Transmeta's Second Generation Efficeon Microprocessor and Technology Roadmap

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October 2004
Fall Processor Forum
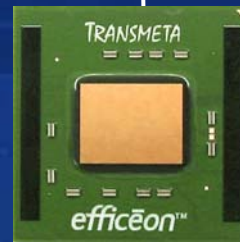
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Agenda

- Efficeon Processor Architecture

- Efficeon Generation 1 Implementation

- Efficeon Generation 2 Implementation

- Technology Roadmap

Transmeta Technology

Efficeon is the sum of

x86 Code Morphing Software **+** **=**

Code Morphing Software

- **Provides Compatibility**
- **Translates the 1's and 0's of x86 instructions to equivalent 1's and 0's for a simple VLIW processor**
- **Learns and improves with time**

VLIW Hardware

- **Very Long Instruction Word processor**
- **Simple and fast**
- **Fewer transistors**

Low Power

x86 PC Compatibility
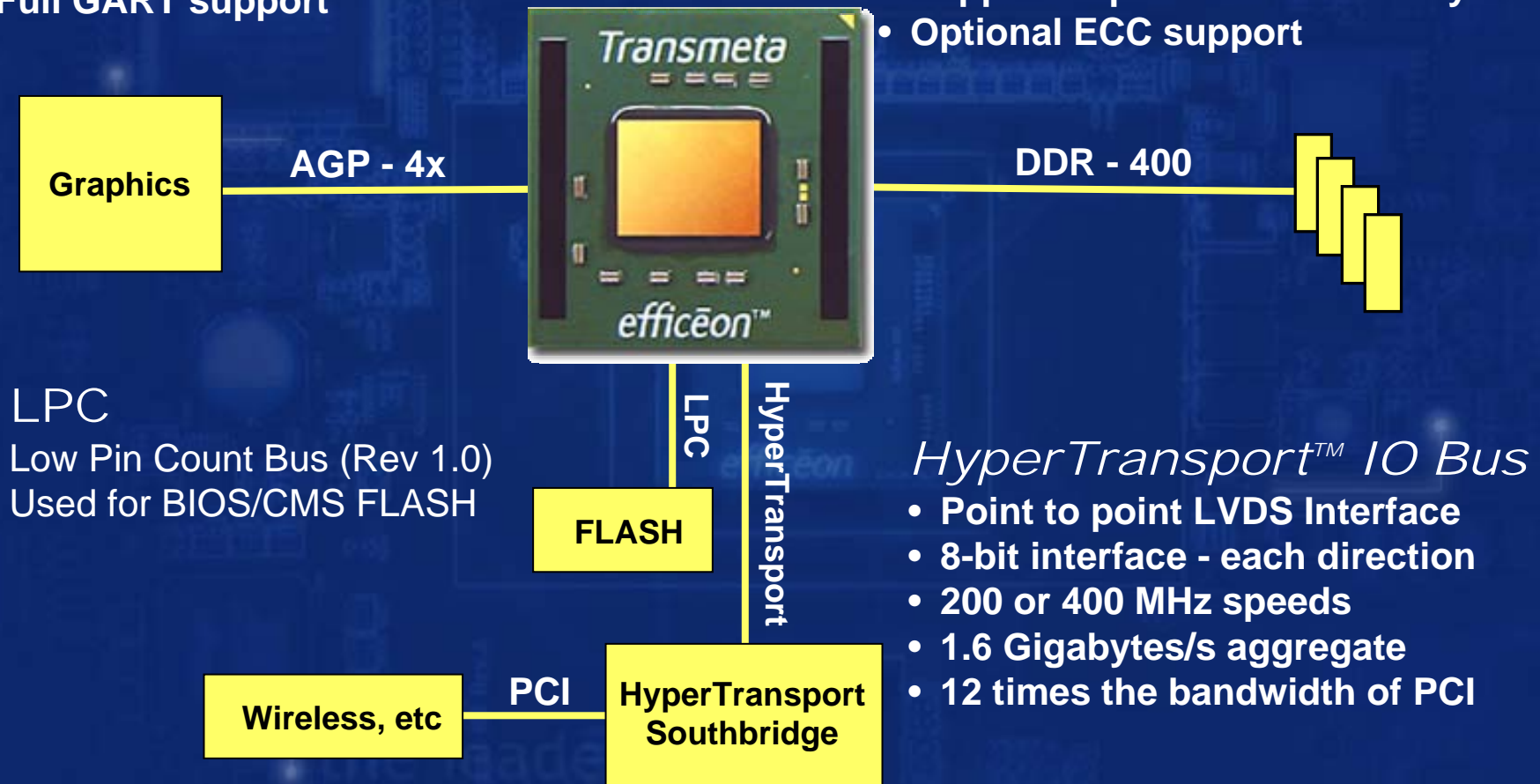
High Performance

Efficeon Interfaces

AGP- 4X Graphics

- **Supports 1X, 2X or 4X speeds**
- **AGP 2.0 compliant**
- **Full GART support**

DDR-400 Memory

- **High performance 64-bit DDR**
- **Up to 200MHz/400 Megaxfers/sec**
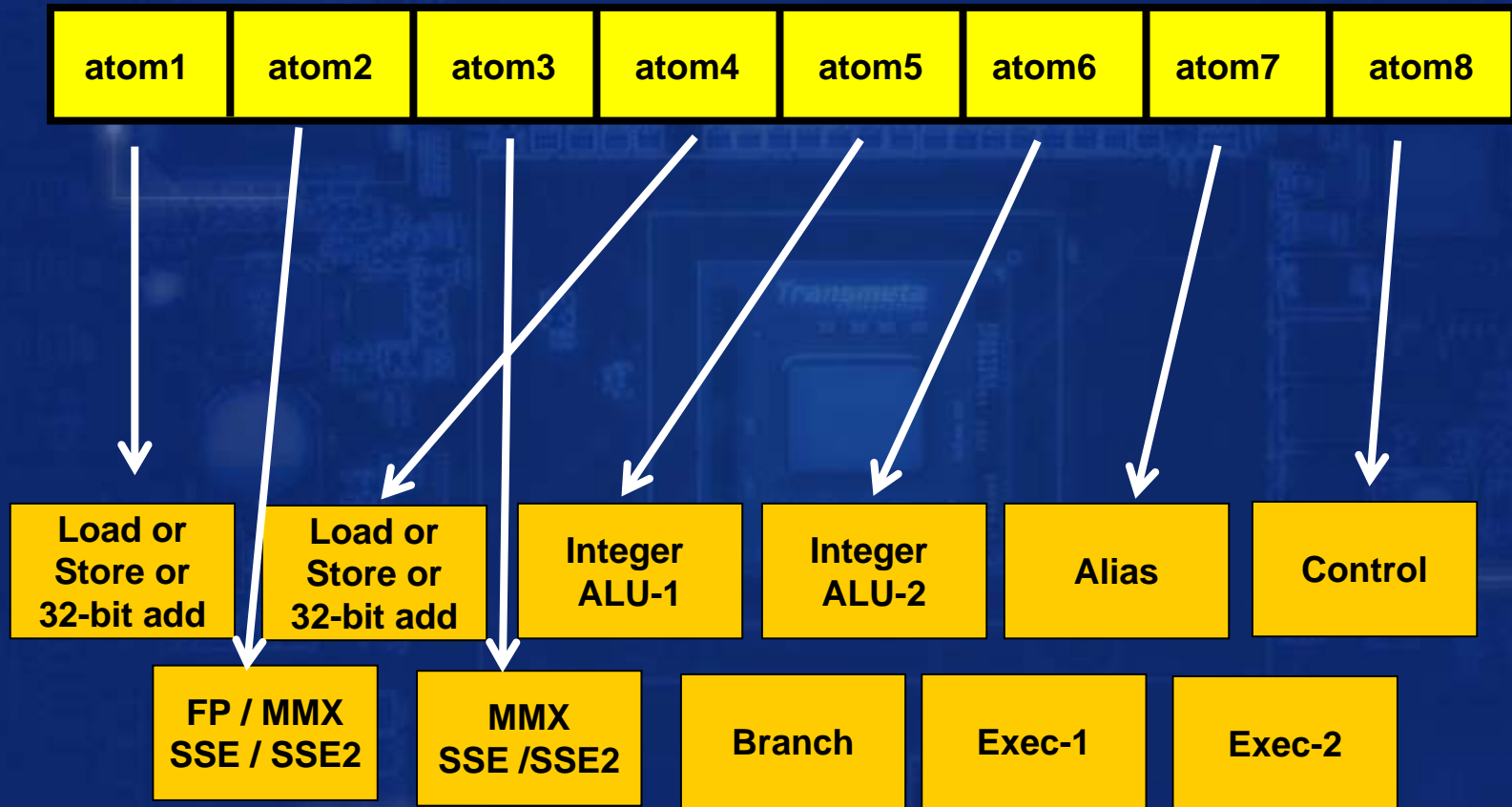- **Supports up to 4GB of memory**
- **Optional ECC support**

Graphics

AGP - 4x

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efficeon™

DDR - 400

LPC

Low Pin Count Bus (Rev 1.0)
Used for BIOS/CMS FLASH

LPC

HyperTransport

FLASH

HyperTransport™ IO Bus

- **Point to point LVDS Interface**
- **8-bit interface - each direction**
- **200 or 400 MHz speeds**
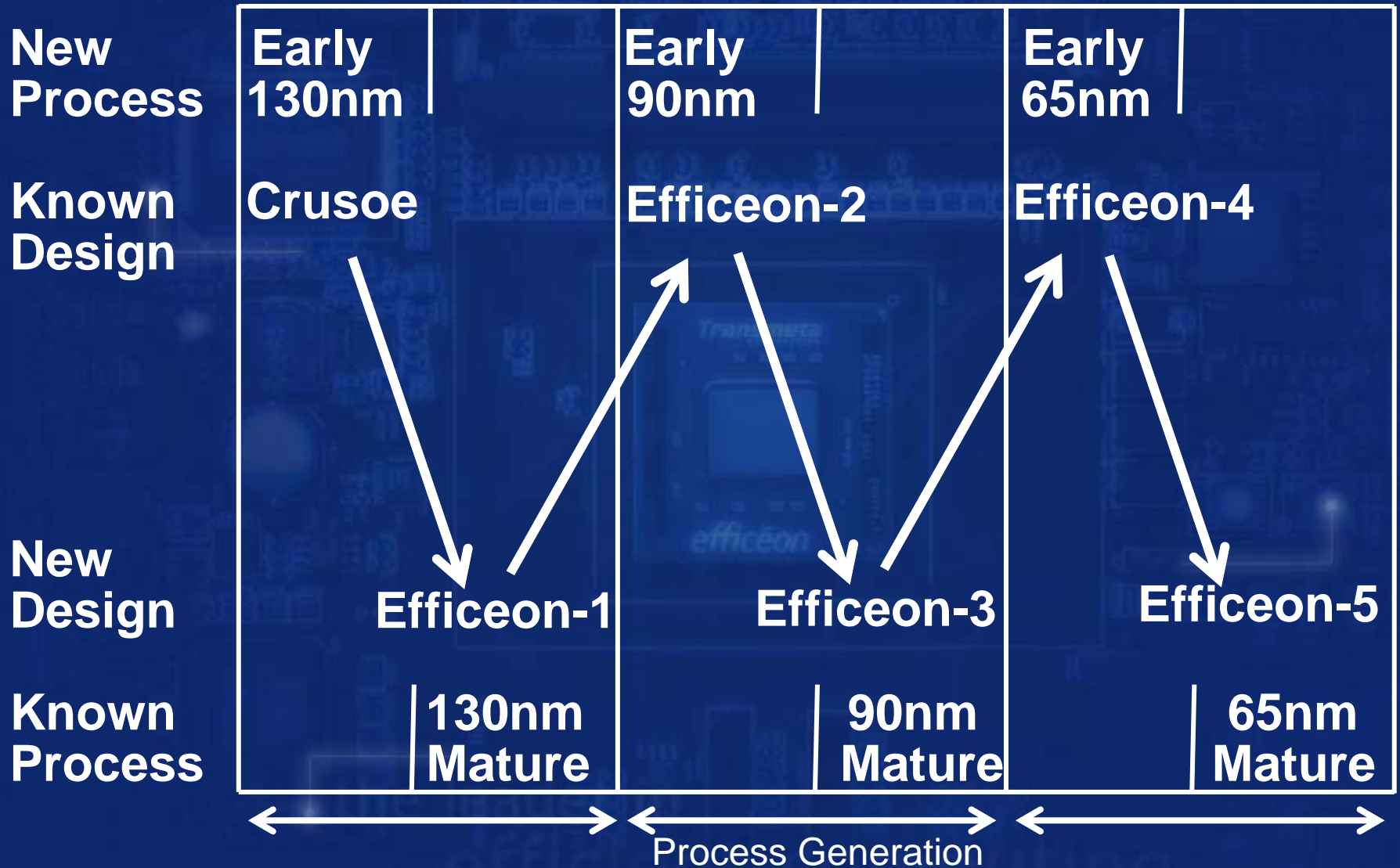- **1.6 Gigabytes/s aggregate**
- **12 times the bandwidth of PCI**

Wireless, etc

PCI

HyperTransport Southbridge

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High Instruction Level Parallelism

Each clock, Efficeon can issue from one to eight 32-bit instruction "atoms". . .

atom1	atom2	atom3	atom4	atom5	atom6	atom7	atom8

Load or Store or 32-bit add	Load or Store or 32-bit add	Integer ALU-1	Integer ALU-2	Alias	Control

FP / MMX SSE / SSE2	MMX SSE /SSE2	Branch	Exec-1	Exec-2

. . . to any of the above eleven logical execution units.

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Transmeta Development Strategy

New Process	Early 130nm		Early 90nm		Early 65nm
Known Design	Crusoe		Efficeon-2		Efficeon-4
New Design		Efficeon-1		Efficeon-3		Efficeon-5
Known Process		130nm Mature		90nm Mature		65nm Mature

Process Generation

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Efficeon

Generation 1

Efficeon Roadmap

TDP= Maximum Thermal Power
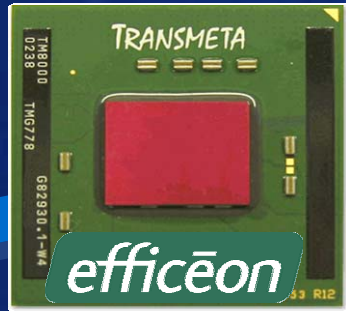
Efficeon Generation-1
TSMC 130 nm
TM8600 Standard Package
TM8620 Small Package

1 GHz
7 Watt TDP

Q4 2003   **2004**   **2005**

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Fall Processor Forum October 5, 2004

First Efficeon Notebook: Jan 04

Sharp Actius MM20

- 2 pounds (990 grams)
- 1.0 GHz Efficeon Processor
- 0.62 inches at thinnest point

February 16, 2004:

"Efficeon is as well armed as the Pentium M with strong performance and cost efficiency, and has the potential to become part of the mainstream in the mobile notebook computer market."
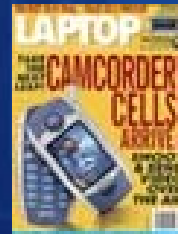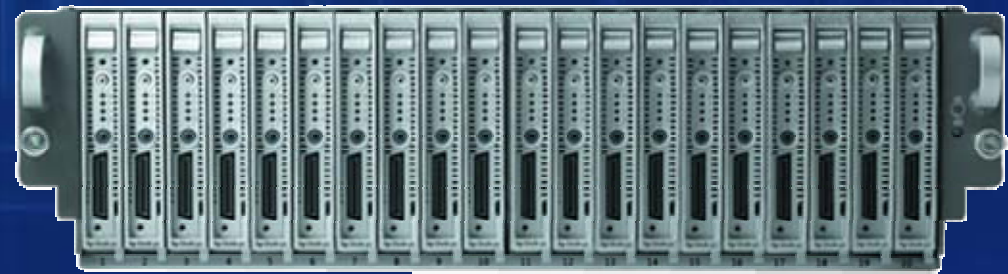
April 2004:

"The MM20 has got the chops to go up against any Centrino machine running the low-voltage version of that processor."

Efficeon in HP Blade PC: April 04

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Efficeon
Processor

280 Efficeon Blades per 42U rack
20 Blades per 3U modular enclosure

Efficeon

Generation 2

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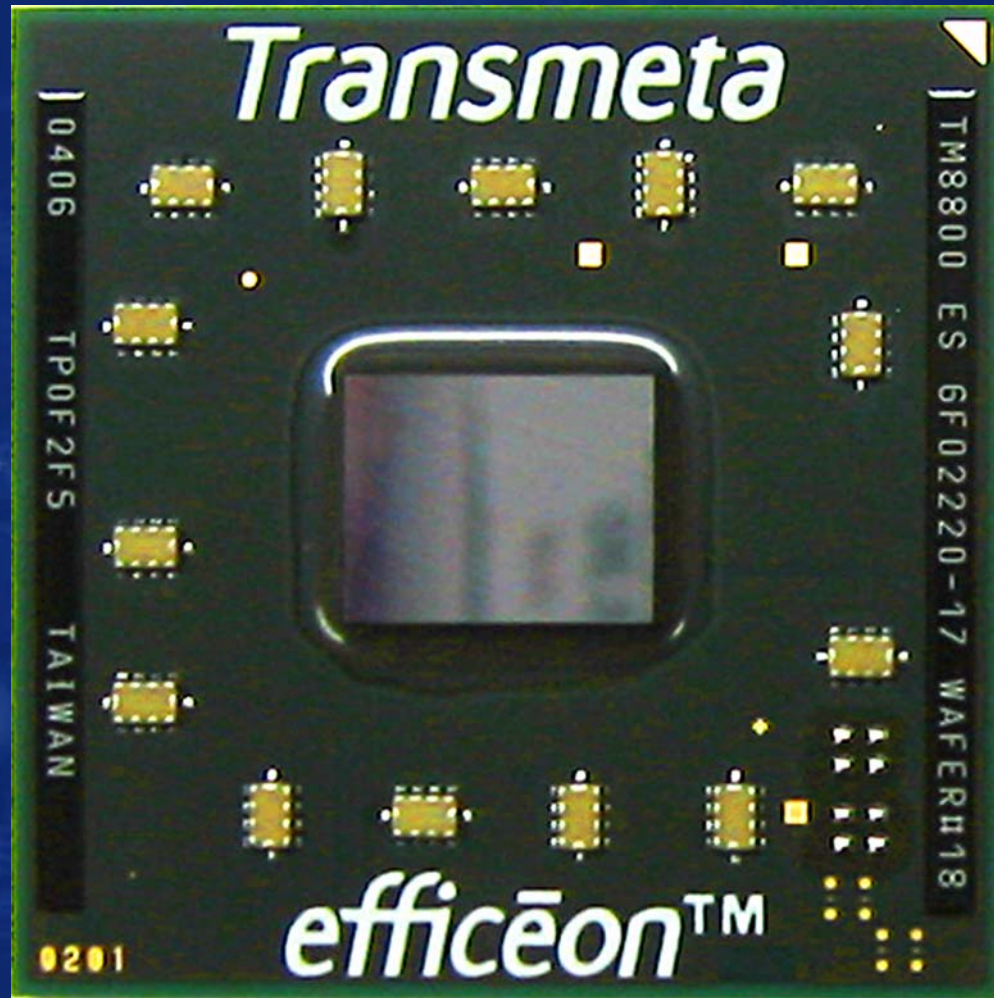**CORPORATION**

Generation 2 Goals

In less than 1 year:

- Double performance from 1 GHz to ~2 GHz

- Move into higher volume 12-25 Watt segment

- Cut power in half for 1 GHz operation

- Remain pin compatible with generation 1 parts

- Provide easily recognizable feature differentiation

  - Virus Protection

  - Advanced Video Processing

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The new 90nm second generation Efficeon Processor from Transmeta

Second Generation Efficeon

TM8800

Same Die, two different packaging options

TM8820

29 mm x 29 mm
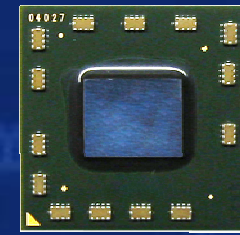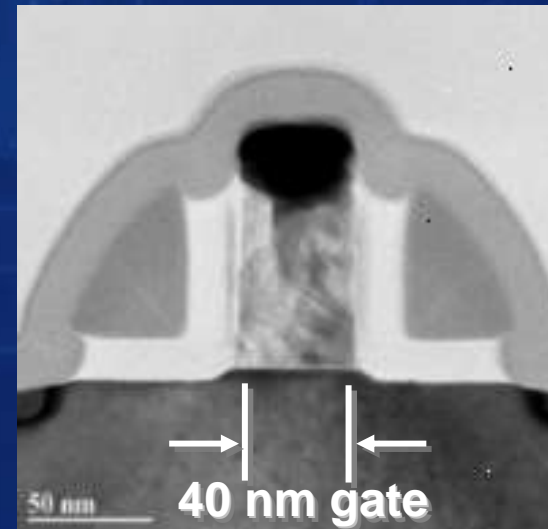
21 mm x 21 mm

- 90 nm CMOS Technology
- Pin compatible with TM8600 and TM8620 130nm parts
- Product goals:
    - 1.0 – 1.1 GHz   ~3 Watts max TDP
    - 1.4 – 1.6 GHz   ~7 watts max TDP
    - 1.6 – 1.8 GHz   ~12 watts max TDP
    - 1.8 – 2.0+ GHz   < 25 watts max TDP

Technology Choice: Fujitsu 90nm

- Fujitsu provided the best 90nm technology choice for speed

- Up to 10 layers interconnect (8 used in Efficeon)

- Low-K dielectric

- Industry leading 40nm transistor gate length

- Small ~1u^2 SRAM cell
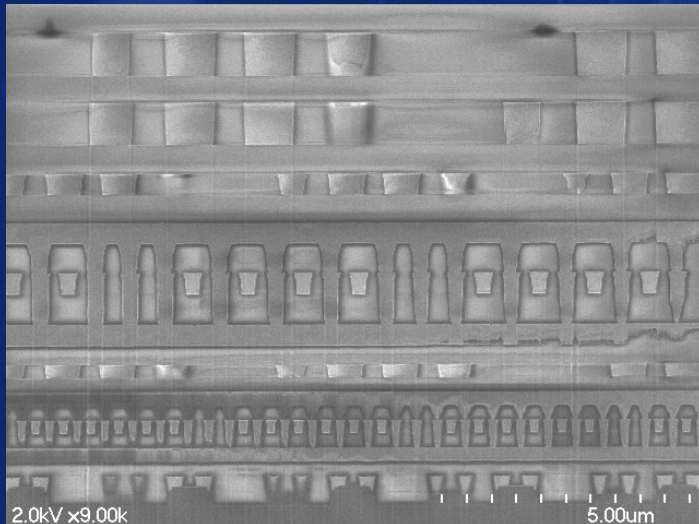
**9Cu / 1Al Interconnect**

Transistor Photo

Anti-Virus Protection

- Efficeon 2 is the first low-power mobile processor to provide support for Antivirus protection

- New x86 memory management extension to protect against viruses exploiting buffer overflows – a common entry point for viruses and worms

- Allows Efficeon processor to mark memory locations as non-executable unless it explicitly contains executable code

- Works in conjunction with Microsoft's Data Execution Protection (DEP) feature in Windows XP Service Pack 2 (SP2)

New Multimedia "SSE-3" Instructions

- **Graphics support:**
  - *haddpd, haddps, hsubpd, hsubps:* Horizontal add/subtract

- **Complex arithmetic support:**
  - *movddup, movshdup, movsldup:* loads and duplicates data
  - *addsubpd, addsubps*: adds and subtracts simultaneously

- **Video encoding support for MPEG-4**
  - *lddqu*: loads unaligned 128-bit data

- **General**
  - *fisttp*: x87 floating point to integer conversion

Space Efficiency Comparison
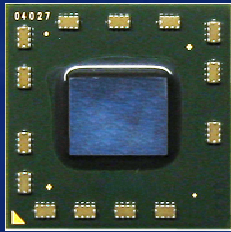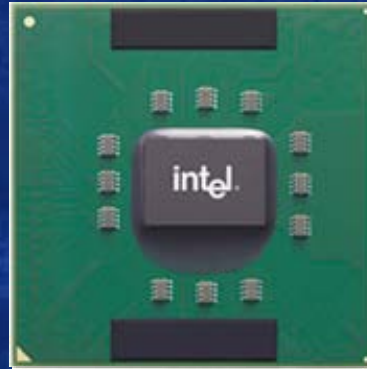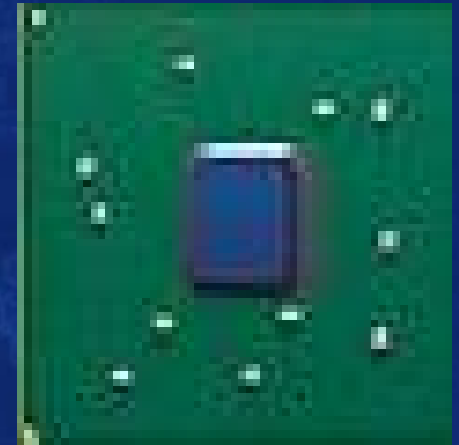
Transmeta TM8820
CPU + Northbridge
21mm x 21mm

Intel Pentium-M
CPU
35mm x 35mm

Intel 855PM MCH
Northbridge
37.5mm x 37.5mm

TM8820 is <u>36%</u> the size of Pentium-M alone

TM8820 is <u>17%</u> the size of Pentium M + Northbridge

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Small Form Factor Design Example

- Entire core PC logic on a tiny board
  - TM8620 CPU/NB(21mm x 21mm) and
  - ULI1563S Southbridge (23mm x 23mm)

- Enables compact form factors

- Total Board Size – 78mm x 62mm similar to PCMCIA card

PCMCIA Card
(Size reference)
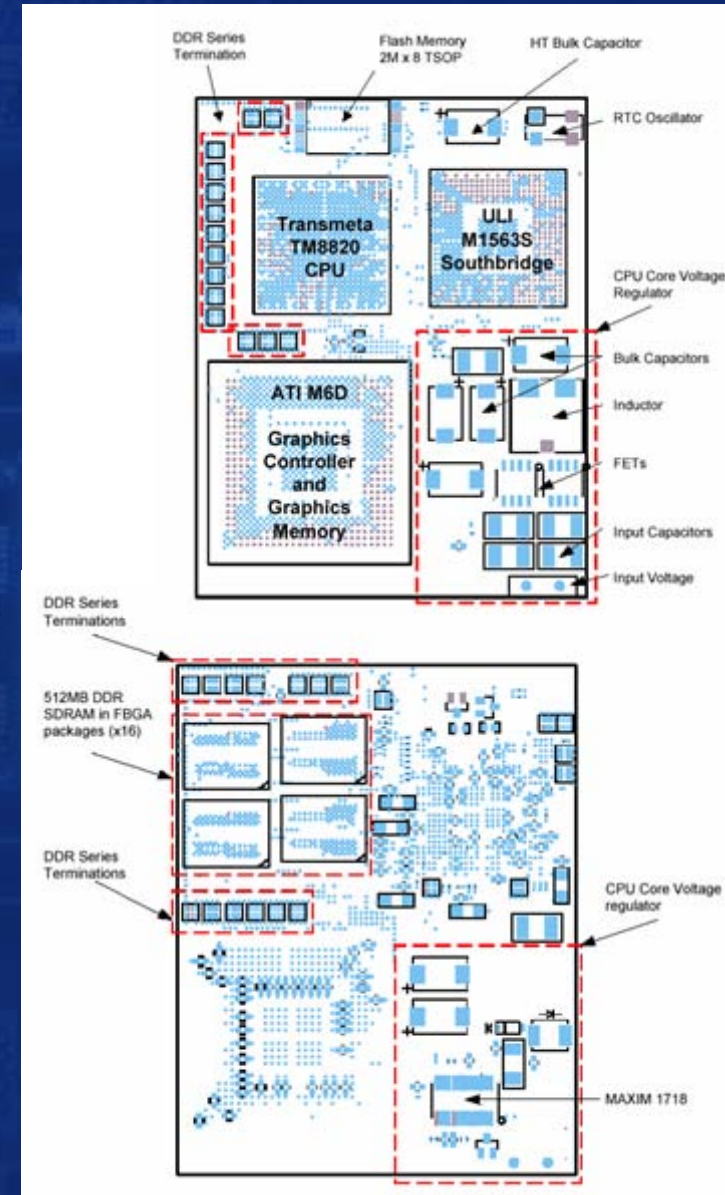
Efficeon 2 Die Photo and Layout

LongRun2 Power Management

1 M Byte Combined I+D Level 2 Cache

DRAM Controller

64 K Byte Level 1 Data Cache

128 K Byte Level 1 Instruction Cache

TLB

Integer Datapath

AGP Graphics Interface

Floating Point Unit

HyperTransport Bus Interface

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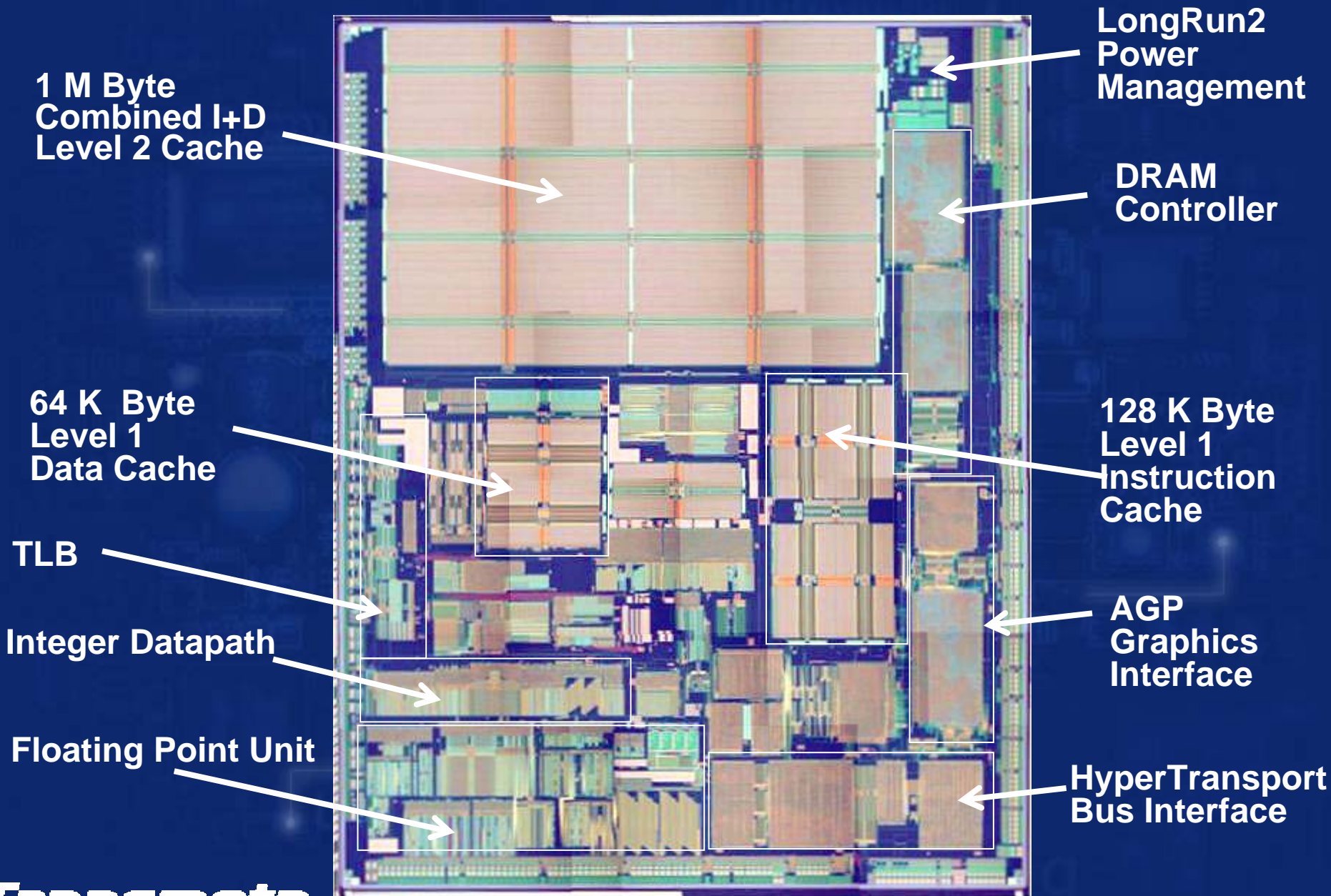
First Efficeon-2 Notebook Sharp PC-MP70G

- Launched in Japan Sept 9th, 2004

- Uses 1.6 GHz Efficeon TM8800 Processor

- 2.8 pounds (1.26 kg)

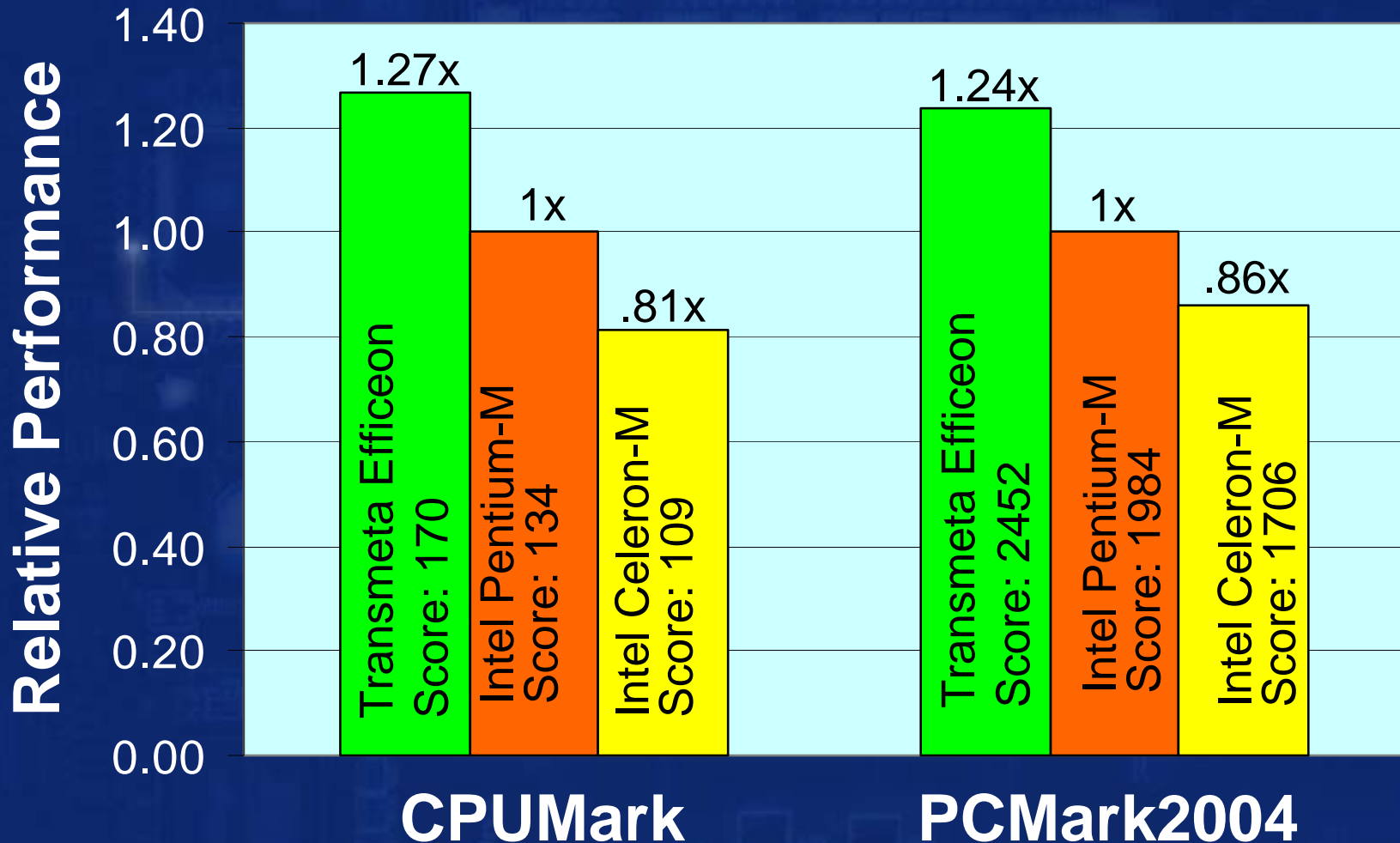- 10.4 inch LCD screen

- 2 spindle (Hard Disk and DVD)

Nearest competitive systems are new SONY T-Series
3 pounds, 10.6" LCD, 2 spindle
CPU: 1.1 GHz Pentium-M model 733 and
            933 MHz Celeron-M model 353

Performance Comparison
using best MHz of recent < 3 lb 10.6" notebooks

Relative Performance

CPUMark			PCMark2004		
1.27x	1x	.81x	1.24x	1x	.86x
Transmeta Efficeon Score: 170	Intel Pentium-M Score: 134	Intel Celeron-M Score: 109	Transmeta Efficeon Score: 2452	Intel Pentium-M Score: 1984	Intel Celeron-M Score: 1706

Benchmarks run at Transmeta on systems as similarly configured as possible
Efficeon-2 data measured at 1.6 GHz with 512MB DDR333, 5400rpm 2.5" HDD, NV17 graphics
Intel Pentium-M data measured at 1.1 GHz with 512MB DDR333, 5400rpm 2.5" HDD, i855GMCH
Intel Celeron-M data estimated by measuring Celeron-M at 800 MHz (scores: 97/1517) and estimating 933 MHz score

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First Clustered Workstation with TM8800

Orion Multisystems DS-96

- **Deskside Personal Supercomputer**
- **96 Efficeon TM8800 Processors**
- **300 GigaFlops on DP Linpack**
- **Standard electrical wall outlet**

Efficeon excels at "Dense Computing"   ~Performance

	Frequency	Power	SpecInt/Watt	SpecFP/Watt
Efficeon	1.5 GHz	7 Watts	97.6	77.5
AMD Opteron 148	2.2 GHz	86 Watts	16.3	17.5
Intel Xeon	3.2 GHz	86 Watts	14.8	14.0
IBM Power4	1.7 GHz	100 Watts	10.8	16.0
Intel Itanium 2	1.5 GHz	130 Watts	10.2	16.3

source: Microprocessor Report December 2003 and Transmeta

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Technology Roadmap

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Efficeon Roadmap

Announced
October 2003

Announced
October 2004

Efficeon Generation-1
TSMC 130 nm
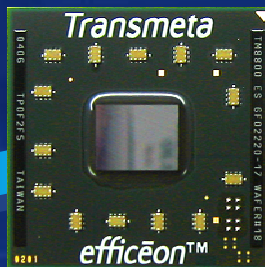
1 GHz / 7 Watt

Efficeon Generation-2
Fujitsu 90 nm

Product Goals
1.8 - 2.0 GHz / < 25 Watt
1.6 - 1.8 GHz / 12 Watt
1.4 - 1.6 GHz / 7 Watt
1.0 - 1.1 GHz / 3 Watt

Efficeon Generation-3/4*
90 nm / 65 nm

Improved Microarchitecture
Higher Work/Clock
Fewer Gates/Clock
2x More Cache
3x Faster DRAM bus
4x Faster HT bus

2003

2004

2005

* = Current plans, subject to change

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What's Next?

Here are a few things we're working on:

- More MHz moving up into mainstream notebooks

- Lower Power

- LongRun2 Power Management

- Virtualization

- Licensing of Transmeta Technology for SOC Cores

- 64-bit instruction extensions

- 65 nm CMOS Technology

Summary

- Second generation 90 nm Efficeon-2 is a major leap forward

- Able to ship first all layer silicon, using only metal and CMS changes

- Subsequent tapeouts will improve MHz and reduce power further

- Efficeon-2 leads in performance when low power is a constraint

- Efficeon-2 leads in compact space solutions

- Efficeon-2 opens the door to higher volume platforms

    - Mainstream notebooks

    - Media center PC, STB's and PVR's

    - Blade servers and Blade PC's

    - UPC handheld devices

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