Intel® Itanium® Architecture Update

5th October, 2006

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Intel EMEA

Agenda

→ Itanium® Processor Family Roadmap

Itanium® 2 Processor update & technology highlights

Montecito Processor Performance update

Itanium® 2 Processor Vs Power 5+ competitive position
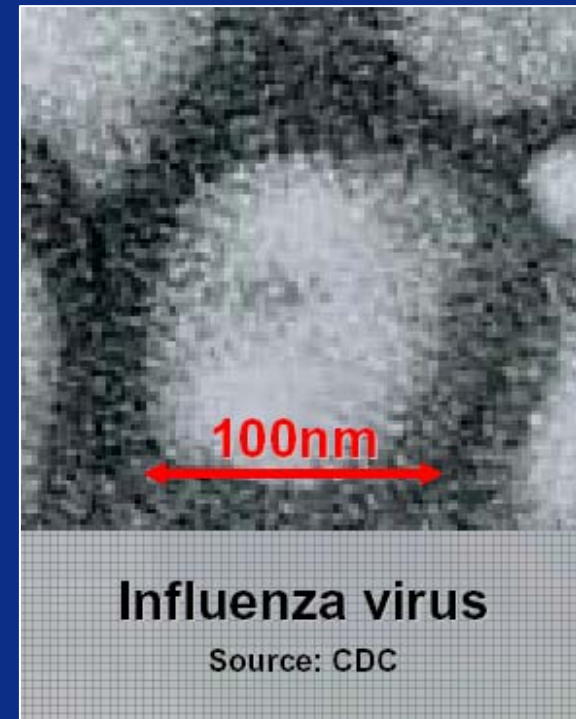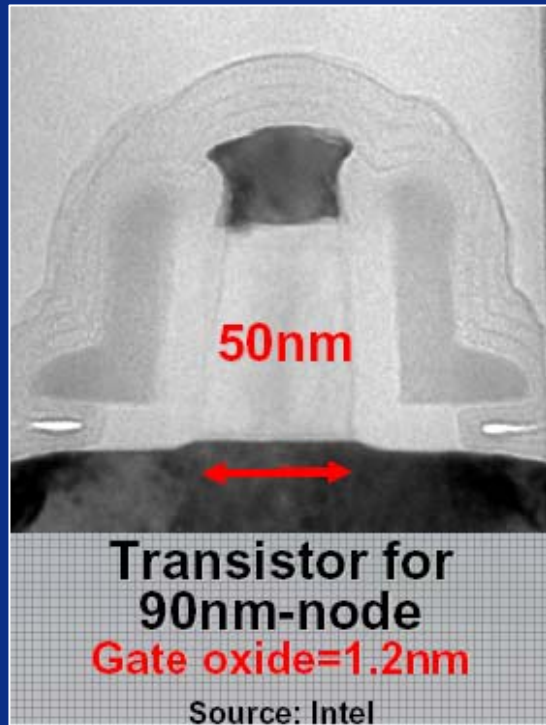
Itanium® 2 Processor Vs X86 Positioning

Quiz

How many transistors in the next generation of Intel® Itanium® 2 processors?

1.72 billion transistors

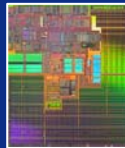# How big is the transistor in the next generation Itanium® Processor?

50nm

Transistor for
90nm-node
Gate oxide=1.2nm

Source: Intel

100nm

Influenza virus

Source: CDC

Intel® Itanium® Processor Family

2001	2002	2003	2004	2006	future
		Itanium® 2 Madison**	Madison9M	Montecito**	Tukwila**
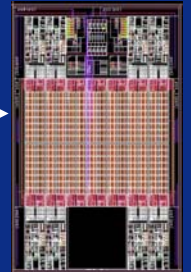
Common Platform

800MHz	1GHz	1.5GHz	1.5GHz	1.5GHz	Multi-Core
4MB L3-Cache	3MB iL3-Cache	6MB iL3-Cache	9MB iL3-Cache	24MB iL3-Cache	Developed by
460GX Chip-set	E8870 Chip-set	E8870 Chip-set	E8870 Chip-set	Dual-Core	former Alpha
OEM Chip-sets	OEM Chip-sets	OEM Chip-sets	OEM Chip-sets	E8870	team
180nm	180nm	130nm	130nm	OEM Chip-sets	
				90nm	

**codename

All features and dates specified are targets provided for planning purposes only and are subject to change.

Intel® Itanium® Processor Family Roadmap Update

2005	2006	2007	2008	Future

Richford Platform

Itanium 2 (Madison 9M)	Montecito	Montvale	Tukwila	Poulson

Intel® E8870 Chipset/OEM

Rose Hill/OEM
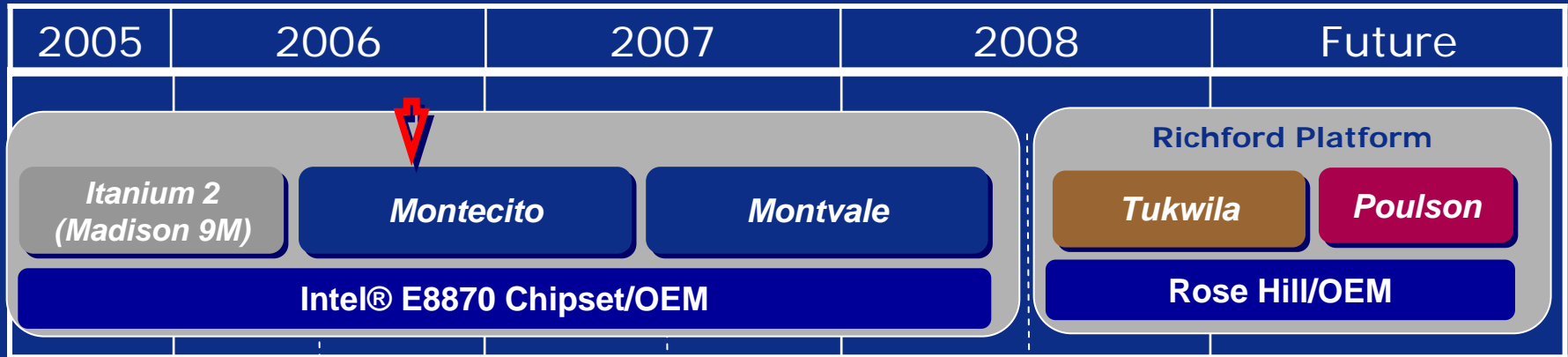
New Technologies

- Dual-core
- Multi-threading
- Intel® Virtualization Technology
- New instructions
- Cache reliability (Intel® Cache safe Technology)
- Faster FSB

Itanium 2 inside™

Single Core	Dual Core	Quad Core	Multi Core

- Multi-core
- Common system architecture w/ Intel® Xeon®
- Enhanced RAS
- Enhanced virtualization
- Enhanced I/O & memory

All features and dates specified are targets provided for planning purposes only and are subject to change without notice

Rev i1.1_4718844   Intel Confidential

Agenda

Itanium® Processor Family Roadmap

➡ Itanium® 2 Processor update & technology highlights

Montecito Processor Performance update

64-bit Windows and SQL Server 2005 on Itanium® processor

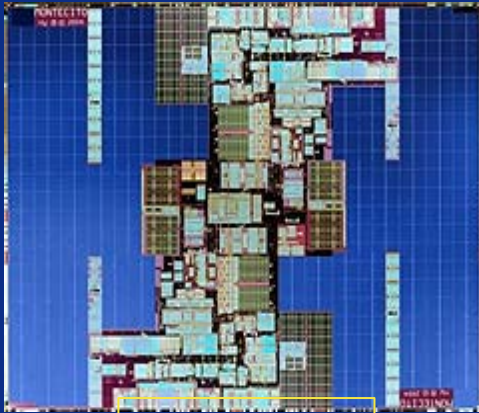Itanium® 2 Processor Vs Power 5+ competitive position

Itanium® 2 Processor Vs X86 Positioning

Itanium®2 *inside*™

Introducing

Dual core Intel® Itanium® 2 Processor 9000 Series processor

Performance 2X Higher

Power 20% Lower

New features for performance

Dual-Core

24MB on-die level 3 cache + new 1MB L2 D-cache

Intel® Hyper-Threading Technology

Intel® Virtualization Technology

Intel® Cache Safe Technology

104W, 2.5x performance/watt improvement

PCI-Express & DDR2

Plus…

Based on EPIC architecture

Scalability: Systems scaling to 32P, 64P, and beyond

Mainframe class reliability features

First 1.72 billion transistors processor

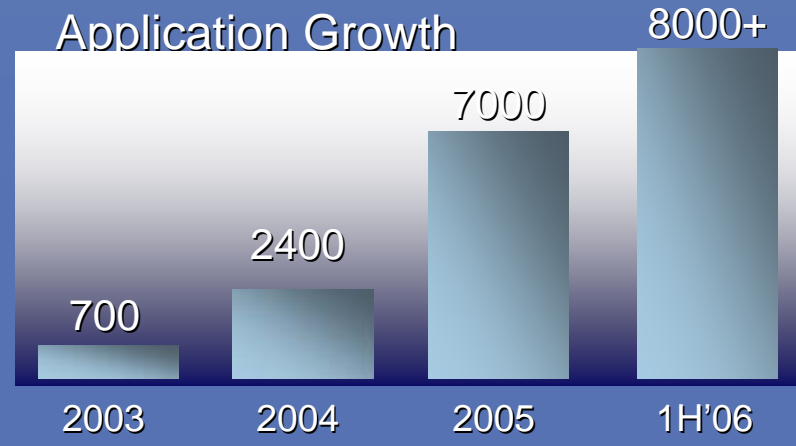(intel)

Itanium® Momentum Continues

"Global 100" Deployments

- More than 70 of the world's 100 largest companies committed to IPF

$10B ISA investment '06-'10

Application Growth

2003	2004	2005	1H'06
700	2400	7000	8000+

Source: Itanium Solutions Alliance

Price / Performance Leadership
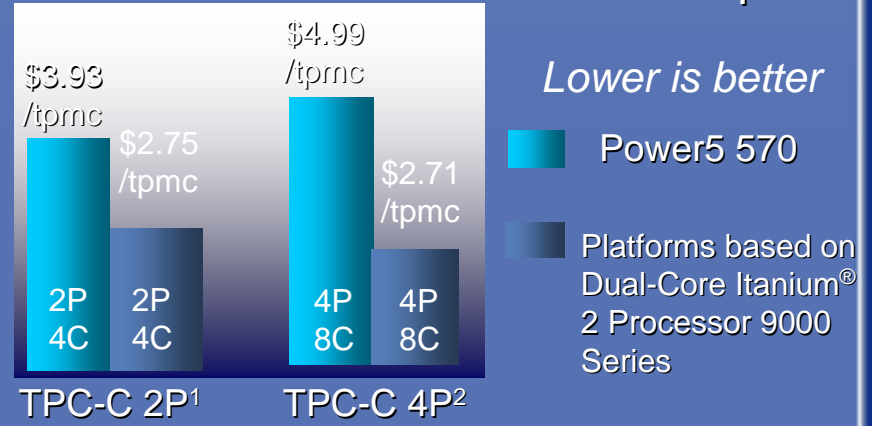
Lower is better

- $3.93/tpmc — 2P 4C
- $2.75/tpmc — 2P 4C
- $4.99/tpmc — 4P 8C
- $2.71/tpmc — 4P 8C

TPC-C 2P[1]   TPC-C 4P[2]

Power5 570

Platforms based on Dual-Core Itanium® 2 Processor 9000 Series

Rapid Growth in System Revenue

Relative Itanium System Revenue vs. SPARC[1] and Power[1]

Legend:
- vs. SPARC[1]
- vs. Power[2]

Chart values: 45%, 42%

X-axis: Q103, Q303, Q104, Q304, Q105, Q305, Q106
Y-axis: 0%, 10%, 20%, 30%, 40%, 50%, 60%
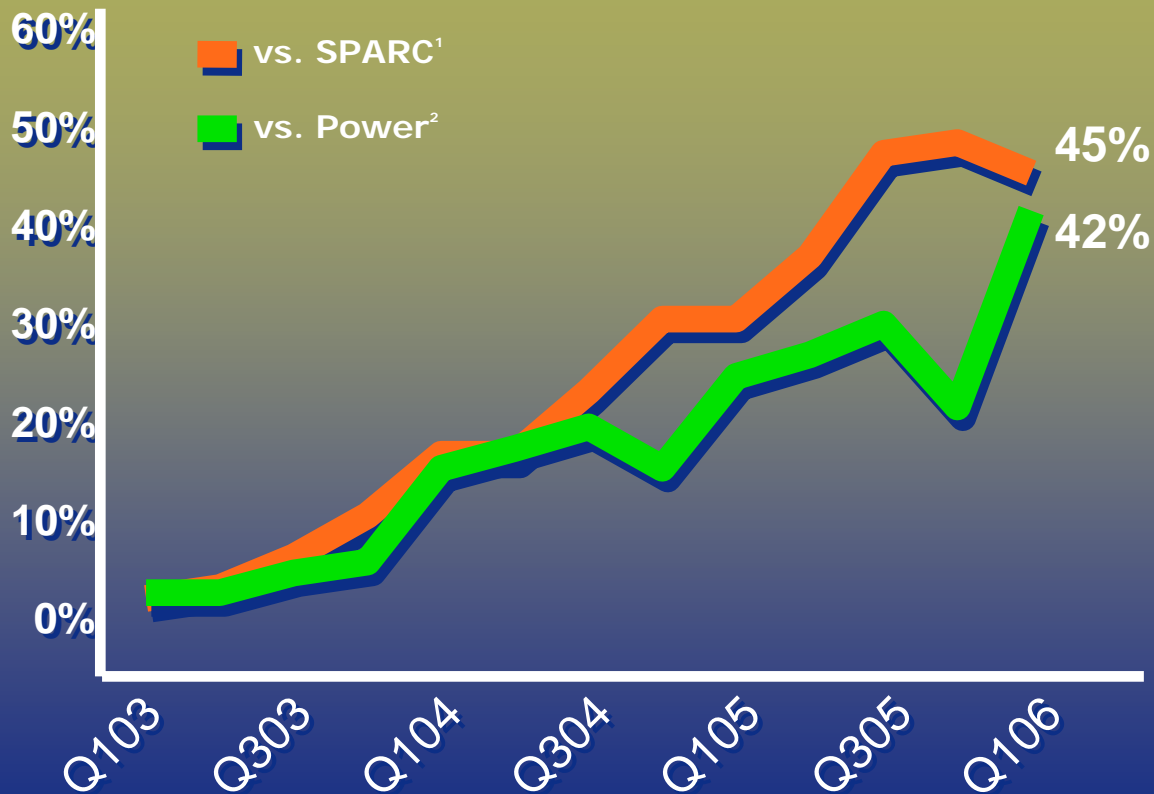
Specific Countries

	versus SPARC[1]	versus Power[2]
Japan	110%	109%
Korea	68%	51%
PRC	55%	43%
Russia	352%	97%

1: SPARC Includes: SPARC I, SPARC II, SPARC III, SPARC IV, SPARC 64 and SPARC 64 V;
2: POWER Includes: Power RS64 II, Power RS64 III, Power RS64 III, Power 3, Power 4, Power 5, and PowerPC
Source: IDC Q1'06 WW Quarterly Server Tracker
Other names and brands may be claimed as the property of others

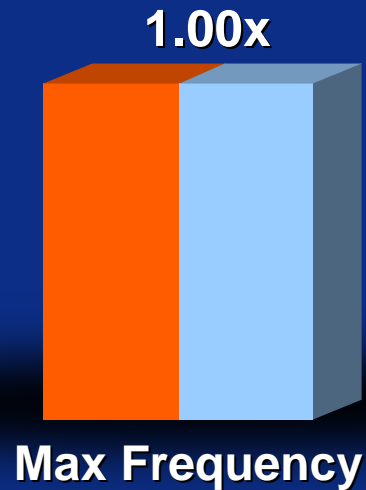(intel)

Intel® Itanium® Architecture Processors

	Madison9M	Montecito
Technology	130nm	90nm
Number of cores	1	2
Clockrate	1600MHz	1600MHz
- INT Units	6	6
- MM Units	6	6
- FP Units	2 (*,+)	2 (*,+)
- ADDR Units	2L+2S or 4L	2L+2S or 4L
L1-Caches (I/D)	16/16KB	16/16KB
L2-Cache (I/D)	256KB Unified	1MB/256KB
L3-Cache	9MB	24MB on die
System Bus	6.4GB/s	8.5GB/s
- Clockrate	400MHz	533MHz
- Width	128 bit	128 bit

Why Multi-Core?

Performance

Power

1.00x

Max Frequency

Relative single-core frequency and Vcc

(intel)

Over-clocking

Performance

Power

1.73x

1.13x

1.00x

Over-clocked (+20%)　　Max Frequency
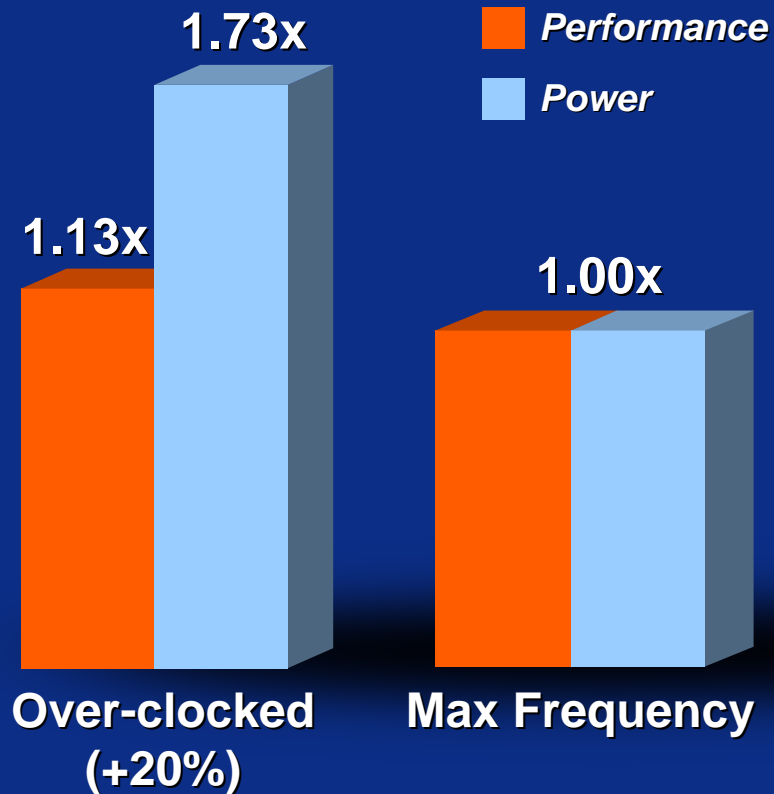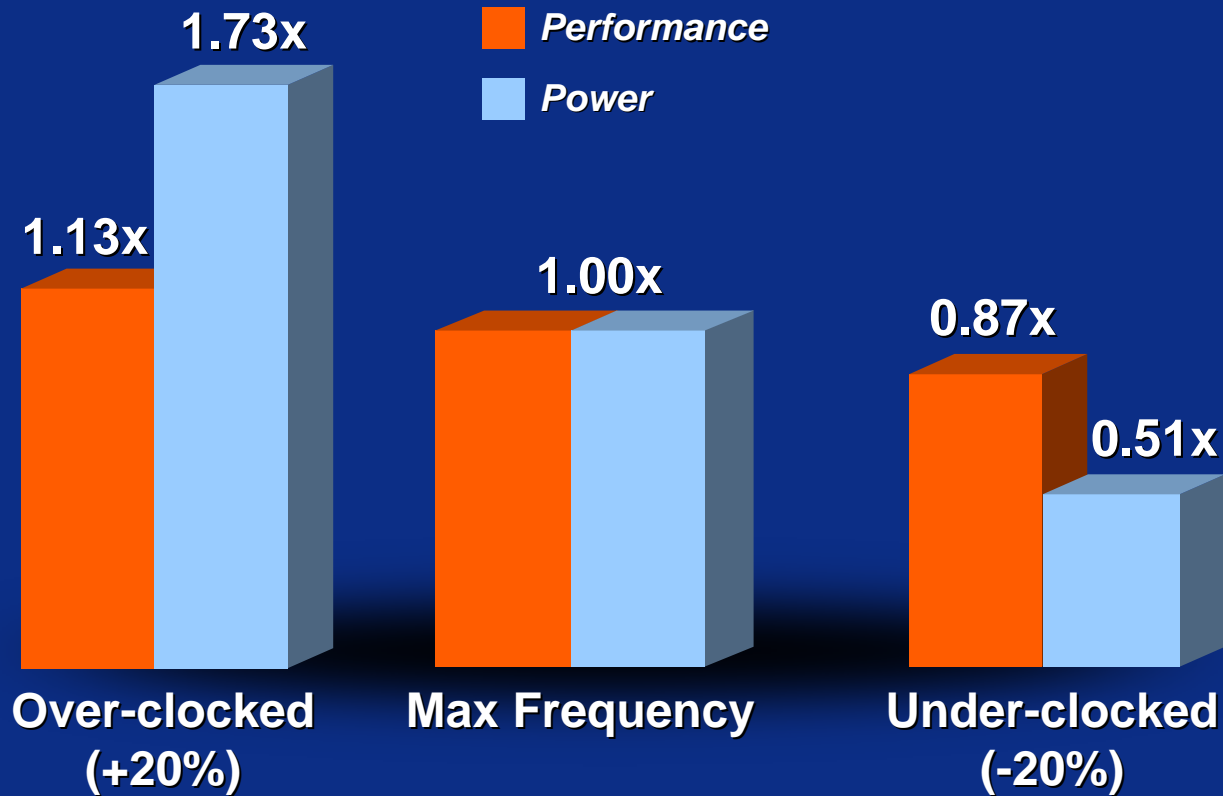
Relative single-core frequency and Vcc

Under-clocking

Relative single-core frequency and Vcc

Multi-Core = Energy Efficient Performance

Legend:
- Dual-Core (yellow)
- Performance (orange)
- Power (light blue)

Over-clocked (+20%): 1.13x, 1.73x

Max Frequency: 1.00x, 1.00x

Dual-core (-20%): 1.73x, 1.02x
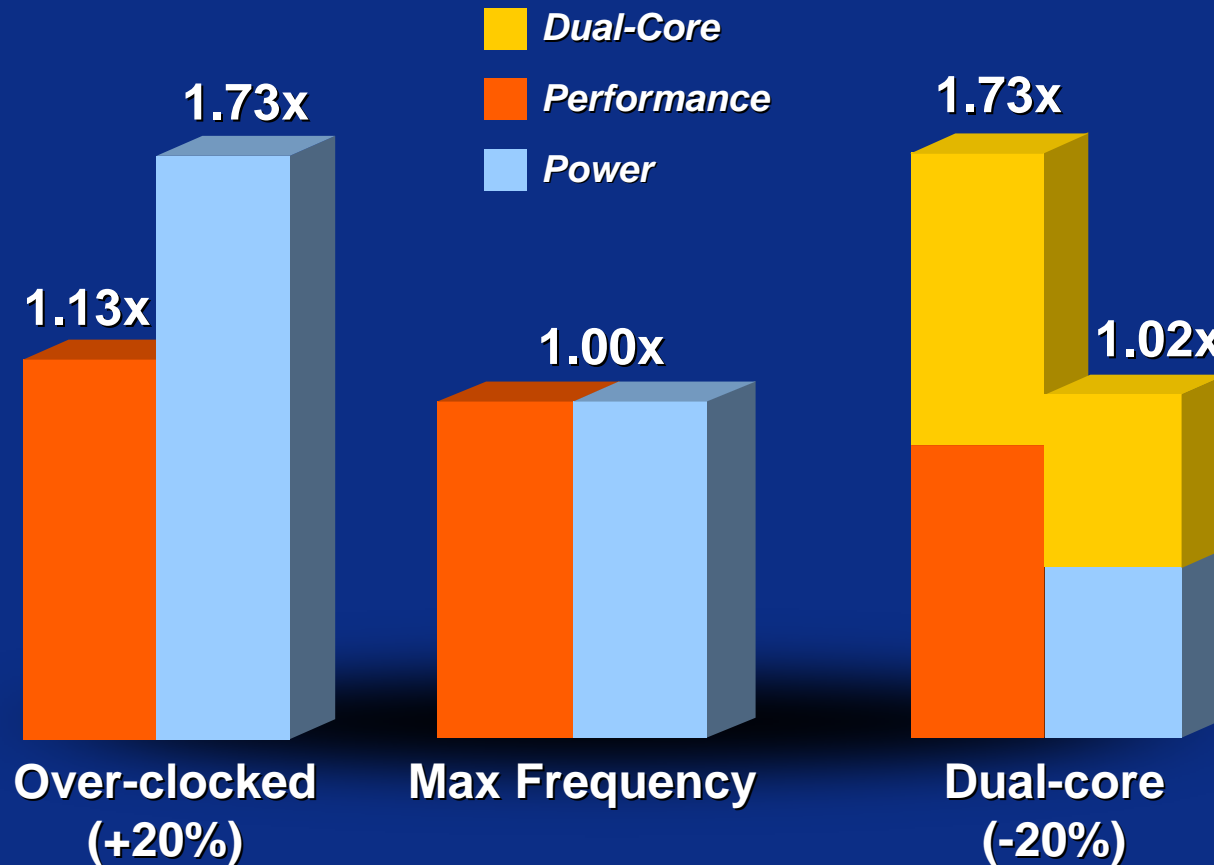
Relative single-core frequency and Vcc

Out-of-order versus Explicit Parallelism

Legacy Architecture

Original Source Code

compiler

Sequential Machine Code

Hardware

Implicitly parallel

Execution Units difficult to use efficiently

Itanium® Architecture

Original Source Code

Itanium 2-based compiler

Parallel Machine Code

M... ecution ... more ... but more ...

Massive Resources
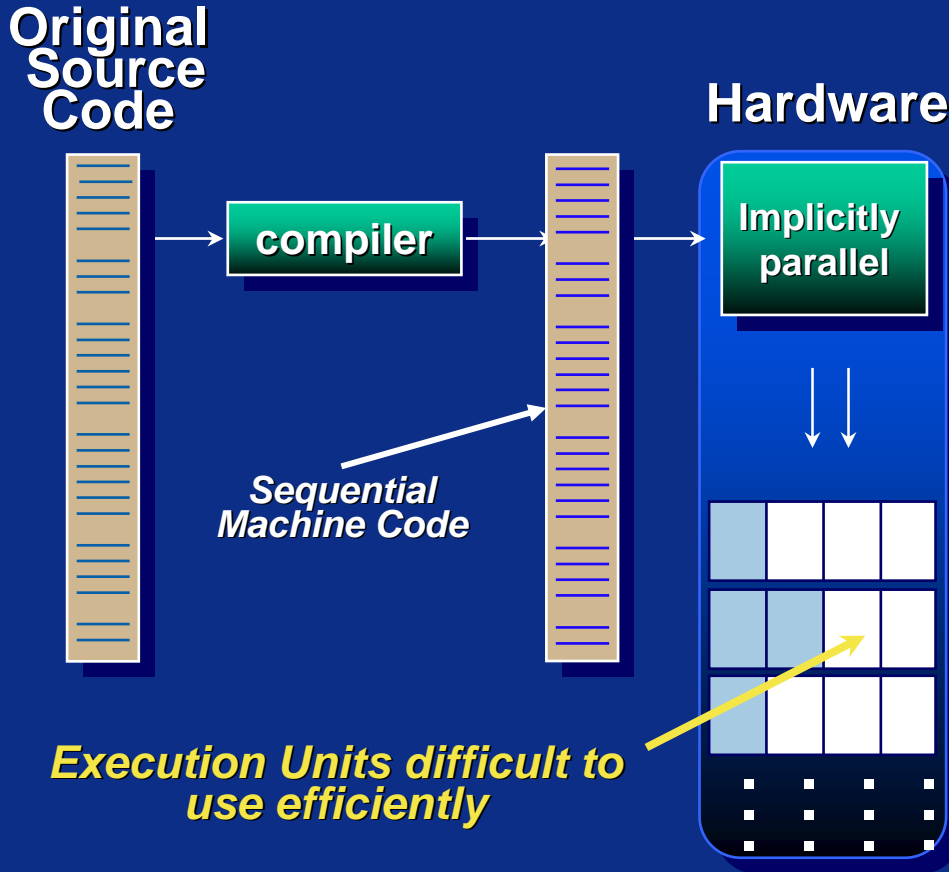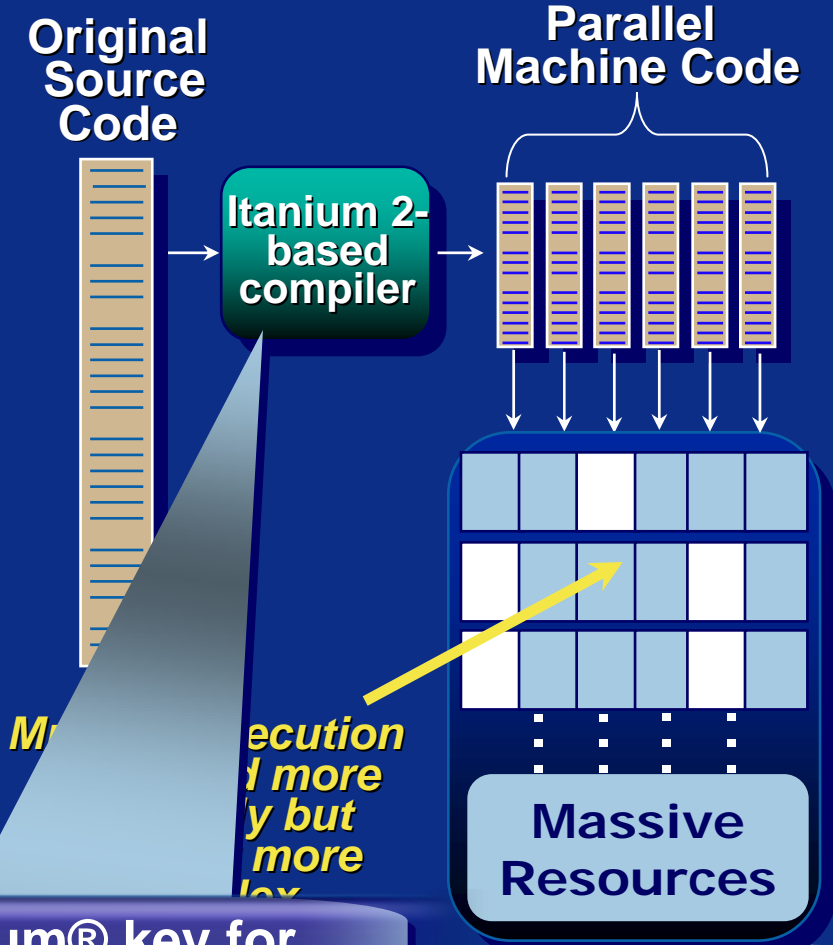
Compiler for Itanium® key for successful exploitation of resources

Multi-Threading Approaches

Sharing resources

High utilization
High complexity
Medium latency hiding

Single thread/cycle

TMT

Multiple thread/cycle

SMT

Medium utilization
Low complexity
Medium latency hiding

Temporal

Event

A	A	A	B	B	
A	A	B	B	B	
A	A	B	B	B	
A	A	A	B	B	B
A	A	B	B	B	B

A	A	A			
B	B	B	B	B	
A	A	A	A		
B	B	B			
A	A	A			
B	B	B	B	B	

A	A	A	A		
A	A	A	A	A	
B	B	B			
B	B	B	B		
B	B	B	B	B	

Medium utilization
Low complexity
High latency hiding

"Event" for the core and "Multiple" for the caches

(intel)

Montecito Thread Switching

- ## Switch events

  - L3 miss/return
    - Instruction, Data or HPW access
  - Time slice expiration
  - Low power state entered/exited
  - Switch hint execution (hint@pause instruction retired)
  - ALAT invalidation

Montecito Multi-threading

Serial Execution

A_i	Idle	A_{i+1}	B_i	Idle	B_{i+1}

Montecito Multi-threaded Execution

A_i

Idle A_{i+1}

B_i

B_{i+1}
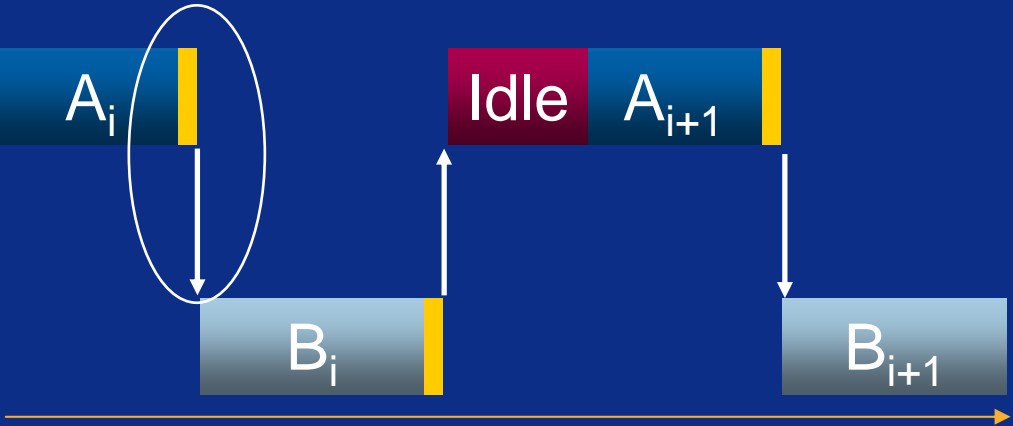
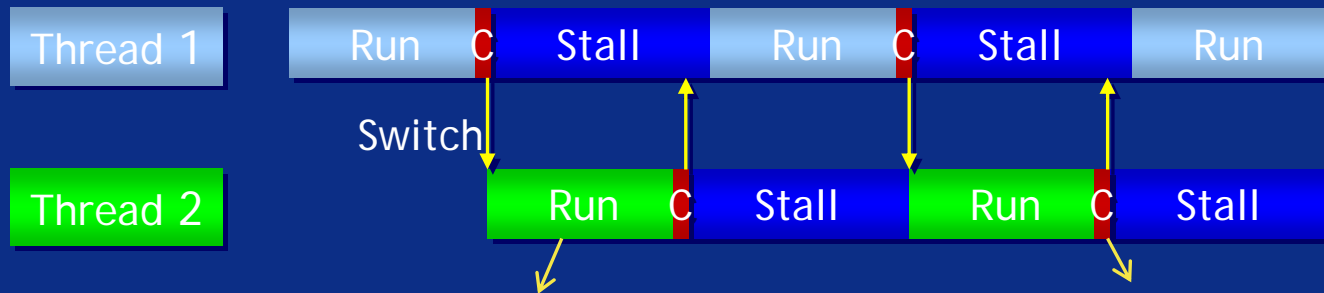**Multi-threading decreases stalls and increase performance**

Temporal Multi-Threading

Overlap memory latency stall of **Thread 1** with execution of **Thread 2**

15 cycle penalty

Stalled Cycles

15-35% Performance Gain
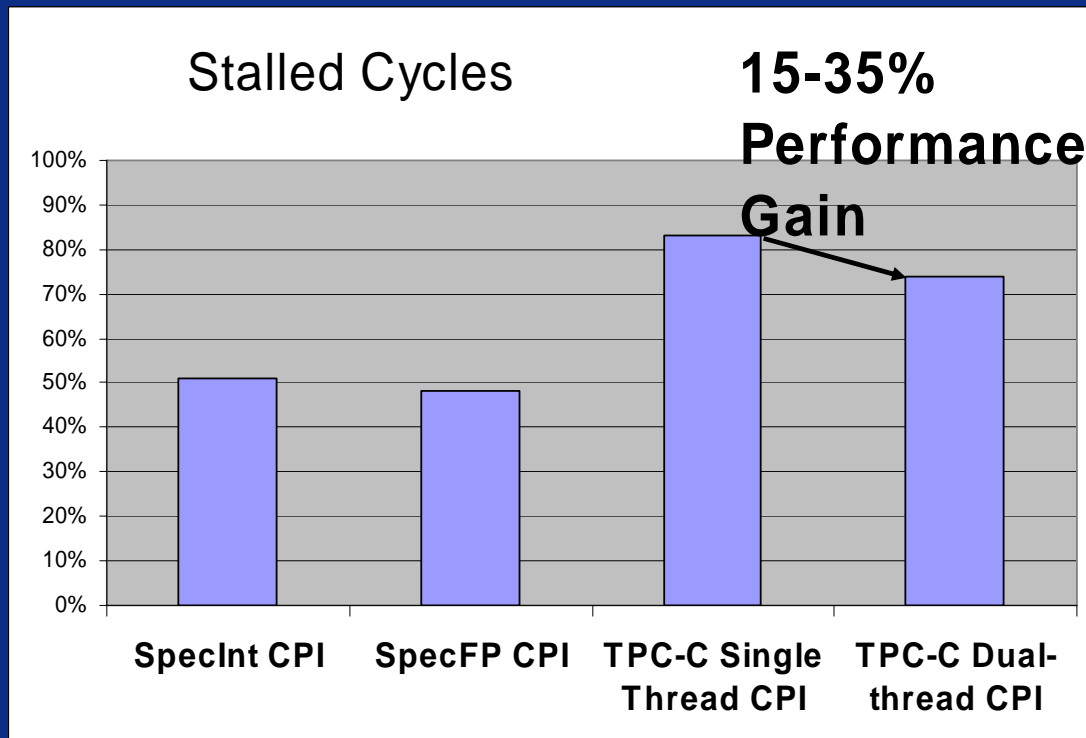
Database workloads get a significant speedup

2% core area impact and 0% cycle time impact

Itanium® 2 Architecture Virtualization Benefits

Reduce Data Center Complexity

Consolidate applications

Rapid deployment

Smaller data center footprint

Reduce Costs

Increase server utilization

- Dynamic load balancing between apps

Improve manageability
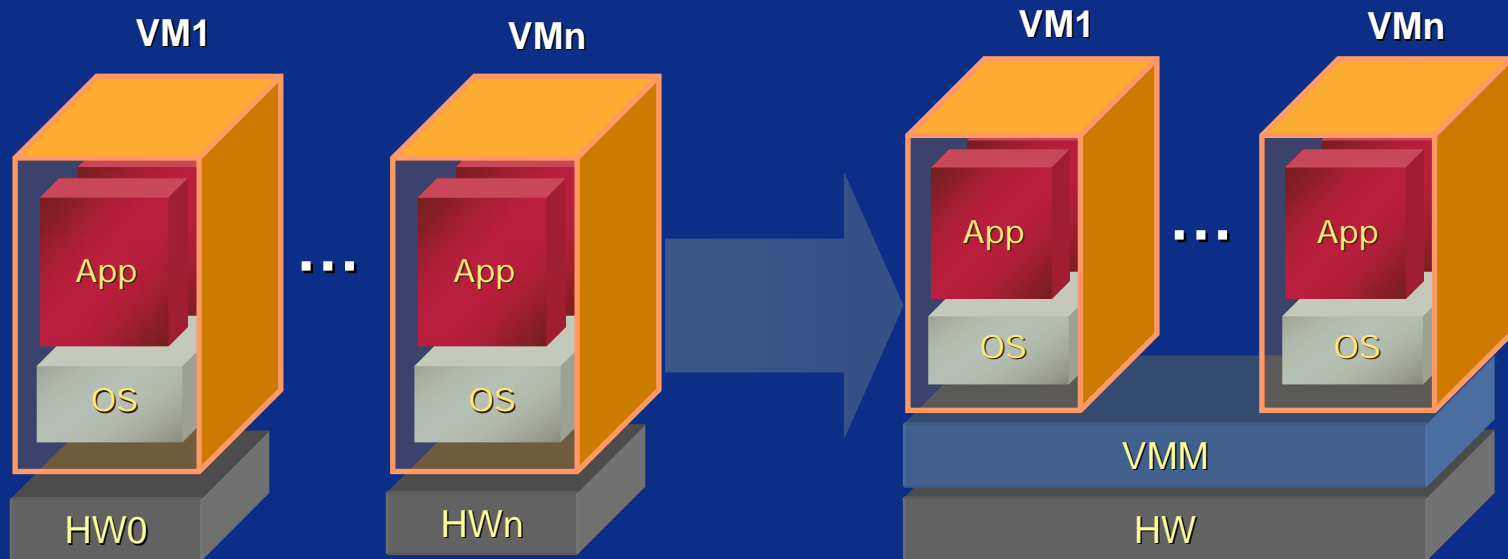
Hardware Assisted Virtualization on Itanium ® Architecture

Itanium® Virtualization Architecture

- Combination of new processor hardware and PAL firmware functionality

- PAL provides a uniform programming interface across different processor generations

- Extended the PAL to provide run-time services for VMM to manage application and system register state

System Abstraction Layer (SAL)

Processor Abstraction Layer (PAL)

Processor (Hardware)

Platform (Hardware)
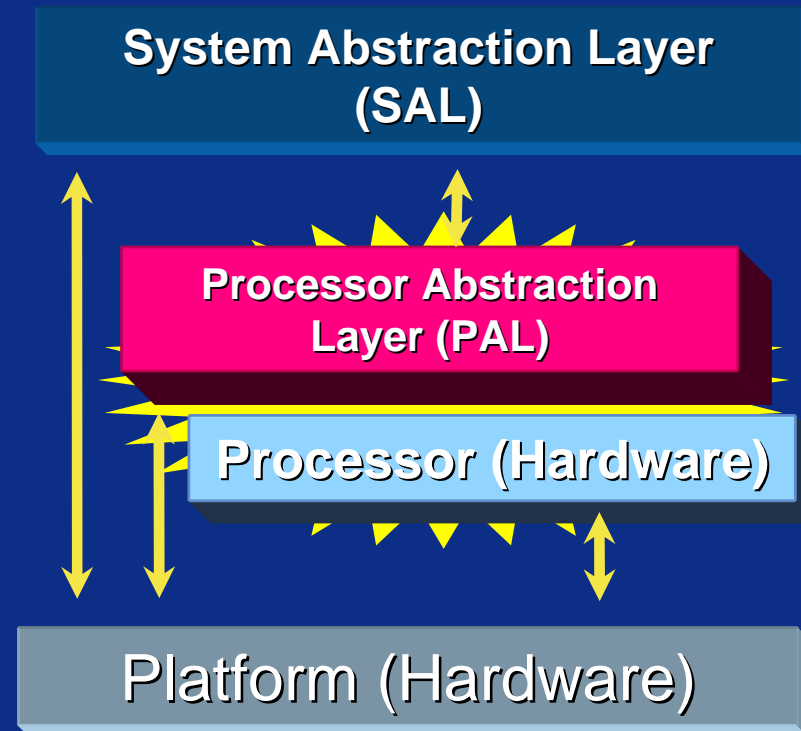
Itanium® Virtualization Overview

Guest Software (Virtualized)

Processor Status Register

PSR.vm=1

Host Software/ VMM

PSR.vm=0

Intercepts

Non-privileged Resources

Privileged Resources

- **TLB Accesses**
- **Privileged Registers (PSR, Control, Debug)**
- **Register Stack Engine (RSE)**

Host Virtual Address

Virtualization-supported CPU

(intel)
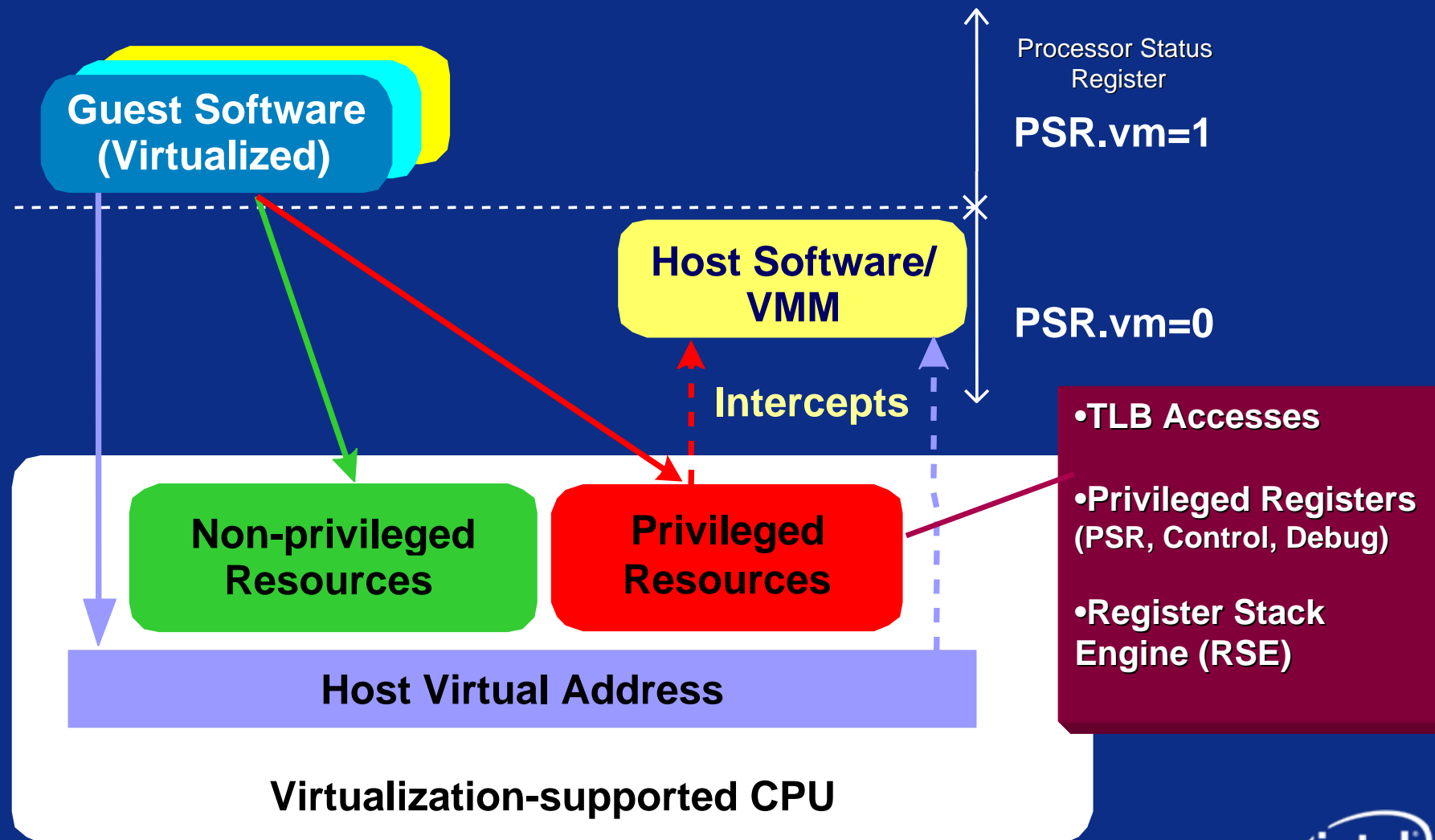
Shared and Dedicated VMs

Dedicated Policy

- OS solely owns a set of processor resources

- Reduce conditions that cause intercepts
  - (Disable controls)

Shared Policy

- Processors are shared across multiple virtual images

- Avoid intercepts by using shadowed processor state
  - (Accelerations)
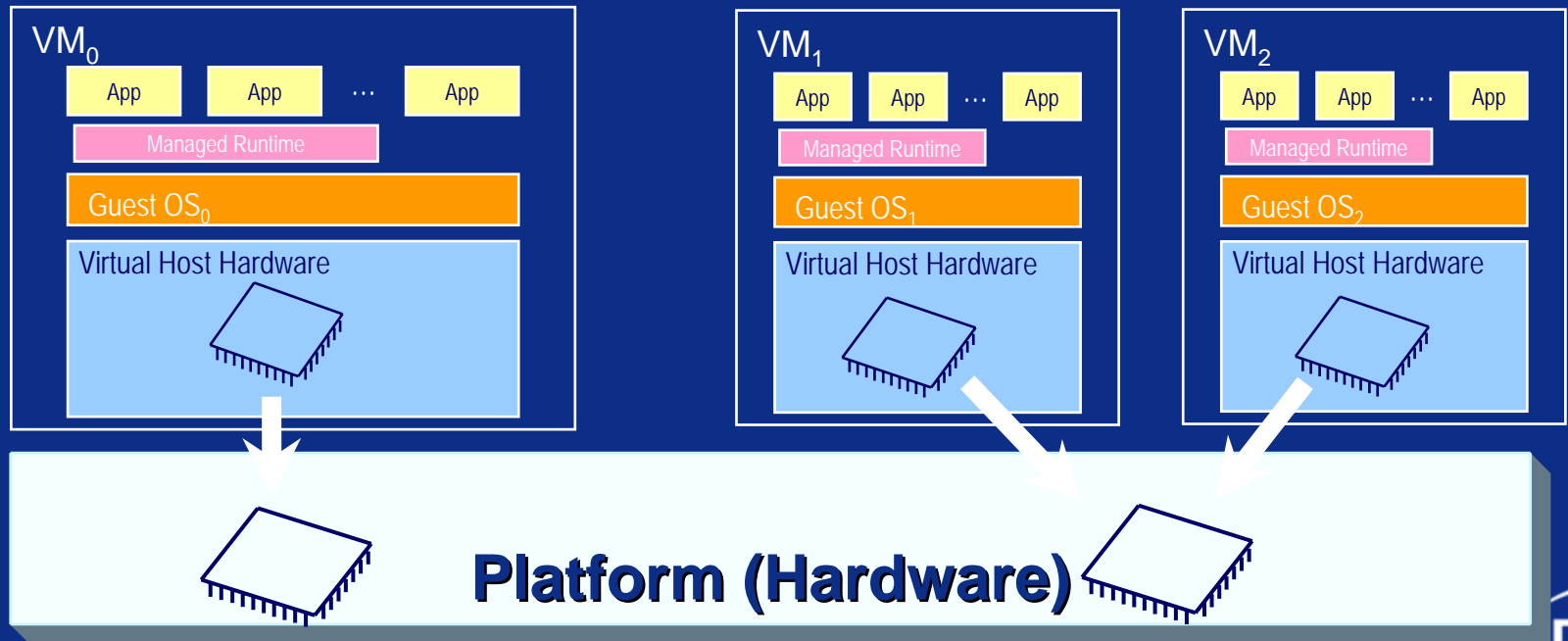
Advanced Cache Reliability

Intel® cache safe Technology

1. Cache line access with error detected

2. Montecito test for hard error in cache line

3. If hard error is detected, cache line is disabled. Processor and system continue normal operation

L3 cache

2

3

PAL

If hard error detected, cache line disabled

Error Check → **Corrected Path**

Data is Consumed by Core

1

Error detected

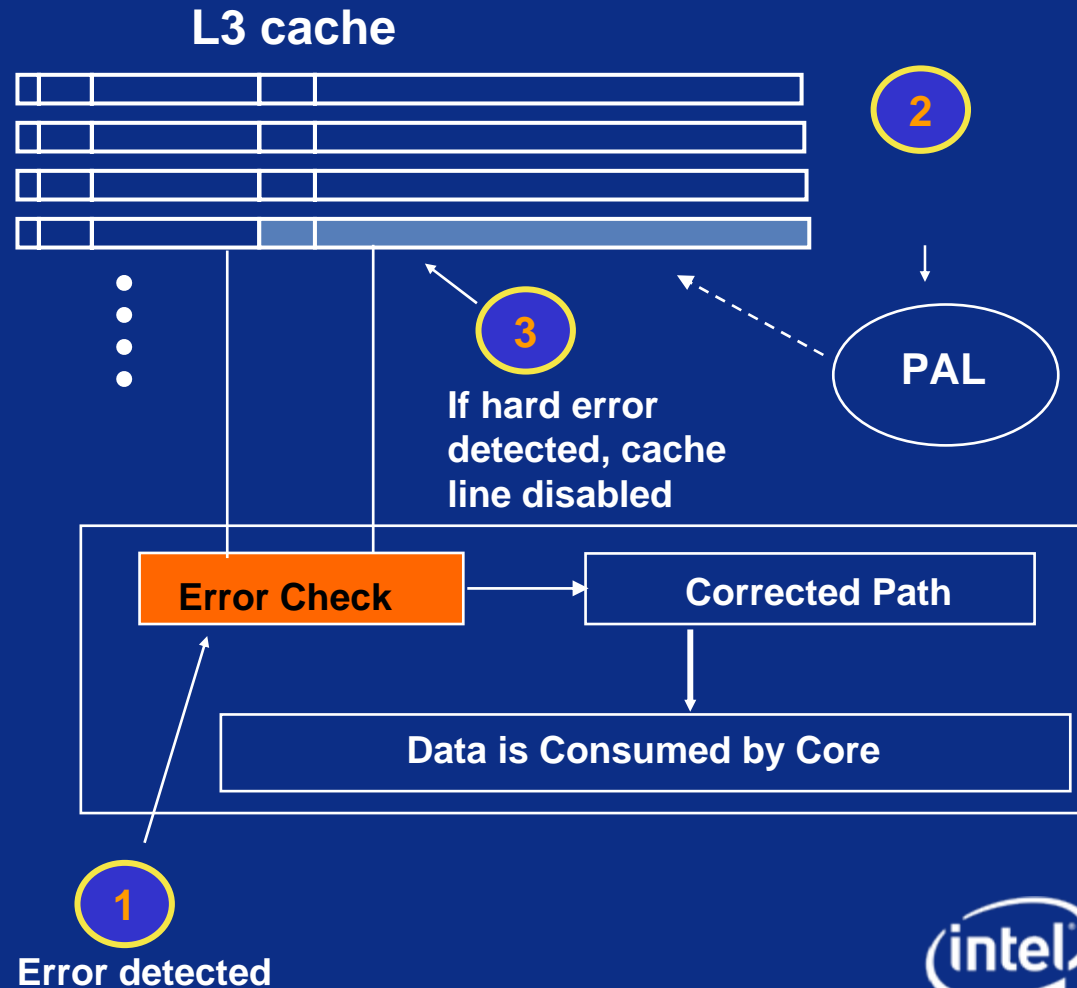# Montecito Processor Error Coverage

Structure	Hardware	Action
L1 data cache	Parity	PAL-correctable
L1 tags	Parity	PAL-correctable
L2 cache data	ECC	HW-correctable
L2 cache tags	ECC	HW-correctable
L3 cache data	ECC	HW-correctable + Cache Safe® cache reliability
L3 cache tags	ECC	HW-correctable
Register	Parity	Recoverable
TLB	Parity	Recoverable
Bus	ECC	1-bit errors HW-correctable, 2-bit errors recoverable

PAL-Correctable and Recoverable errors are dependent upon microarchitectural state

(intel)

Comparing reliability Features

Characteristic	Itanium® 2	IBM* Power* 5	Intel® Xeon™ MP	Intel® Xeon™ DP	AMD* Opteron*
Advanced error detection/ correction/ recovery/ logging (MCA)	✓				
Internal soft error logic check	Montecito				
Cache reliability (Pellston)	Montecito				
Processor-level lockstep	Montecito				
Error recovery on data bus (ECC and retry)	✓	✓	✓		
Partitioning	✓	✓	✓		
Memory SDEC, retry on double-bit	✓	✓	✓	✓	
Memory scrubbing	✓	✓	✓	✓	
Memory mirroring and sparing	✓	✓	✓	✓	
Hot Plug I/O (PCI-X, PCI-E) & I/O CRC	✓	✓	✓	✓	✓

Reliability required to replace RISC and mainframes

(intel)

Mission Critical Reliability

HP Integrity NonStop	**3 Seconds per Year**	**99.99999%**
IBM zSeries	**5 Minutes 15 Seconds Downtime per Year**	**99.999%**

0   1   2   3   4   5   6
Minutes

*Other brands and names are the property of their respective owners.

(intel)

Agenda

Itanium® Processor Family Roadmap

Itanium® 2 Processor update & technology highlights

➡ Montecito Processor Performance update
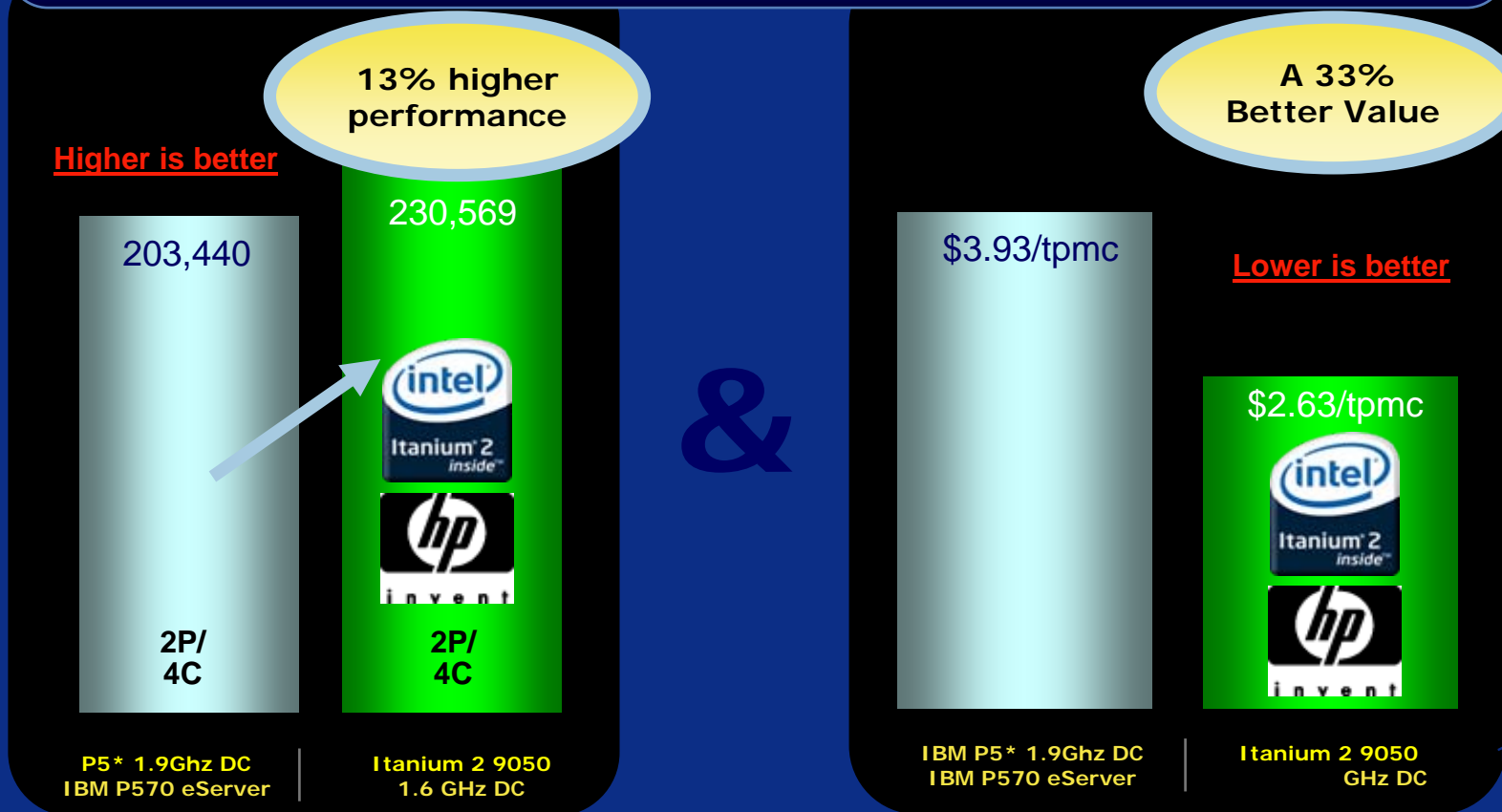
Itanium® 2 Processor Vs Power 5+ competitive position

Itanium® 2 Processor Vs X86 Positioning

Powerful Database Performance
Comparison to RISC

2P/4C TPC-C* Database

13% higher performance

A 33% Better Value

Higher is better

230,569

203,440

$3.93/tpmc

Lower is better

$2.63/tpmc

&

2P/4C

2P/4C

P5* 1.9Ghz DC
IBM P570 eServer

Itanium 2 9050
1.6 GHz DC

IBM P5* 1.9Ghz DC
IBM P570 eServer

Itanium 2 9050
GHz DC

Better Value Compared to RISC based Servers

Dual-Core Intel® Itanium® 2 processor 9000 sequence server

Scaling performance on Java Benchmark

SPECJBB2005

3772246

Near Linear Scaling

1887226

942831

471030

16P   32P   64P   128P
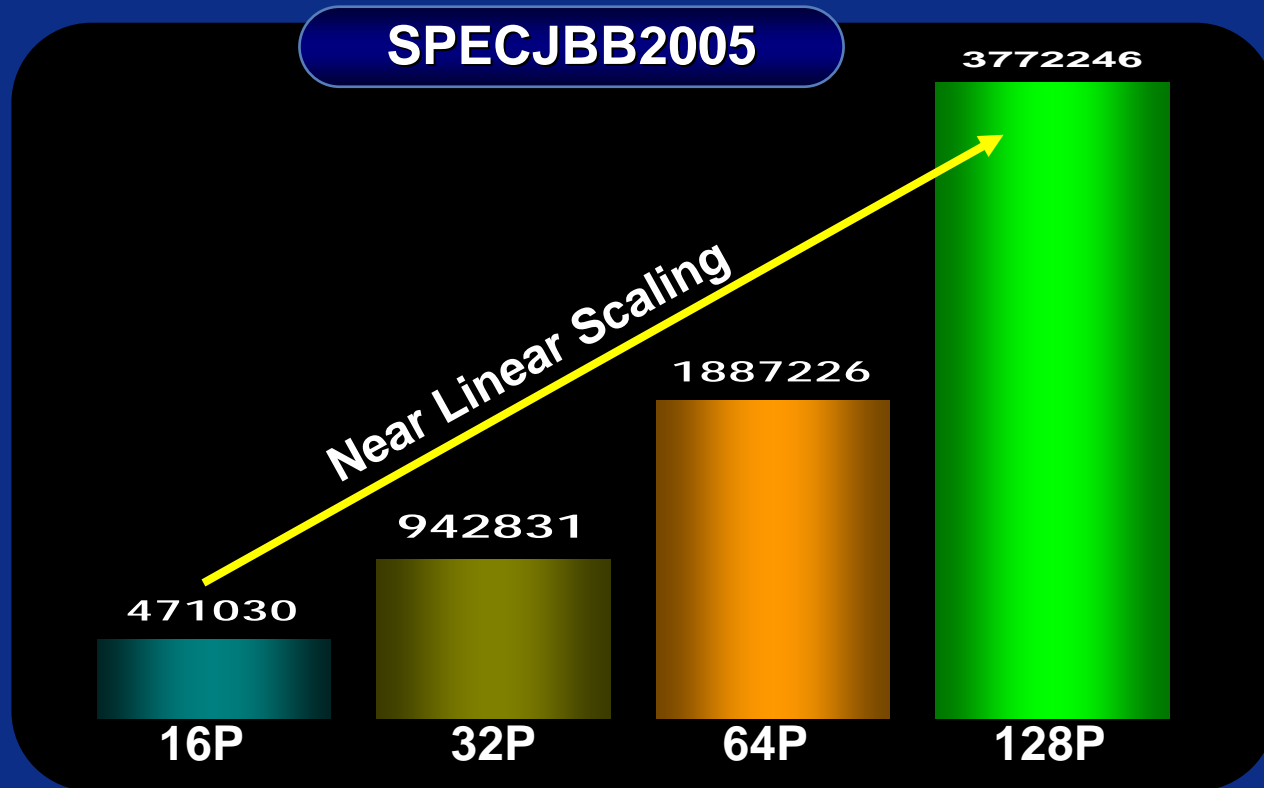
Intel Itanium 2 9000 sequence

Data Source: Published or Submitted results as of July 18th, 2006. See backup for details
Itanium 2 9000 sequence: Dual Core Itanium 2 "Montecito 1.6Ghz"
"p" is a processor or socket and "C" is a core

Itanium 2 Platform Shows Excellent scaling

(intel)

Business Analytics Performance
1000 GB database

Maximum Performance
2.35x faster than before

OR

Maximum Value
With **HALF the Processors,** *And* **Lower SW Licensing Costs** *Still* **80% faster**

TPC-H* with Microsoft* SQL server

Higher is better

33488

2.35x

14203

16P/ 16C

16P/ 32C

Queries per minute

Intel Itanium 2 processor 9M

Itanium 2 9050 1.6 GHz DC

TPC-H* with Oracle 10g R2*

27143

1.80x

15069

16P/ 16C

8P/ 16C

Queries per minute

Intel Itanium 2 processor 9M

Itanium 2 9050 1.6 GHz DC

Compare 8P to 16P

Data Source: Published or Submitted results as of August 30th, 2006 (http://www.tpc.org Dual Core Itanium® 2 Processor 9050. "p" is a processor or socket and "C" is a core

Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/resources/limits.htm or call (U.S.) 1-800-628-8686 or 1-916-356-3104.
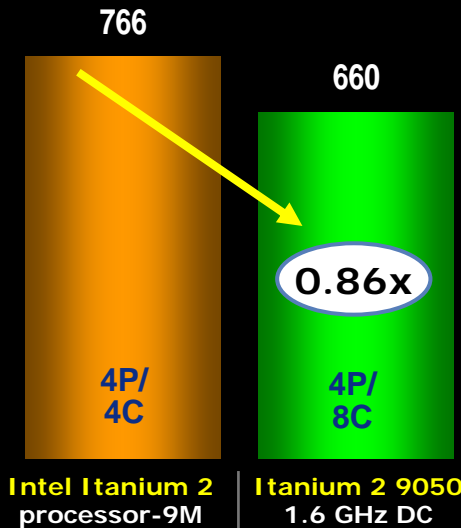
Dual-Core Intel® Itanium® 2 processor 9000 sequence server
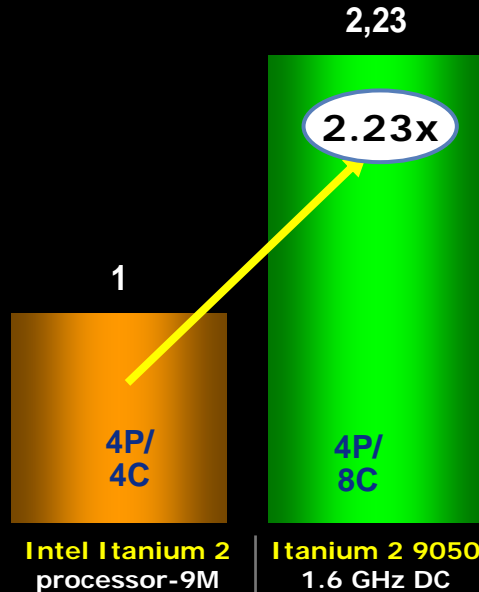## Energy efficiency on STAR-CD* 3.22

Lower System Power	AND	Higher Performance	=	Superior Performance/Watt

Lower is better

Measured System Power in Watts

766

660

0.86x

4P/4C — Intel Itanium 2 processor-9M

4P/8C — Itanium 2 9050 1.6 GHz DC

Higher is better

2,23

2.23x

1

4P/4C — Intel Itanium 2 processor-9M

4P/8C — Itanium 2 9050 1.6 GHz DC

Higher is better

2,6

2.60x

1

4P/4C — Intel Itanium 2 processor-9M

4P/8C — Itanium 2 9050 1.6 GHz DC
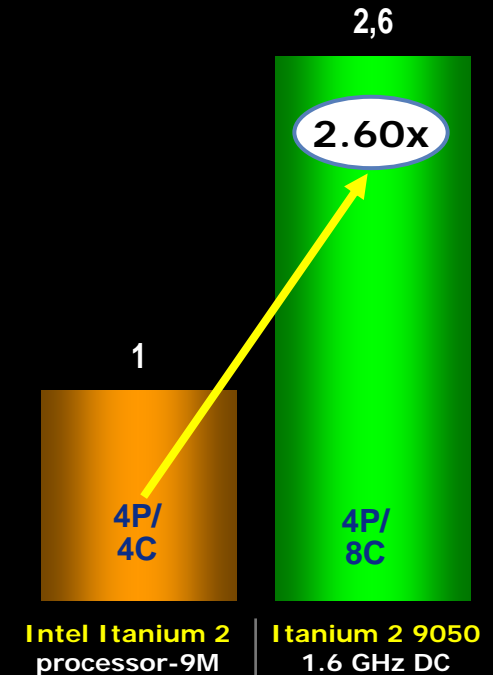
Data Source: Intel internal measurement, See backup for details
Itanium 2 9000 sequence: Dual Core Itanium 2 "Montecito 1.6Ghz"
"p" is a processor or socket and "C" is a core

Itanium 2 shows 2.6x better performance/watt over Previous generation

(intel)

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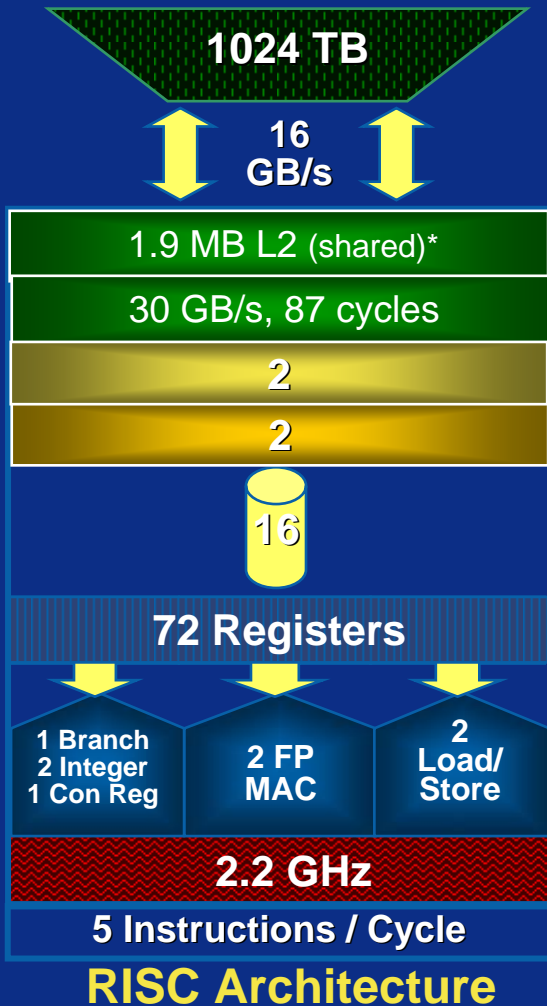Montecito Processor Performance update

Itanium® 2 Processor Vs Power 5+ competitive

Itanium® 2 Processor Vs X86 Positioning

High-end microarchitectures comparisons

IBM POWER5+ Processor		Itanium® 2 processor (Montecito)
1024 TB	Physical Memory Addressing	**1024 TB**
16 GB/s	◀ Max memory bandwidth	**8.5 GB/s****
1.9 MB L2 (shared)*	On-die Cache ▶	24 MB L3 (split – 12MB/core)
30 GB/s, 87 cycles	L3 cache b/w, latency ▶	102 GB/s***, 14 cycles
2	Cores / Socket	2
2	Threads / Core	2
16	Pipeline Stages ▶	8
72 Registers	On-die Registers ▶	264 Application + 64 Predicate
1 Branch 2 Integer 1 Con Reg / 2 FP MAC / 2 Load/Store	Execution Units ▶	6 Integer, 3 Branch / 2 FP MAC / 2 Load and 2 Store
2.2 GHz	◀ Core Frequency	**1.6 GHz**
5 Instructions / Cycle	Max Instructions Retired / Cycle ▶	6 Instructions / Cycle
RISC Architecture		**EPIC Architecture**

* Off-die 36MB shared L3 Cache
** Shared per FSB, assumes one CPU/FSB

*** 51 GB/s for each core

(intel)

Industry standards-based platform for mission-critical solutions *provides choice & flexibility*

Itanium 2 inside

OS Choice
- **Linux***,
- **Unix***,
- **Windows***,
- **VMS**,
- & more

Application Choice
- 8000+ native applications
- **IA-32** & **MIPS** application support
- **Solaris***, **z/OS***, & **OS/390*** app support

Server Systems Choice
- Broad selection from **top global & regional OEM**s
- **1P to 512P** systems
- >15 large SMP systems

Choice & Flexibility

Wide OS support helps lower cost and risk for your mission-critical solution

Choice & Flexibility

Migrate and run your mission-critical application on industry standard platform at your own pace

Choice & Flexibility

Take advantage of rich and broad vendor support infrastructure

Greater choice helps lower *cost and risk*

New Oracle pricing structure for multi-core processors

Processor	Oracles Core Multiplier
Niagara	.25
AMD / Intel	.5
All other Multi-core	.75
All Single Core	1.0

Processor	Number of Oracle licenses
Madison	1
Montecito (dual core)	1
Power5+* (dual core)	1.5

The Intel Advantage:

- Montecito take the advantage away from Power5+*
  - 1 Montecito (dual core) = 1 Oracle license
  - 1 Power5+* (dual core) = 1.5 Oracle licenses

With the new Oracle pricing structure for multi-core processor Montecito gains the advantage over Power5+*

(intel)

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Itanium® Processor Family Roadmap

Itanium® Montecito Processor refresh and Recap and technology highlights
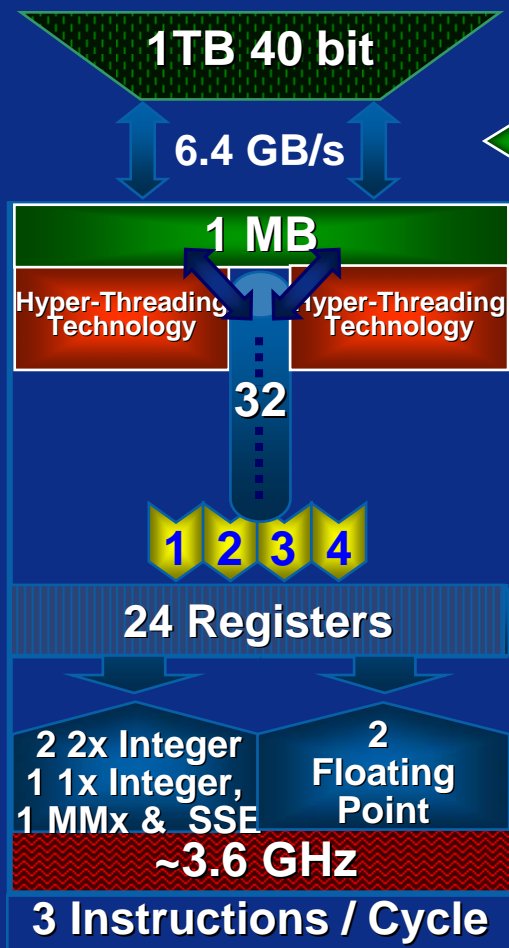
Montecito Processor Performance update

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Intel's 64-bit enterprise microarchitectures

Xeon™ EM64T (X86)

Itanium® 2 Processor 9M

Xeon™ EM64T (X86)		Itanium® 2 Processor 9M
1TB 40 bit	Memory Addressing ▷	1024 TB
6.4 GB/s	◁ System Bus Bandwidth ▷	6.4 – 10.6 GB/s
1 MB	◁ On-die Cache ▷	9 MB
Hyper-Threading Technology / Hyper-Threading Technology	◁ On-die multi-thread ▷	8
32	◁ Pipeline Stages ▷	1 2 3 4 5 6 7 8 9 10 11
1 2 3 4	◁ Issue Ports	
24 Registers	◁ On-die Registers ▷	264 Application Registers + 64 Predicate Registers*
2 2x Integer 1 1x Integer, 1 MMx & SSE / 2 Floating Point	◁ Execution Units ▷	6 Integer, 3 Branch / 2 FP, 1 SIMD / 2 Load and 2 Store
~3.6 GHz	◁ Core Frequency ▷	1.6 GHz
3 Instructions / Cycle	◁ Instructions / Clk ▷	6 Instructions / Cycle
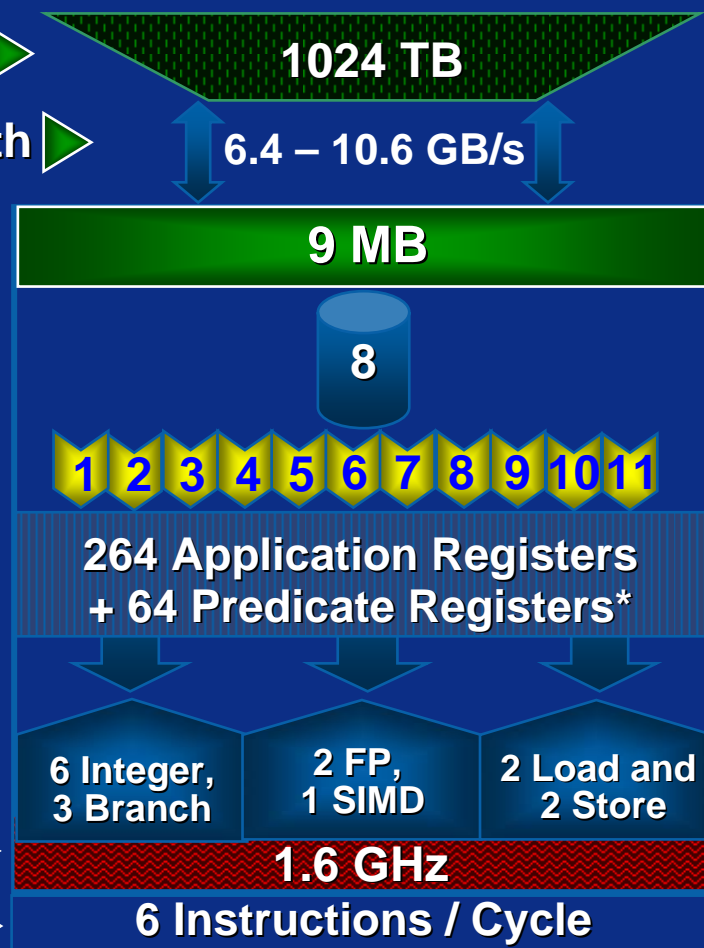
Performance via Megahertz

Performance via Parallelism

* Intel's EPIC technology includes 64 single-bit predicate registers to accelerate loop unrolling and branch intensive code execution.

(intel)

Intel® Itanium®2 or Intel® Xeon®?

**For Your Most Critical
Data Center Requirements**

**Scalable
Mainframe-class server
Ultimate Flexibility & Reliability**

Itanium
9000 Sequence

RISC / Mainframe Replacement

Medium and Large Enterprise

**To Standardize
Your IT Infrastructure**

**Cost Effective
Reliable
High Performance Servers**

Xeon
7000 Sequence
5000 Sequence
3000 Sequence

Small, Medium & Large Enterprise

Small and Medium Business

Summary

- Itanium architecture's strong roadmap delivers investment protection
  - Multi-core, virtualization, power management, and enhanced system bandwidth in 2006 with Montecito

- Itanium 2-based platforms deliver outstanding price/performance along with choice that you don't get with RISC

- Itanium® = Platform of choice for SQL server Database

- Itanium® = Alternative to proprietary RISC platforms

- Itanium® = Choice of hardware, OSs and Applications

- Itanium® = RISC/ mainframe class reliability &

  scalability & Performance

Quiz

1) What Micro-architecture is dual-core Itanium 2 (Montecito) CPU based?

EPIC

2) How many threads an 8-way integrity server can support

32 threads

3) What is L3 cache memory size in the new dual-core Itanium 2 (Montecito) processor?

24 MB !

4). What new technology is used in Montecito Processor to provide advanced Cache reliability?

Intel Cache Safe Technology

(intel)

For More Information

Intel® Itanium® 2 processor product information

- intel.com/products/server/processors/server/Itanium®2/

End-user usage – case Studies, testimonials

- intel.com/business/casestudies/prodserv/index.htm

Reference Solutions and configurations guides

- www.intel.com/business/bss/products/server/itanium2/index.htm?iid=ibe_server+dss&#DSS

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Thank   You

Questions?

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