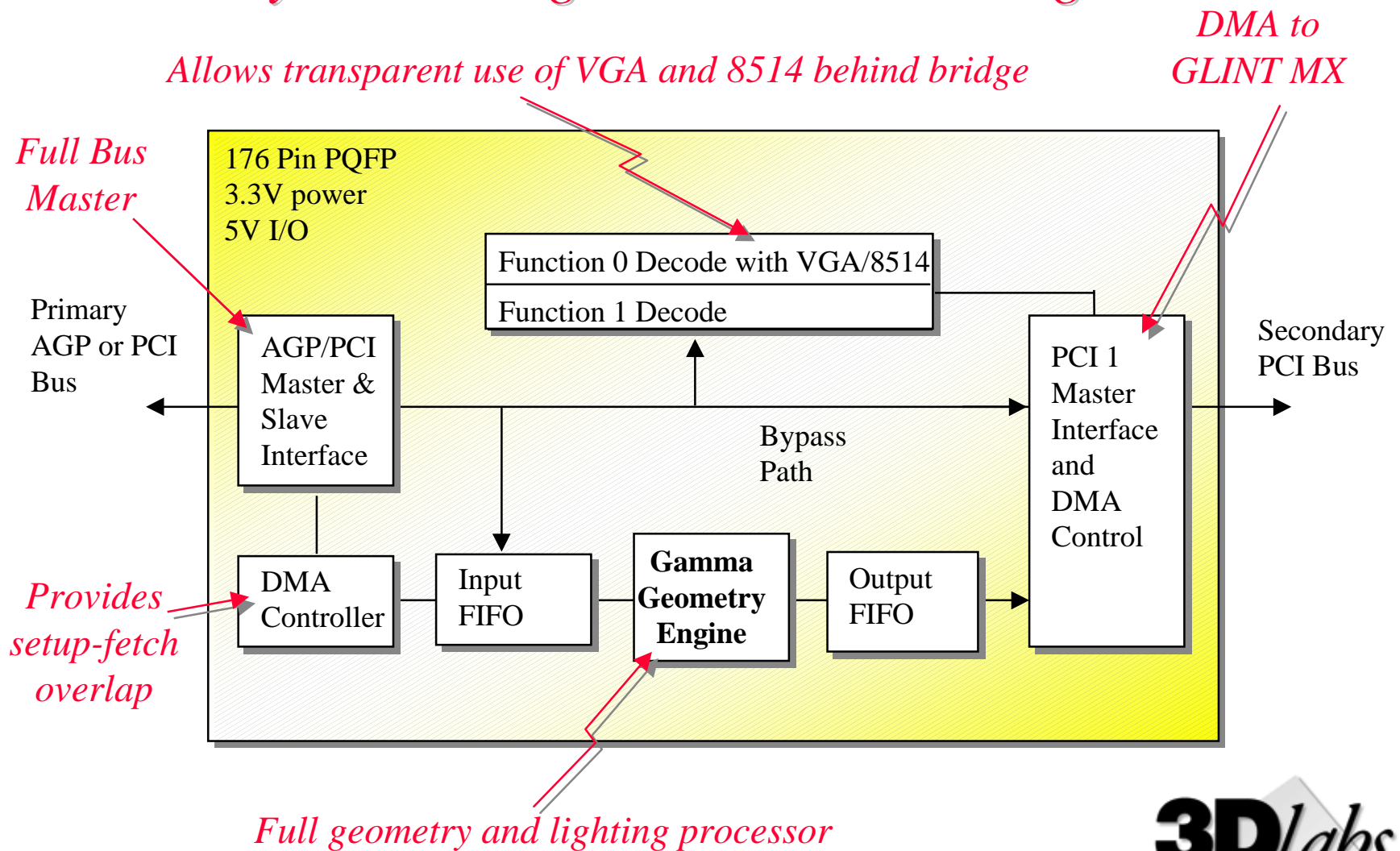
Clipping to Setup

- Full Clipping
 - Frustrum clipping
 - Six user clip planes
 - Backface culling
- Full lighting calculations
 - Up to 16 Light sources
 - Soft degrade to unlimited number of lights
 - Point or directional lights
 - Local lights, Spot lights, Attenuated Lights
 - Two-side lighting
- Triangle, Line and Point Set Up
 - Same as GLINT Delta, but faster
 - Aliased or anti-aliased
 - Stippled or non-stippled

Parameter Fetch
Primitive Processing
Transforms
Texture Coordinates
Fog Calculations
Clipping
Lighting
Setup

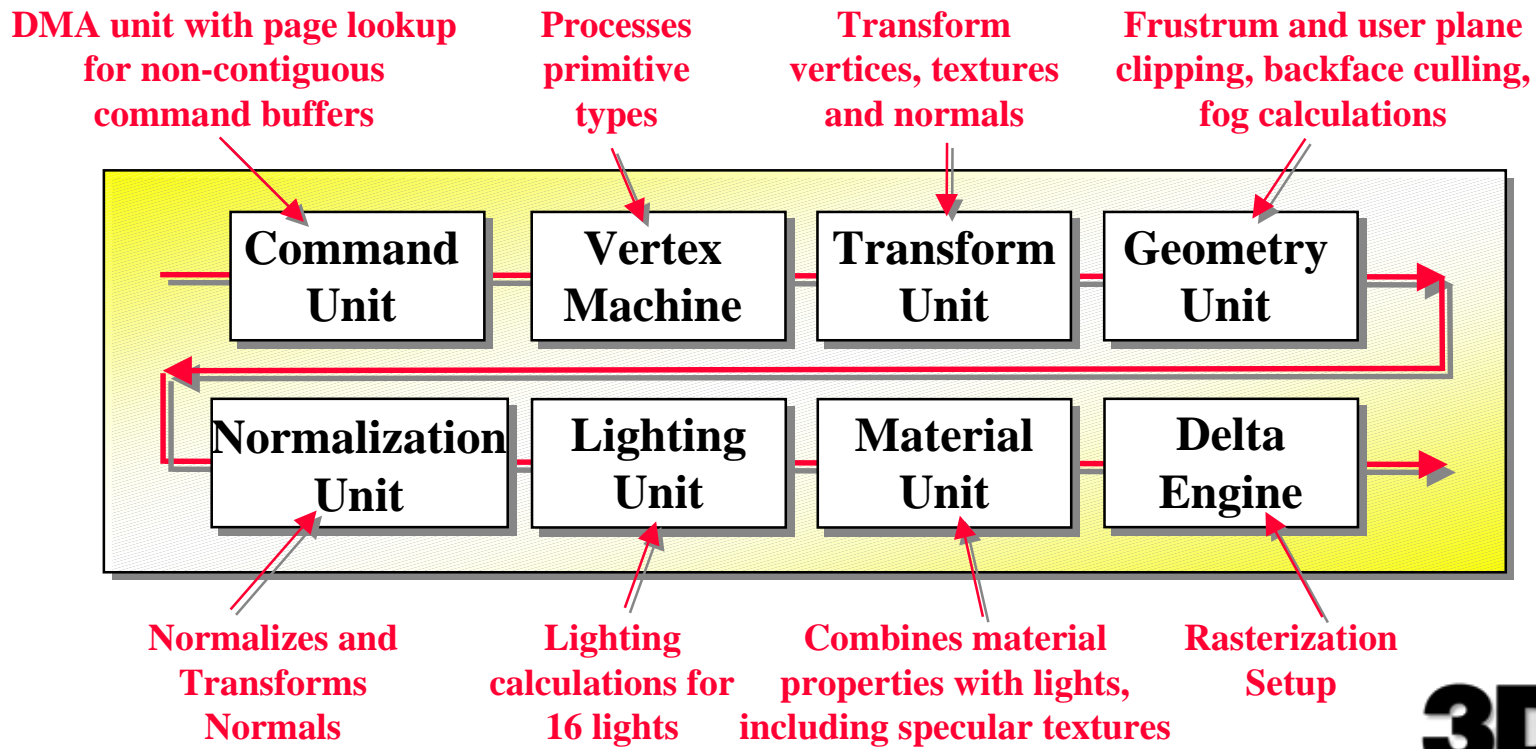
GLINT Gamma Architecture

Geometry Processing in a AGP/PCI Bridge



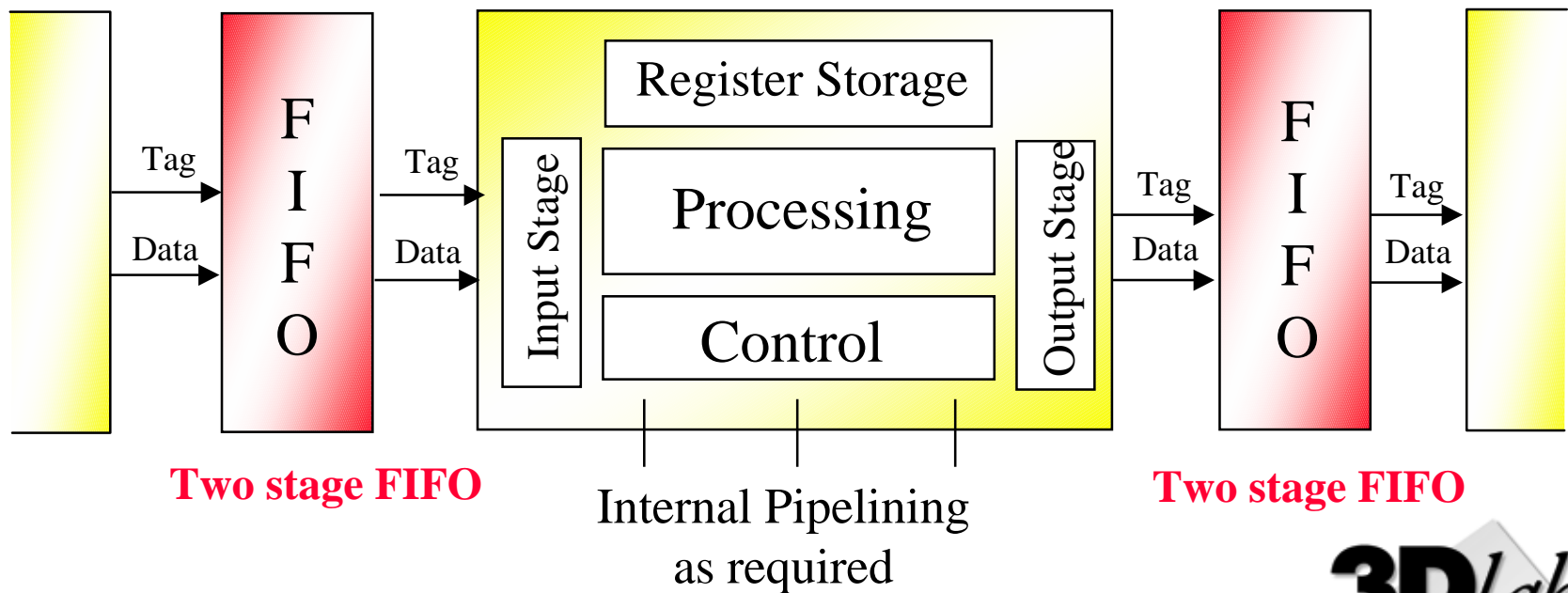
GLINT Gamma Pipeline

- Pipeline of function units
- Message passing protocol between units
- Each unit heavily-pipelined internally
- 150 total pipeline stages through the chip



Function Unit Structure

- The unit pipeline uses a message passing paradigm
- A message is made up of a tag field and a data field
 - 11 bit tag identifies the message type
 - 128 bit data holds four 32 bit floats = complete vertex eg rgba or xyzw
- The unit processes each message according to message type



GLINT Gamma is Hardwired

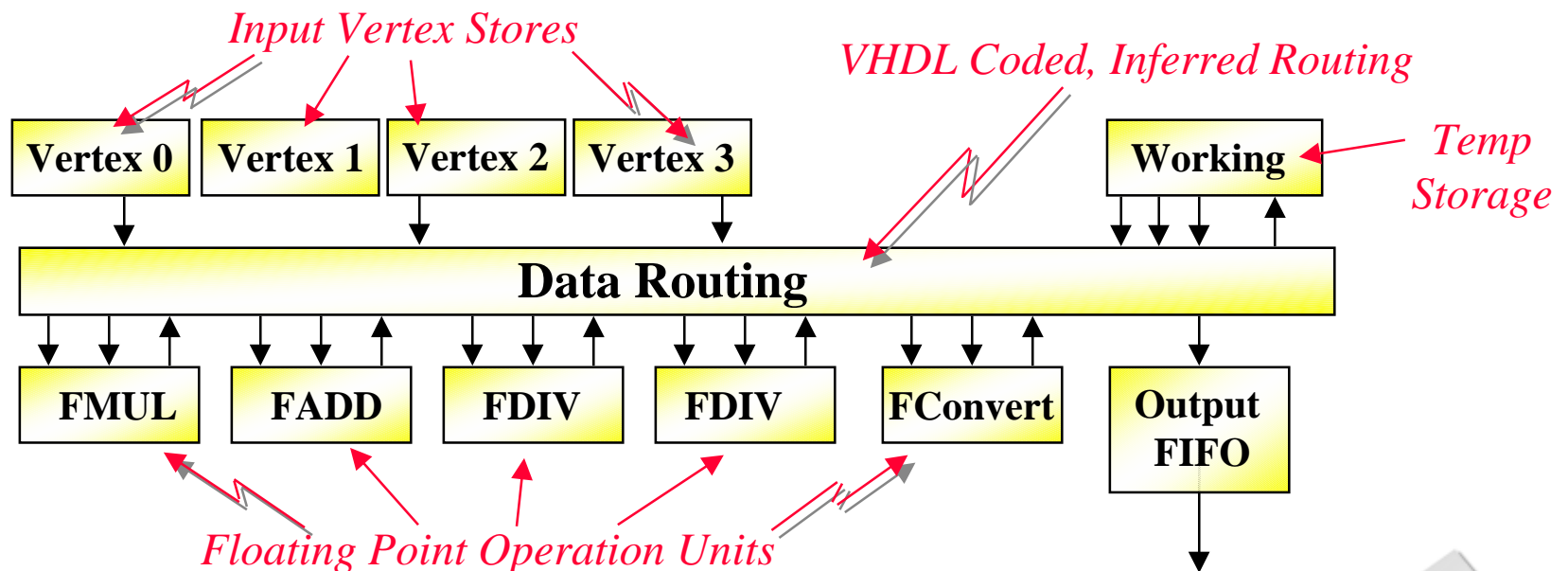
Maximum performance per \$

- 3D Geometry is well-understood
 - Don't need the luxury of programmability
- Functionality encompasses 100% of all key APIs
 - OpenGL 1.1, Direct 3D, Heidi and QuickDraw 3D
- Control in GLINT Gamma is a VHDL state machine
 - No RAM or ROM for program storage (less gates)
 - No program sequencer or instruction set (less gates)
 - No program fetch (less memory bandwidth)
- Data paths are inferred directly from VHDL
 - No general purpose routing costs
- 3Dlabs design technology enables devices of this complexity
 - Rapid conversion of floating point algorithms into hardwired silicon
 - Design tools first used to develop GLINT Delta

Typical Unit Processing Structure

Hardwired processing

- All operations are IEEE compatible
 - NAN handling not implemented
- Type and number of operation units varies from unit to unit



Total Floating Point Units

- All units are independent
- All units can be used simultaneously
 - No restriction on mix of operations
- Latency varies according to the unit

# Units	Type of Units	Throughput (cycles/result)
15	Multipliers	1
10	Adders,	1
25	Misc. conv. and comparators	1
4	Divide	5
1	Power	5
2	Inverse Square root	10

GLINT Gamma

Physical and Project Characteristics

- IBM CMOS 5S6 $.35\mu$, 4 layer metal
- 176 pin PQFP
- 66MHz, 5 watts

- 8 man years design time
- 600 page design specification

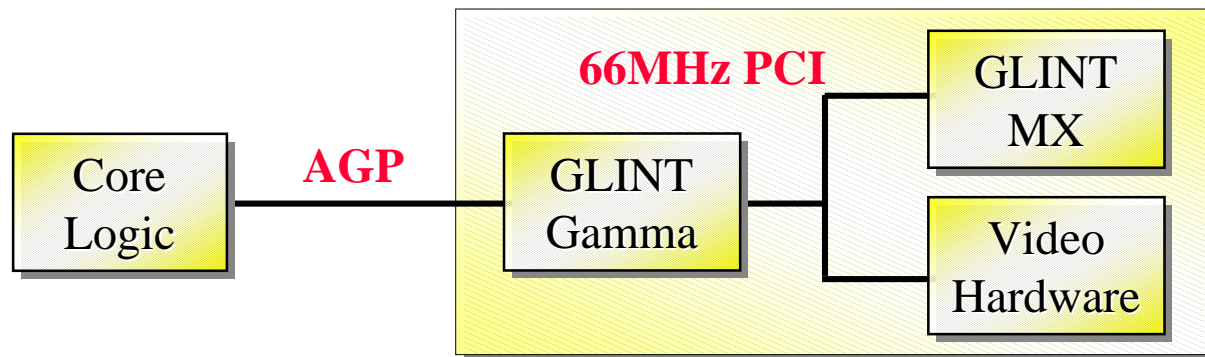
- Over 1 million gates
 - FP operators - 35%
 - Registers - 15%
 - Random logic - 50%



GLINT Gamma as AGP Bridge

Multi-function AGP Boards

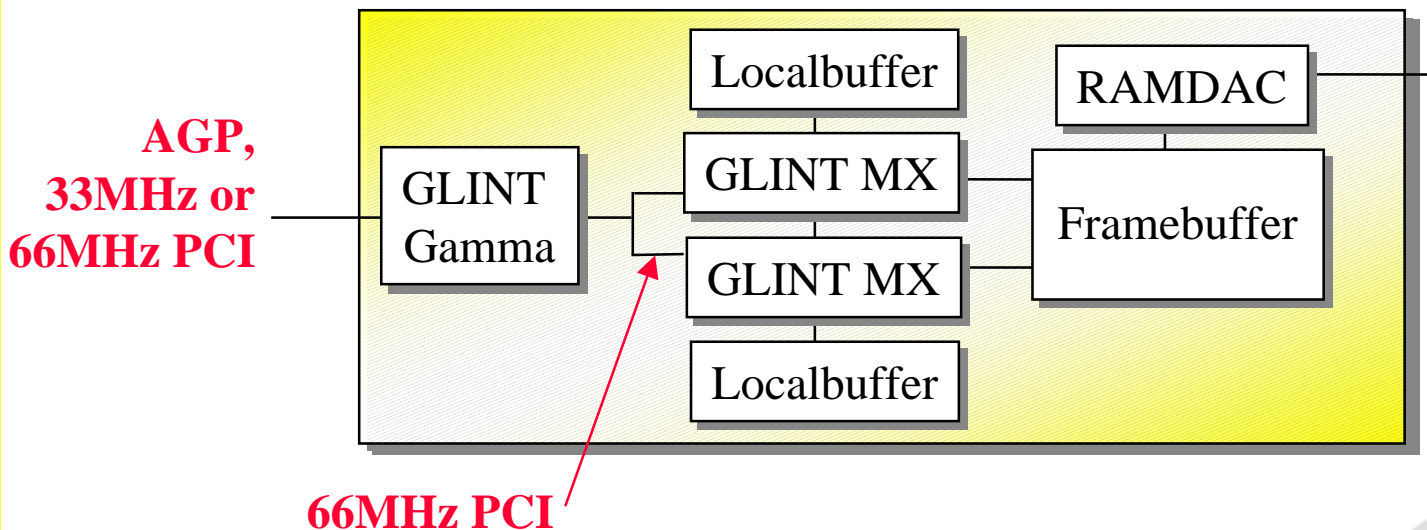
- AGP is point-to-point connection only
 - Only one slot and only one device on the AGP bus
 - Makes multi-functions on AGP problematic
- GLINT Gamma acts as a full AGP bridge
 - Multiple devices on an AGP board can access main memory
 - Via internal 66MHz PCI bus
- Enables multi-function boards
 - Uses for high performance video devices



Twin GLINT MX Design

A graphics pipeline well-matched with Pentium II

- GLINT MX is scalable from 2 to 8 processors
 - Transparently increases fill-rate
 - Interleaved scan-line rendering for effective load-balancing
- Pentium II -> GLINT Gamma -> Twin GLINT MX
 - Well-balanced application, geometry, rasterization pipeline
 - 2 Million visible, rendered polygons with full geometry processing
 - 66 Million Pixels/sec bilinear-mip-mapped filtered texture
 - 33 Million Pixels/sec trilinear-mip-mapped filtered texture





Summary

- 3D Geometry is floating point intensive
- It is the current bottleneck for increased 3D PC performance
- 3D geometry functionality is well understood and encapsulated in standard APIs
- It can be hard-wired for maximum performance per \$
- GLINT Gamma implements the geometry and lighting for all key APIs - including OpenGL and Direct3D