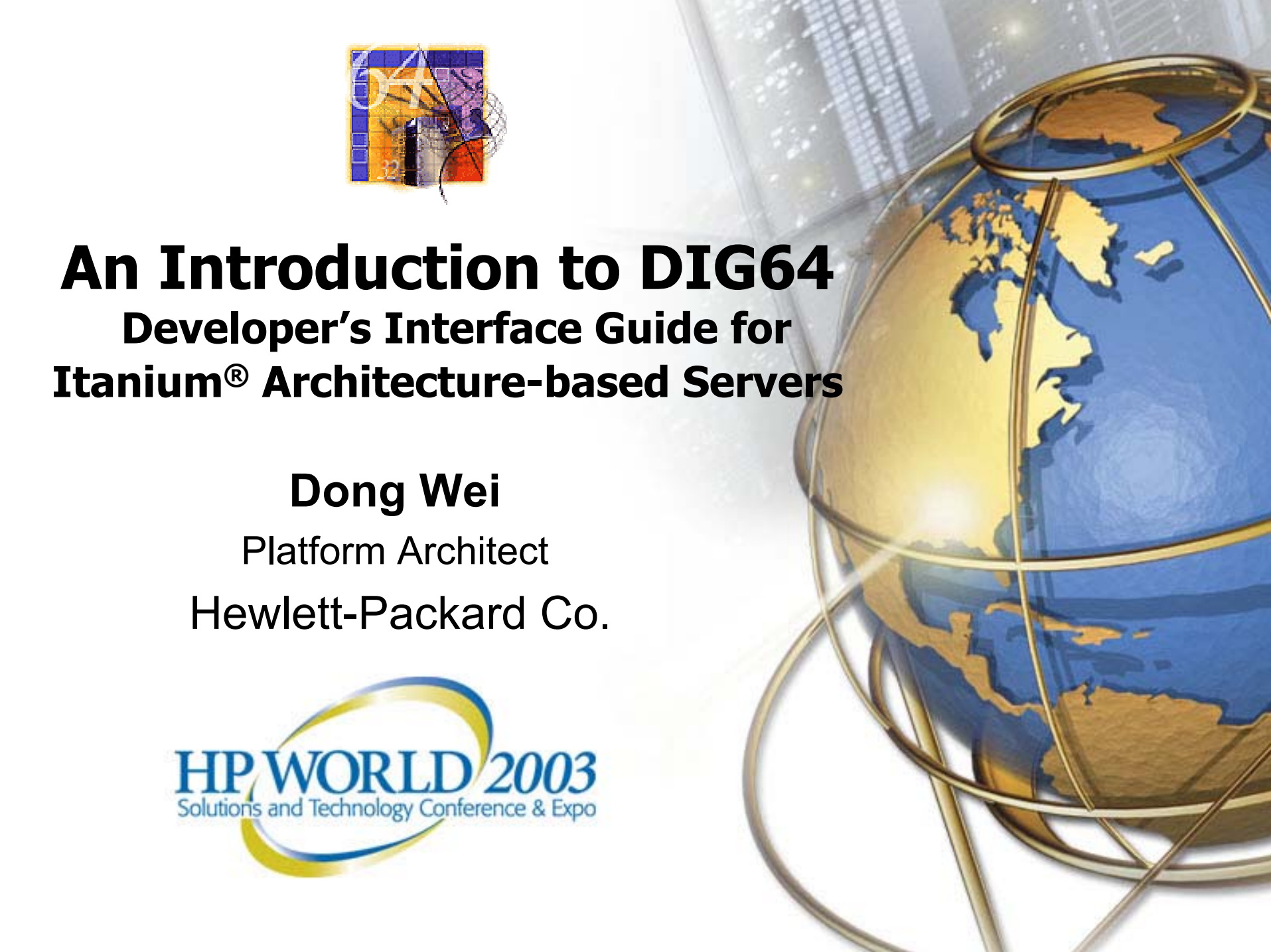

An Introduction to DIG64

Developer's Interface Guide for Itanium® Architecture-based Servers

Dong Wei

Platform Architect

Hewlett-Packard Co.

HP WORLD 2003

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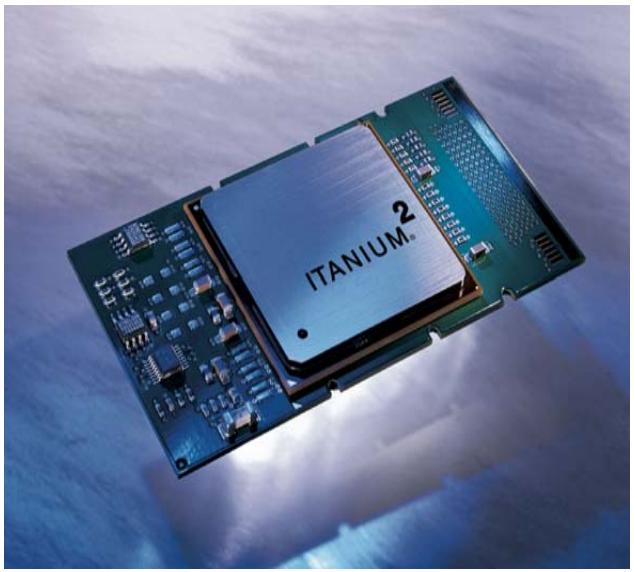
Agenda

- Itanium® Architecture Ecosystem
- DIG64 Specification Overview and Examples
- DIG64 Foundations in HP Integrity Servers

Itanium Architecture Ecosystem

- Itanium® Processor Family Roadmap
- Record-breaking Performance
- Breadth of OEMs, Platforms, Systems

Intel® Itanium® Architecture A Quick Review



- **EPIC: Clean sheet approach to addressing enterprise needs**
  - **Handling largest data requires new approach**
  - **Benefits from the experience of past architectures**
  - **Designed for the largest, most demanding workloads**
- **Convergence of the best minds in the industry**
  - **Intel® architecture, design, validation, manufacturing**
  - **HP advanced architecture and systems expertise**
  - **Multiple and growing number of OEM designs**

Explicit Parallelism

- Maximizes instructions executed in parallel
- Multiple execution units and issue ports

Massive On-Chip Resources

- Large and fast on-die cache
- 128 general registers, 128 floating point registers, 8 branch
- Efficient management engine
  - Register stack engine
  - 4 GB page size

Architectural Scalability

- Modular
- Able to seamlessly add execution resources, issue ports

Itanium® Processor Family Roadmap

Maintaining World Class Performance

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	2002	2003	2004	2005
MP Capable	**Itanium® 2** Processor 1GHz 3MB L3 cache	**Itanium 2** Processor (Madison) 1.5GHz 6MB L3 cache	**Itanium 2** Processor (Madison 9M) >1.5GHz 9MB L3 cache	**Montecito** Dual Core Larger caches
DP Capable Low Voltage		**Low Voltage Itanium 2** Processor (Deerfield) 1GHz 1.5MB L3 cache 62W	**Low Voltage Itanium 2** Processor (Deerfield follow-on)	**Montecito-based**
Technology	0.18µm	0.13µm		90nm

All dates specified are target dates, are provided for planning purposes only and are subject to change.

Itanium®2 Processor's Record-setting Performance

Application Benchmarks			#1 Results
Enterprise Computing	On-line Transaction Processing	TPC-C	64P and Overall†
	Enterprise Resource Planning	Oracle ASB	4P
	Enterprise Resource Planning	SAP SD	4P*
	Supply Chain Demand Planning	SAP APO-DP	4P
	Web Server Secure Connections	SPECweb99_SSL	1P, 2P, 4P
	Java Application Performance	SPECjbb2000	4P, 64P
Technical Computing	Matrix Multiplication	Linpack	64P
	Floating Point Computation	SPECfp_base2000	Overall
	Memory Bandwidth	Stream Triad	64P*

Based on publicly available benchmark results as of 7/31/03.

HP Systems Performance: http://www.hp.com/products1/servers/integrity/performance.html

† Non-clustered results
✷ Non-HP systems

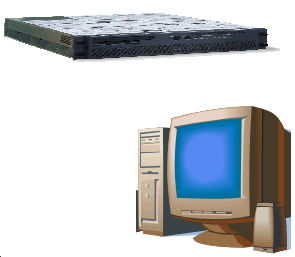
Broad Range of Systems based on Itanium® Architecture

hp invent, sgi, NEC, IBM, UNISYS, Bull, HITACHI, DELL, FUJITSU SIEMENS COMPUTERS, CELESTICA, SUPERMICRO An Internet Server Solutions Provider, MAXDATA, SAMSUNG, lenovo 联想, Itautec, kraftway, FOUNDER

and many others

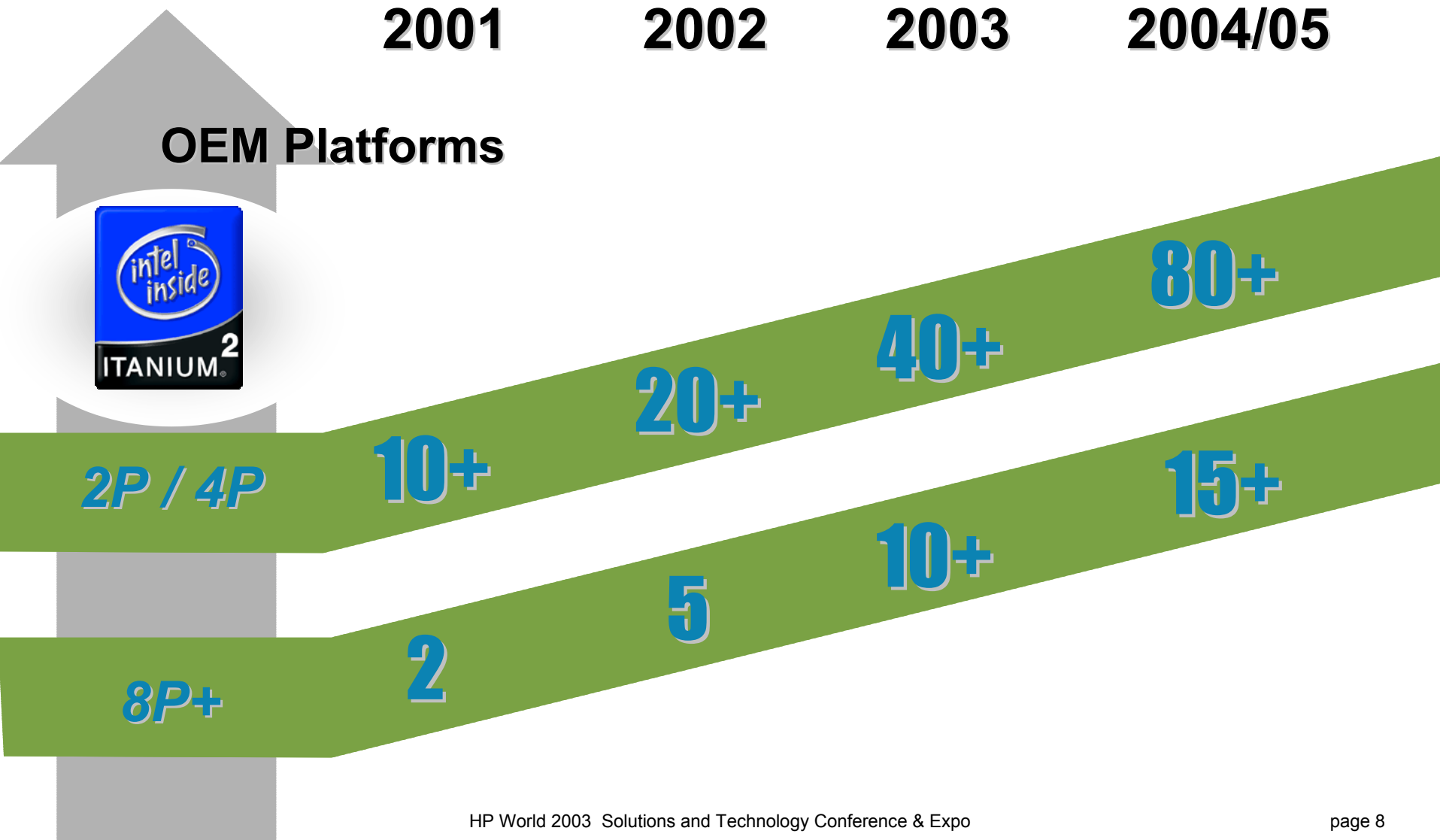
Range of systems from over 40 OEMs available in 2003

UP – DP	4P	8P	16P	32P – 128P
>40 OEMs	*>40 OEMs*	*7 OEMs*	*6 OEMs*	*5 OEMs*



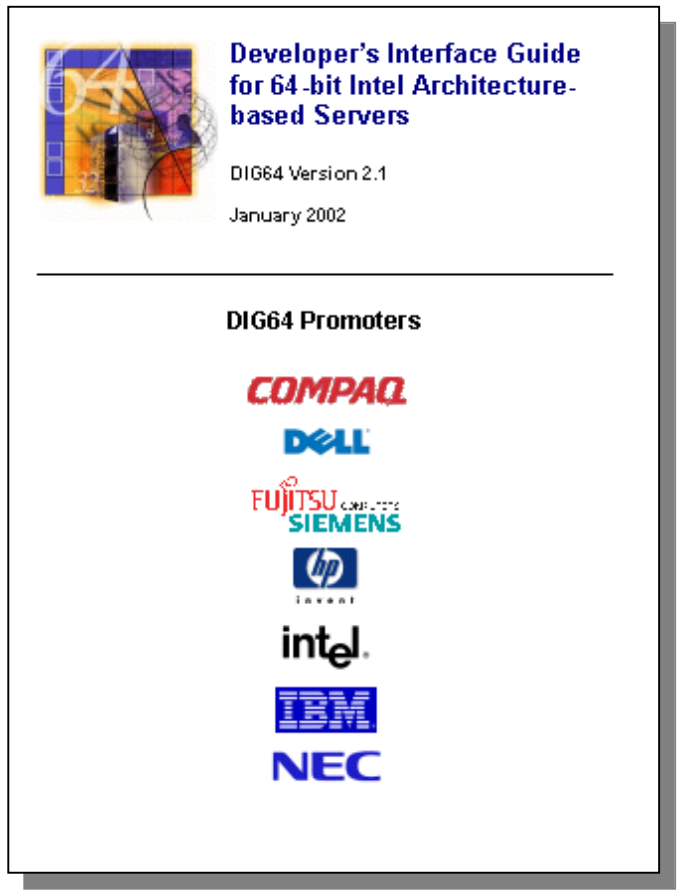
Source: Intel estimates. All products, dates, and information are preliminary and subject to change without notice.

Broadening Itanium® Architecture Platforms



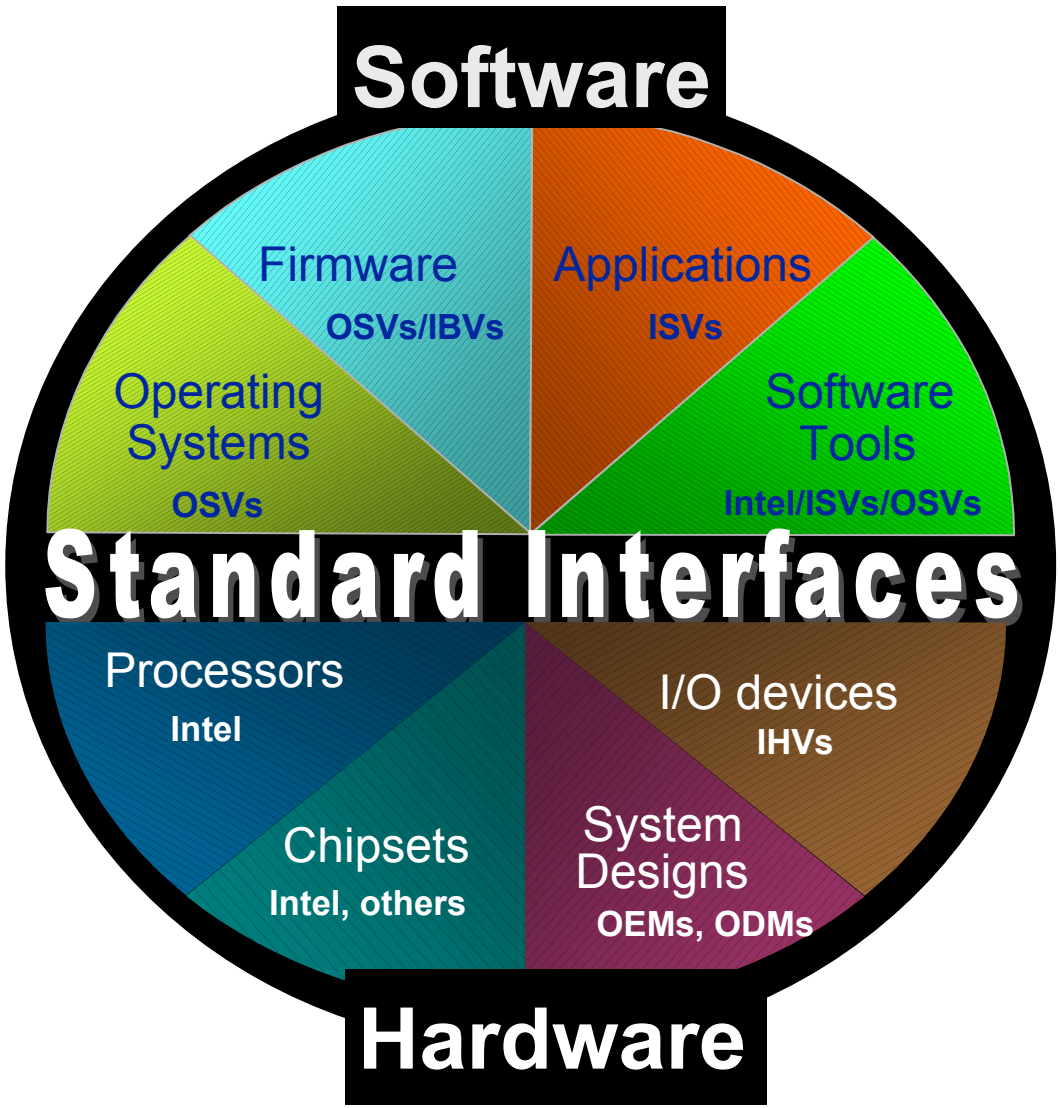
Developers Interface Guide for Itanium® Architecture-based Servers

- **A set of guidelines for developers on Itanium Architecture**
  - Baseline interfaces
  - Required platform features
  - OS-independence
- **An industry consortium**
  - Top vendors in the enterprise
  - Leaders in technology and product innovation
  - Committed to industry-wide enabling of key technologies



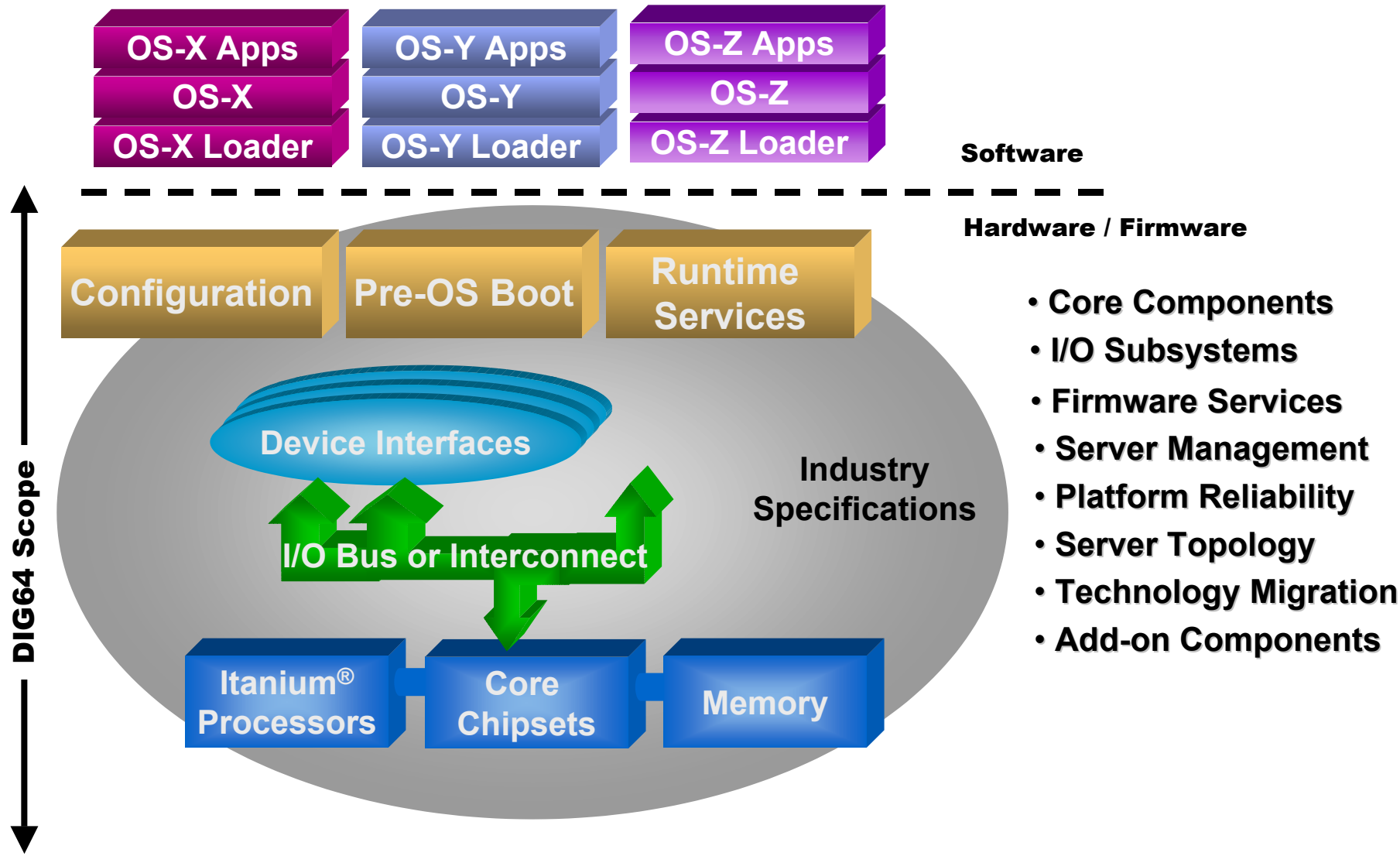
DIG64 is for developers in the Itanium Architecture Ecosystem

DIG64 Drives Interoperability thru Interfaces



- **Interoperability**
  - System building blocks
  - S/W interfaces
  - OS-agnostic platforms
- **Platform Advancement**
  - Technology Migration
  - Legacy Removal

DIG64 Specification Scope



- Core Components
- I/O Subsystems
- Firmware Services
- Server Management
- Platform Reliability
- Server Topology
- Technology Migration
- Add-on Components

HP Integrity Server Family

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High end	Launch: 6/30/03  Superdome 16,32,64-socket	Fall 2003  HPTC cluster
Midrange	Launch: Fall 2003  8-socket  16-socket	
Entry	Launch: 6/30/03  rx2600 (2-socket)  rx5670 (4-socket)	Fall 2003  carrier grade (2-socket)

DIG64 is the foundation of HP Integrity Server platforms

Unprecedented choice and breakthrough flexibility

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Unprecedented Choice

- Operating Environments
- Type of systems
- When to adopt new technology
- Applications
- Scale up and scale out

Benefits:

- Standardization through DIG64
- Streamline operations
- Increased asset utilization
- Consistent support levels

HP-UX 11i
Internet critical. E-services ready.
Proven Solution with added Performance and RoIT

Microsoft Windows Server 2003
Unparalleled Scalability, Performance & RoIT

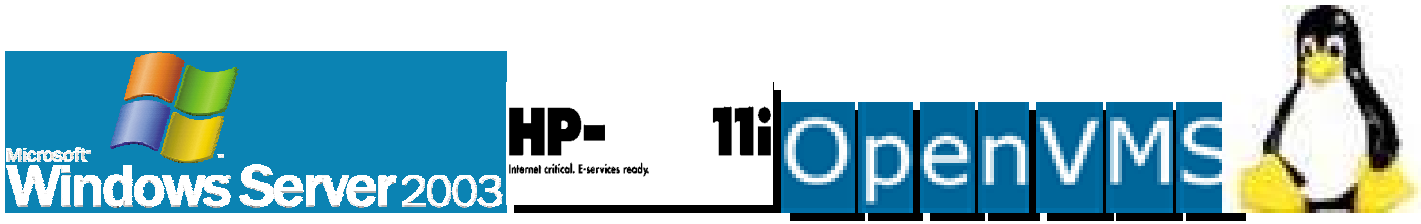
Industry standard for 64-bit and RoIT

OpenVMS
Investment Protection

Breakthrough Flexibility

- Superior solution for single operating systems
- Industry leading multi-operating system support:
  - Repurpose
  - Consolidation
- Lasting value
  - 15-20 year architecture
  - in-box upgrades & binary compatible

Itanium® Architecture Platforms from HP



SHDG

DIG64

HP Features

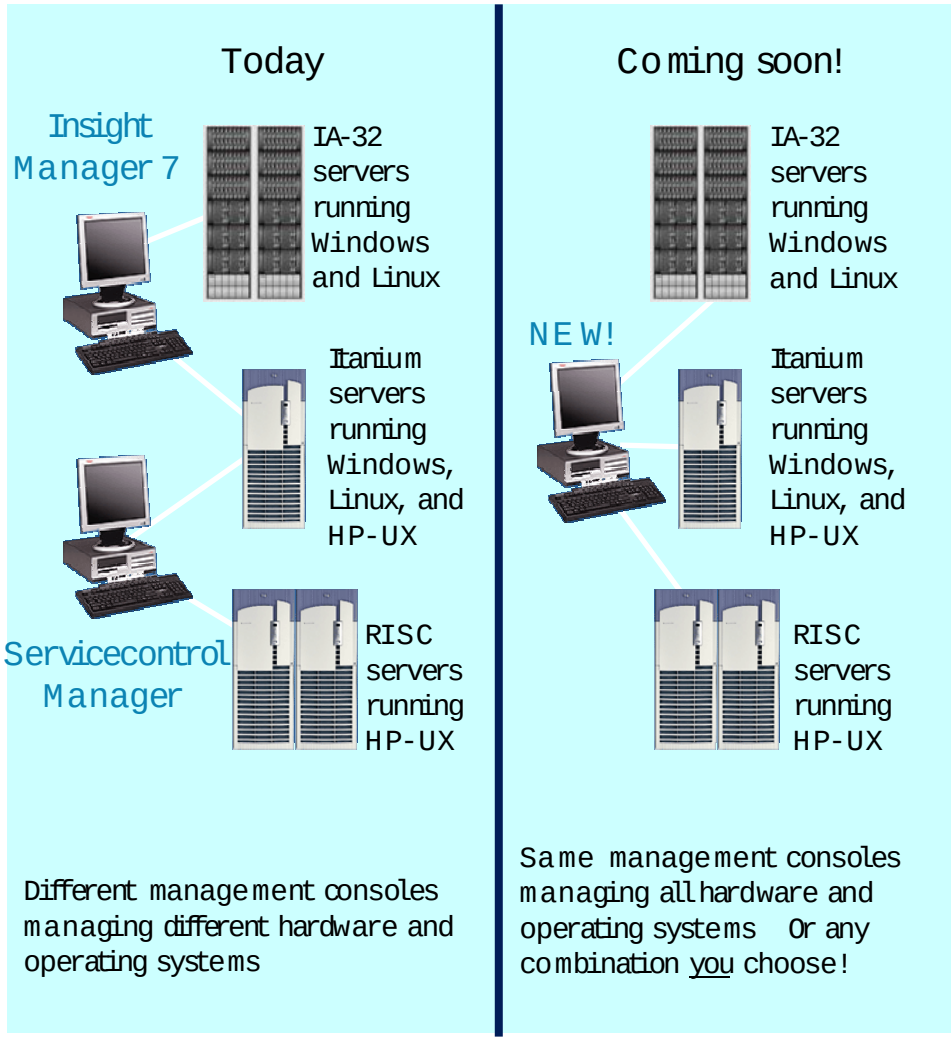
Industry Standards
(SAL, EFI, ACPI, IPMI, PCI-X, USB, etc.)

DIG64 Foundations of HP Servers - Example

- **Feature:** Unprecedented choice and breakthrough flexibility in Multi-OS support

- **Sample DIG64 Guidelines**
  - *Support EFI Boot Loader* (10.3.3), *Driver Model and Byte Code* (10.3.5), *Preboot Environment* (10.3.3)
  - *Support for PAL/SAL and related component update, authentication, and I/O configuration functionalities* (4.1~4.2)

Next generation system level management



Single management architecture and application for HP-UX, Linux and Windows

- Unifies Insight Manager, Toptools and Servicecontrol Manager
- Delivered as an upgrade to Insight Manager and Servicecontrol Manager
- Easy-to-use for highest efficiency
- Modular, customizable structure for maximum flexibility
- Standard-based for optimum integration

Note: Similar functionality planned for OpenVMS

DIG64 Foundations of HP Servers - Example

- **Feature:** Single management architecture and application
- **Sample DIG64 Guidelines**
  - *Support for ACPI System Description Tables* (5.2), *Register Interfaces* (5.3~5.4), and *State Definitions* (5.5)
  - *Server management features, including event logging, power, temperature and security monitoring, management channels, etc.* (7.2)
  - *Platform reliability features, including Machine Check Architecture, error detection and tolerance, interconnect transaction retries, etc.* (8.1)

DIG64 Foundations of HP Servers - Example

- **Feature:** Legacy-free I/O

- **Sample DIG64 Guidelines**
  - *No ISA slots and devices* (10.3.1~2)
  - *Optional support for Serial COM, Parallel ports, Floppy Disk, 8259A PIC, 8254 Timer, etc.* (10.3.3~24)
  - *Appropriately implementing I/O technologies like PCI, PCI-X, USB, Infiniband, etc.* (6.1)

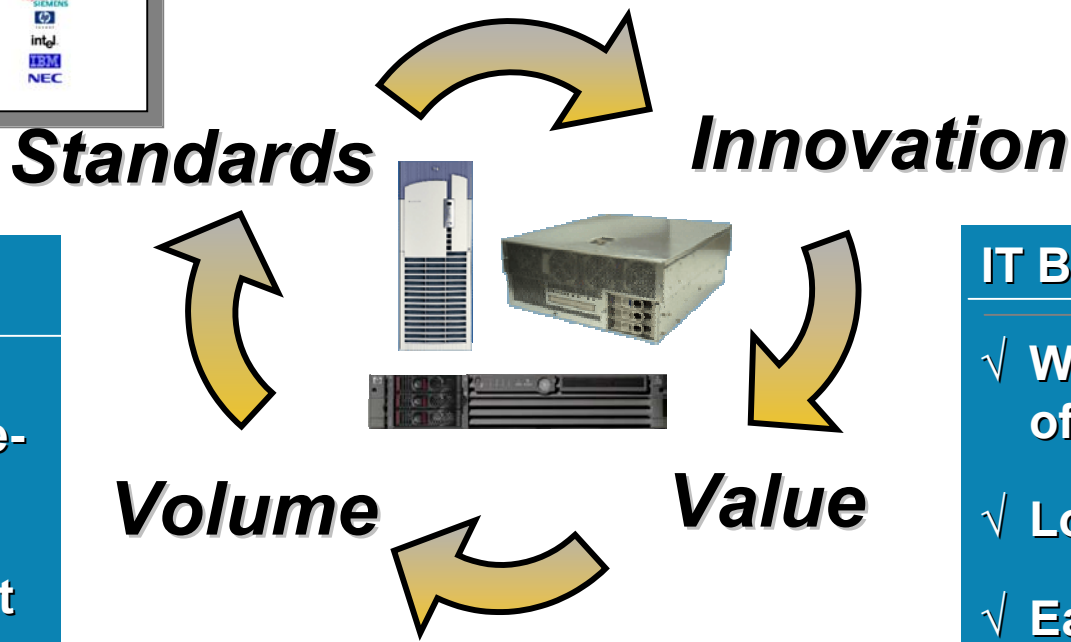
DIG64 Foundations in Windows* Server HDG

- **Many of Microsoft H/W requirements for 64-bit Windows Server are based on DIG64**

Examples:

DIG64 2.1	HDG 3.0 (64-bit Requirements)
[4.4.1] Implementing EFI (is required).	[14] … system complies with EFI 1.0 or later, …
[4.2.1] Implementing SAL on (system) Firmware [4.2.2] SAL Procedure for Updating Firmware	[14.3] … system implements SAL, including firmware update method
[4.2.3] Software PCI Configuration Accesses Must Use SAL Procedures	[53] Software PCI configuration space accesses on an IA-64 system use SAL procedures
[6.2.1.8] System Must Provide Support For Message Signaled Interrupts*	[26] … system supports message-signaled interrupts [34] PCI devices in … system support message-signaled interrupts
[7.2.7] Cooling Device Failure Monitoring [7.2.8] System Temperature Monitoring [7.2.9] Processor Temperature Monitoring …	[225]. System includes alert indicators for imminence of failure

DIG64 Fuels a Virtuous Circle of Product Innovation



Developer Benefits

- √ Quicker time-to-market
- √ Lower development cost
- √ Increased ROI
- √ Provide new standards

IT Benefits

- √ Wider choice of solutions
- √ Lower TCO
- √ Ease of migration
- √ Enable innovation

Summary

- DIG64 is the platform standard for servers based on Intel® Itanium® Processor Family
- DIG64 fuels the virtuous circle of innovation within the Itanium Architecture ecosystem
- DIG64 is a design foundation for the HP Integrity Server Family which delivers unprecedented performance and flexibility for enabling business agility and better RoIT.

Reference

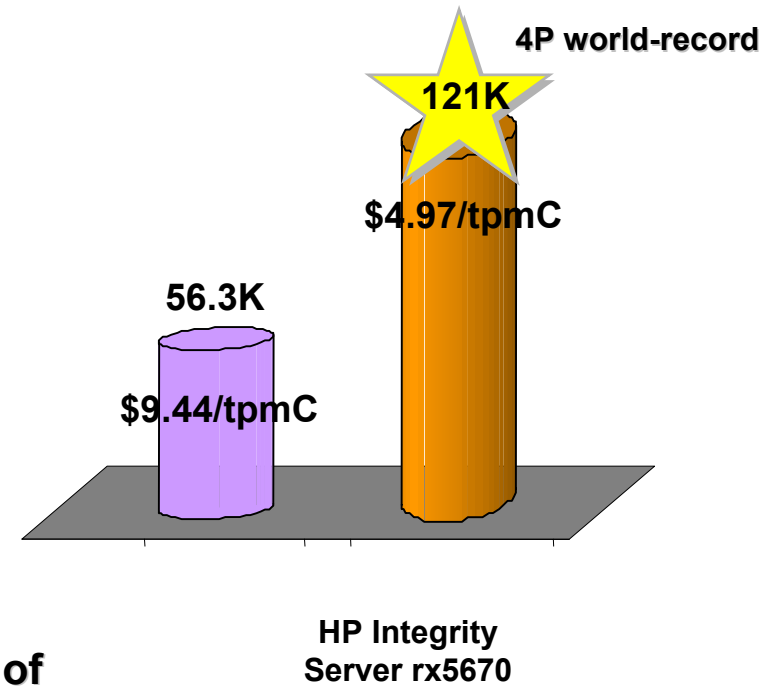
- DIG64 public website
  - DIG64 v2.1
  - Headless & Debug Port
  - Speedy Boot
  - EFI System Partition Directory Name Registration
  - http://www.dig64.org/

Backup

Transaction Processing (TPC-C) Performance on 4 processors

Results as of 7/7/03

- **Description:**
  - Online transaction processing
  - e.g. order entry
- **Advancement:**
  - Server transactions up to twice as faster than comparable RISC systems
  - Database transactions at about ½ of the cost of comparable RISC systems
- **Benefits:**
  - Faster access to large amounts of data
  - Support for a significantly larger number of transactions



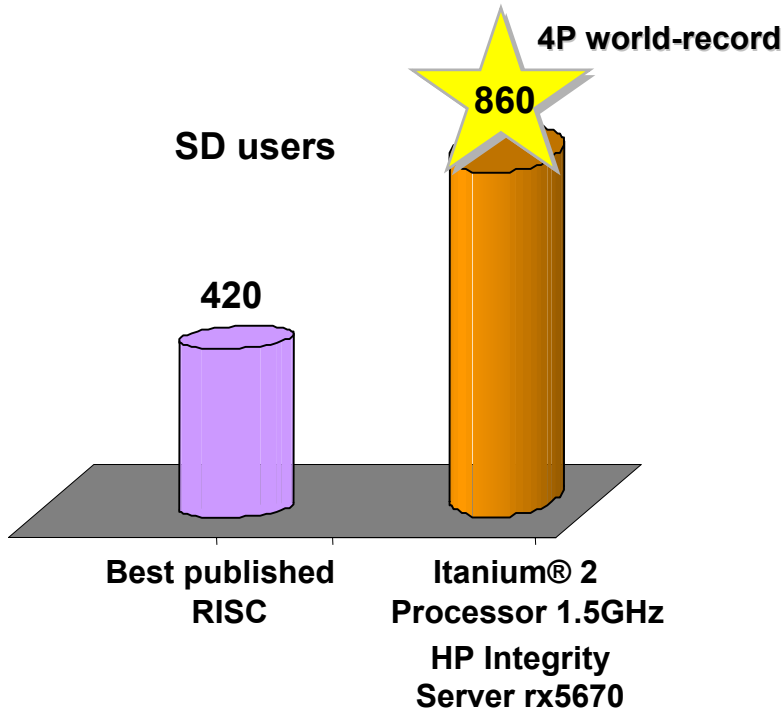
Itanium® 2 processor 6M based systems deliver best of class 4 way transaction performance

Source: www.tpc.org. Itanium® 2 processor results of 121,065 tpmC and $4.97/tpmC on HP Integrity server rx5670 using 4 Itanium® 2 processors 1.5GHz with 6MB L3 cache, 64GB memory, Microsoft* Windows* Server 2003 Enterprise Edition and Microsoft* SQL Server 2000 Enterprise Edition 64-bit, availability date 8/1/03. Best published RISC result of 56,375 tpmC and $9.44/tpmC on HP AlphaServer using 4 ES45 processors 1.25GHz, 32GB memory, availability 09/27/02.

SAP SD* 2-tier Performance on 4 processors

Results as of 7/7/03

- **Description:**
  - Enterprise resource planning
  - e.g. a server handling sales and distribution orders
- **Advancement:**
  - Server transactions > 2X than comparable RISC systems Benefits
  - Ability to handle more complex supply-chain
  - Support for a significantly larger number of sales and distribution transactions



Itanium® 2 processor 6M based systems deliver industry leading 4 way ERP performance

Source: www.sap.com/benchmark. Itanium® 2 processor results measured on HP Integrity server rx5670 using 4 Itanium® 2 processors 1.5GHz with integrated 6MB L3 cache, 24GB of memory, HP-UX 11i, SAP rev 4.6 C, Oracle 9i. Best RISC result of 420 from www.sap.com/benchmark on AlphaServer ES45 1000MHz.

Security Performance (SPECweb99_SSL*) Performance on 2 processors

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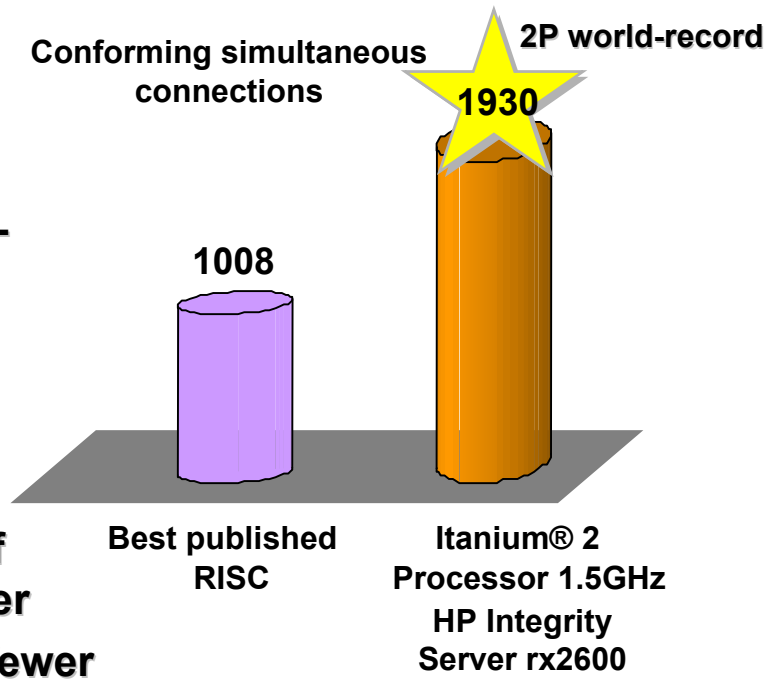
Results as of 7/7/03

- **Description:**
  - SPECweb99_SSL* is a industry-accepted workload to measure the performance capabilities of a web server with added SSL encryption/decryption.
- **Advancement:**
  - > 90% improvement over Best RISC
- **Benefits:**
  - Support for a significantly larger number of secure e-commerce transactions on a server
  - Improved customer response times using fewer servers



The Itanium® 2 Processor delivers industry leading security performance[1]

1 compared to information published on http://www.spec.org as of July 7, 2003 for two processor results.

Source: www.spec.org. Itanium® 2 processor result of 1930 on HP Integrity server rx2600 using 2 Itanium® 2 processors 1.5GHz with 6MB L3 cache, 12GB memory, HP-UX, Zeus 4.2r2 and submitted to SPEC. Best RISC result on Sun Fire* 280R result of 1008 with 2 UltraSPARC* III Cu processors at 1.2GHz with 8MB L2 cache (off chip), Solaris* 9, Sun ONE Web Server 6.0 SP5, 32GB RAM, published 4/03.

Java Application Performance SPECjbb2000*
First 64P to exceed 1 Million ops/sec

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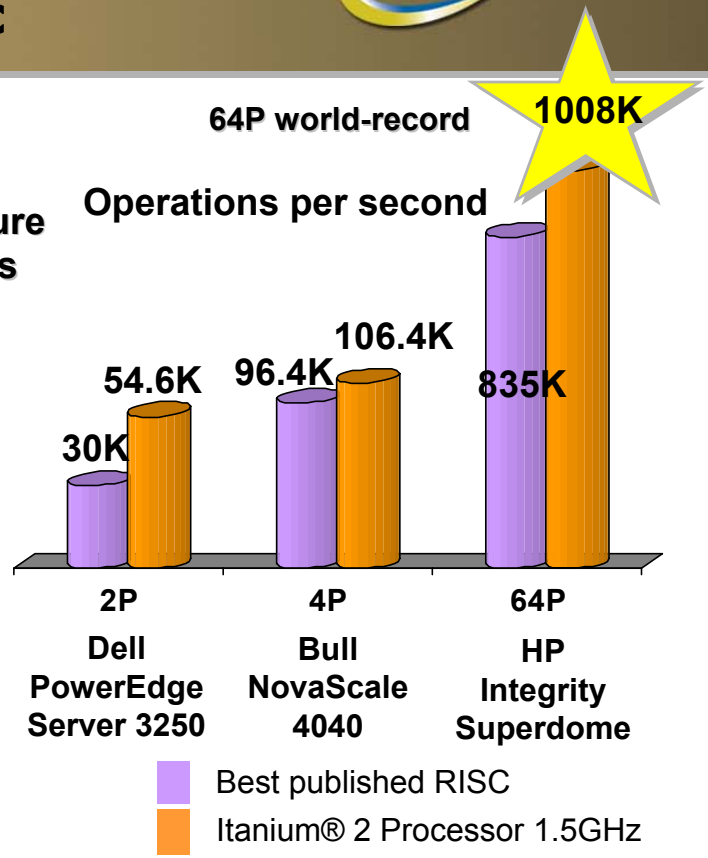
- **Description:**
  - SPECjbb2000* is a industry-accepted workload to measure the server-side Java application performance capabilities
- **Advancement:**
  - Server Java transactions up to 80% faster than best published RISC processor
  - #1 on various platform sizes, 2P to 64P
- **Benefits:**
  - Support for a significantly larger number of Java transactions on a server
  - Improved customer response times using fewer servers
  - Increased client capacity



The Itanium® 2 Processor delivers industry leading Java performance[1]

1 compared to information published on http://www.spec.org as of July 7, 2003 for two, four and sixty-four processor results.

Source for 2P: www.spec.org for Best published RISC result of 30,216 on Fujitsu PRIMEPOWER250 using 2 SPARC64 V 1100MHz processors, 8192MB memory, Solaris8 02/02, JVM HotSpot Server VM on Solaris/SPARC, version1.4.1_02 . Itanium® 2 processor 6M result of 54,617 measured by Dell on Dell PowerEdge 3250 using 2 Itanium® 2 processors 6M at 1.5GHz with integrated 6MB L3 cache, 8192MB of memory, Microsoft* Windows* 2003 Server Enterprise Edition, JVM BEA WebLogic JRockit 64-bit JVM (Build 1.4.1-300903-win-ia64) and submitted to www.spec.org. Source for 4P: www.spec.org for Best published RISC result of 96,377 on eServer pSeries IBM 655 using 4 Power4+ 1.7GHz processors, 16GB memory, AIX 5L V5.2 APAR IY43549, JVM J2RE 1.4.1 IBM AIX build cadev-20030410. Itanium® 2 processor 6M result of 106,451 measured by Bull on Bull NovaScale 4040 using 4 Itanium® 2 processors 6M at 1.5GHz with integrated 6MB L3 cache, 16GB of memory, Microsoft* Windows* 2003 Server Enterprise Edition, JVM BEA WebLogic JRockit 64-bit JVM (Build 1.4.1-300903-win-ia64) and submitted to www.spec.org. Source for 64P: Source: www.spec.org for Best published RISC result of 835,479 on Fujitsu PRIMEPOWER2500 using 64 SPARC64 V 1.35GHz processors, 262144MB memory, Solaris8 02/02, JVM HotSpot Server VM on Solaris/SPARC, version1.4.1_02. Itanium® 2 processor 6M result of 1008,604 measured by HP on HP Integrity Superdome using 64 Itanium® 2 processors 6M at 1.5GHz with integrated 6MB L3 cache, 128GB of memory, HP-UX 11i v2.0, JVM Hotspot 1.4.2.00 and submitted to www.spec.org. SPECjbb* is a trademark of SPEC at www.spec.org.

High Performance / Technical Computing
Linpack* benchmark

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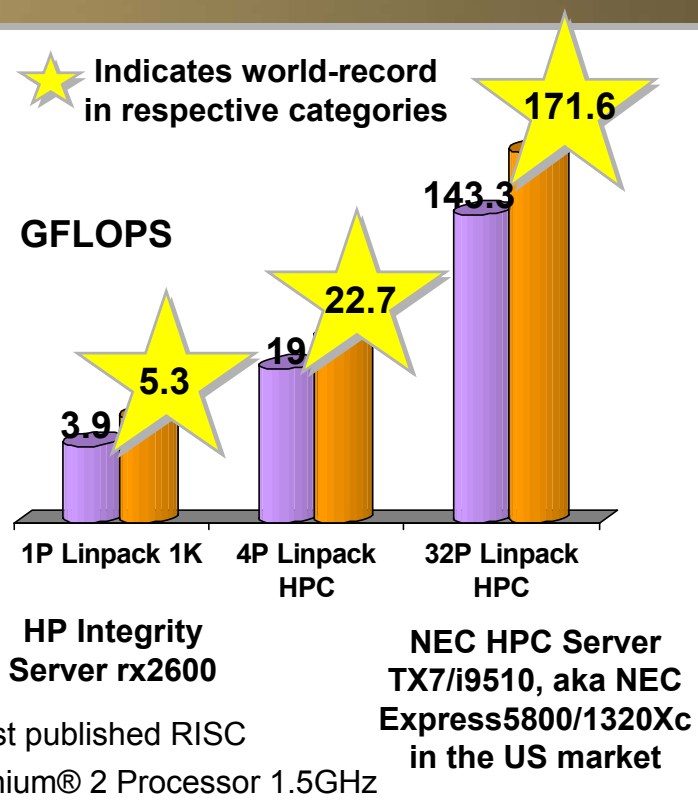
Results as of 7/7/03

- **Description:**
  - Performance of large matrix calculations
- **Advancement:**
  - Upto 36% higher performance compared to RISC platforms
  - Exceeds best in class RISC on 32P Linpack HPC
- **Benefits:**
  - Faster analysis performance
  - Breakthrough in supercomputing power



Itanium® 2 processor based systems provide world-class floating-point performance in the most rigorous technical computing environments

Source for 1P: Itanium® 2 processor 6M results measured by HP on HP Integrity server rx2600 using one Itanium® 2 processor 6M at 1.5GHz. http://www-1.ibm.com/servers/eserver/pseries/hardware/system_perf.pdf for Best RISC result of 3.884 GFLOPs on IBM eServer pSeries 655 using one Power4+ 1.7GHz processor. Source for 4P: Itanium® 2 processor 6M results measured by Intel on Intel Tiger-4 using 4 Itanium® 2 processors 6M at 1.5GHz. http://www-1.ibm.com/servers/eserver/pseries/hardware/system_perf.pdf for Best RISC result of 18.99 GFLOPs on IBM eServer pSeries 655 using 4 Power4+ 1.7GHz processors. Source for 32P: NEC Corporation for Itanium® 2 processor 6M results of 171.6GFLOPs on "NEC HPC Server TX7/i9510, aka NEC Express5800/1320Xc in the US market" with 32 Itanium® 2 processors 6M at 1.5GHz, 256GB RAM, NEC IA-64 Linux R3.2. http://www-1.ibm.com/servers/eserver/pseries/hardware/system_perf.pdf for Best RISC result of 143.3 GFLOPs on IBM eServer pSeries 690 using 32 Power4+ 1.7GHz processors.

Mechanical Computer Aided Engineering MSC.Nastran – Nastran V2004

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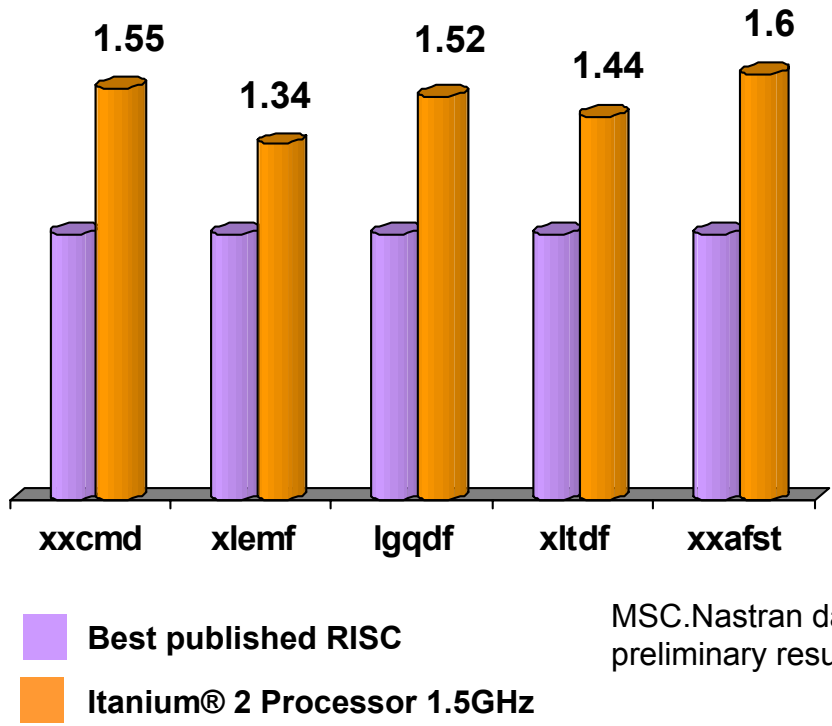
Results as of 7/7/03

- **Description:**
  - Analysis of mechanical models
- **Advancement:**
  - 1.49x faster than Best RISC on 5 workloads (geometric mean)
- **Benefits:**
  - Supports larger, more complex mechanical models
  - Quicker analysis, improved efficiency



MSC.Nastran data, preliminary results

Itanium® 2 processor 6M based systems provide the performance for the most demanding MCAE applications

Source: http://www.mscsoftware.com/support/prod_support/nastran/performance/v0109_sngl.cfm for IBM p655 POWER4 1.3GHz 32GB memory, AIX5.1 ML03,MSC.Nastran V2001.0.9. Intel Measurements on a prototype (Tiger 2) Itanium® 2 processor based system:1.5GHz with integrated 6MB L3 cache; 16GB RAM, Red Hat AS 2.1 2.4.18-e.27smp (binary was built by MSC.Software using MSC.Nastran V2003 round 21 source base), preliminary results.

Floating Point and Integer Performance

Results as of 7/7/03

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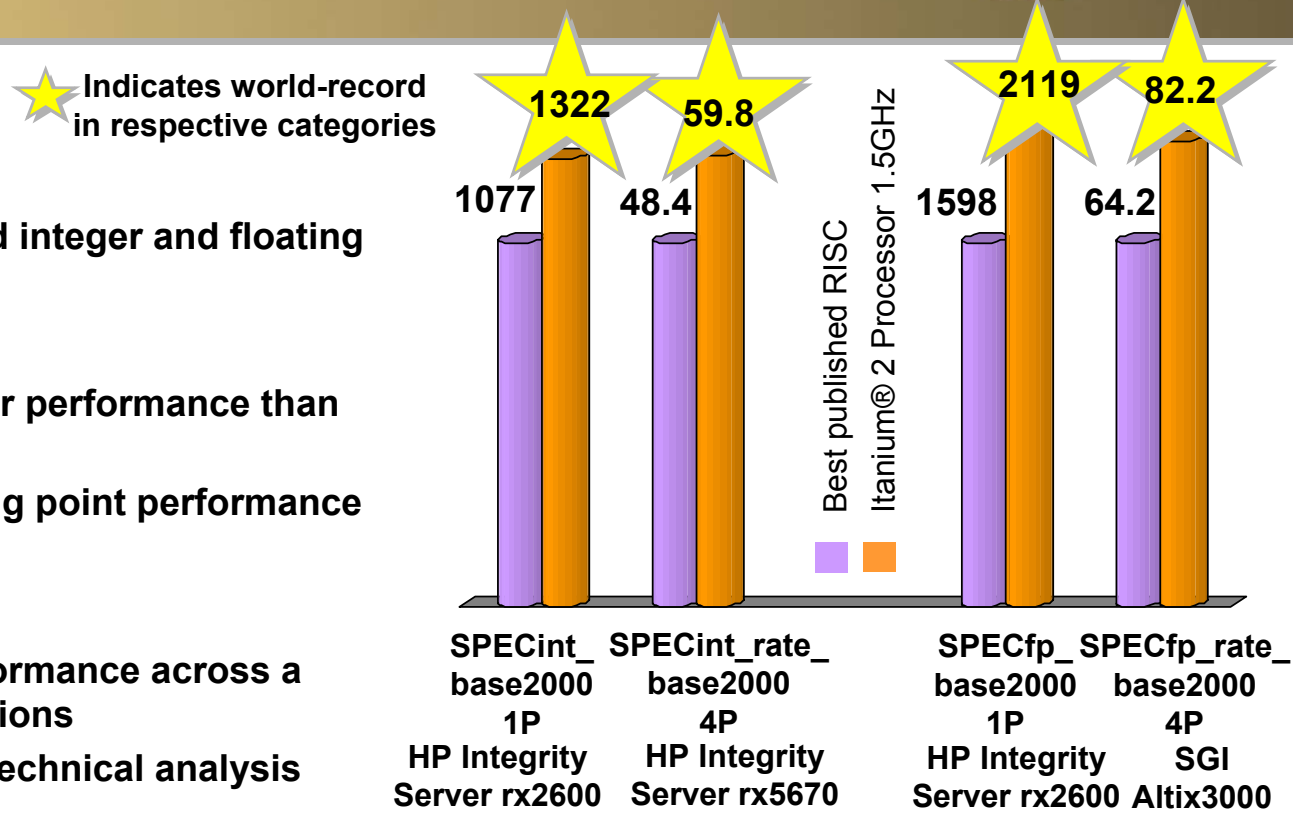
- **Description:**
  - Broad array of standard integer and floating point code
- **Advancement:**
  - Upto 25% higher integer performance than comparable RISC
  - Upto 30% higher floating point performance than comparable RISC
- **Benefits:**
  - Faster application performance across a broad range of applications
  - Quicker scientific and technical analysis



Itanium® 2 processor 6M based systems provide industry leading integer and floating point performance[1]

1 compared to information published on http://www.spec.org as of July 7, 2003 for one processor and four processor results.

Source: Source for SPECint_base2000: www.spec.org. Itanium® 2 processor results measured on HP Integrity server rx2600 using Itanium® 2 processor 6M at 1.5GHz, HP-UX operating system and submitted to SPEC. SPECint* is a trademark of SPEC*. Best RISC result of 1077 on eServer pSeries IBM 690 using Power4+ 1.7GHz processor. Source for SPECint_rate_base2000: www.spec.org. Itanium® 2 processor results measured on HP Integrity server rx5670 using 4 Itanium® 2 processors 6M at 1.5GHz, HP-UX operating system and submitted to SPEC. SPECint* is a trademark of SPEC*. Best RISC result of 48.4 on eServer pSeries IBM 655 using 4 Power4+ 1.7GHz processor. Source for SPECfp_base2000: www.spec.org. Itanium® 2 processor results measured on HP Integrity server rx2600 using Itanium® 2 processor 6M at 1.5GHz, RedHat Linux AS2.1 operating system and submitted to SPEC. SPECfp* is a trademark of SPEC*. Best RISC result of 1598 on eServer pSeries IBM 690 using Power4+ 1.7GHz processor. Source for SPECfp_rate_base2000: www.spec.org. Itanium® 2 processor results measured on SGI Altix3000 using 4 Itanium® 2 processors 6M at 1.5GHz, SGI ProPack* operating system and submitted to SPEC. SPECfp* is a trademark of SPEC*. Best RISC result of 64.2 on eServer pSeries IBM 655 using 4 Power4+ 1.7GHz processor.

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