



The Intel® Itanium® Architecture Comes of Age

Taking the Lead in Performance, Value and Choice

Record-breaking performance is just the most visible sign of the emerging maturity of the Intel® Itanium® architecture. With broad vendor support and extensive hardware and software options, a rich ecosystem is now in place to support comprehensive, end-to-end solutions for a wide variety of enterprise applications.

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Executive Summary

With the release of the Intel® Itanium® 2 processor with 6M L3 cache, the Itanium architecture is taking the lead in enterprise and technical compute performance – in many cases by a wide margin.¹ The new processor has already set best-ever performance records in a variety of major industry benchmarks, including TPC-C, Linpack and SAP SD 2-tier (performance results are shown below).

Further, this new processor is hardware and software compatible with existing Itanium 2-based solutions. Customers can expect a 30-50% performance boost using existing systems and applications.² Software compatibility also extends to IA-32 solutions, since all Itanium 2 processors offer support for IA-32 applications. A new technology called the IA-32 Execution Layer will further enhance this capability in the second half of 2003.

Breakthrough performance is only the most visible sign of the growing maturity of the Itanium architecture. Many businesses will be even more interested in the rich ecosystem that has emerged for supporting comprehensive data center solutions:

- Over 50 platforms will be available by the end of 2003, in sizes ranging from 2 to 64 processors, with larger systems on the way.
- Operating system options include Windows* Server 2003, HP-UX*, and multiple flavors of Linux*.
- Over 400 applications and infrastructure tools are now available from leading ISVs such as BEA, IBM, Microsoft, Oracle, SAP, and SAS.
- A variety of major enterprise customers have already adopted the Itanium architecture, including BMW, Wells Fargo, Reuters, Chevrontexaco, JetBlue Airways, VeriSign, Sony Imageworks, Airbus and many others.

With these developments, the Itanium architecture is now ready for more mainstream deployments. This means that high performance and high value are no longer mutually exclusive in high-end computing environments. Businesses can now achieve the highest levels of performance, scalability and availability using affordable, standards-based components. In the process, they will be laying an agile foundation for cost-effective growth.

Record Breaking Performance

The newly released Intel Itanium 2 processor with 6M L3 cache has already broken records for a variety of industry benchmarks, in some cases more than doubling the performance of the second place performer (Figure 1). It provides a level of balanced performance that drives leading throughput for both enterprise applications and technical computing solutions.

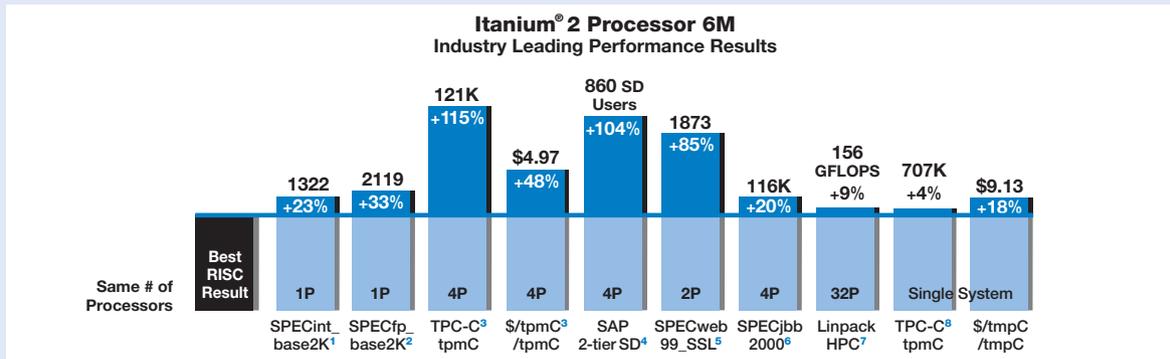
In achieving performance leadership, the Intel Itanium 2 processor (6M) has continued the trend of rapid performance scaling on the Itanium architecture. With a larger L3 cache (6MB versus 3MB) and a faster operating frequency (1.50 GHz versus 1 GHz), the new processor boosts performance by 30-50% over the original Intel Itanium 2 processor (Figure 2).

All of these gains have been realized while maintaining binary software compatibility. The latest upgrade is also pin-compatible, so the Intel Itanium 2 processor (6M) can be swapped into existing Itanium 2-based systems. In short, the Itanium architecture is demonstrating just the kind of affordable, high performance results it was designed for.

1. For current performance information, visit the Intel Web site at www.intel.com/products/server/processors/server/itanium/

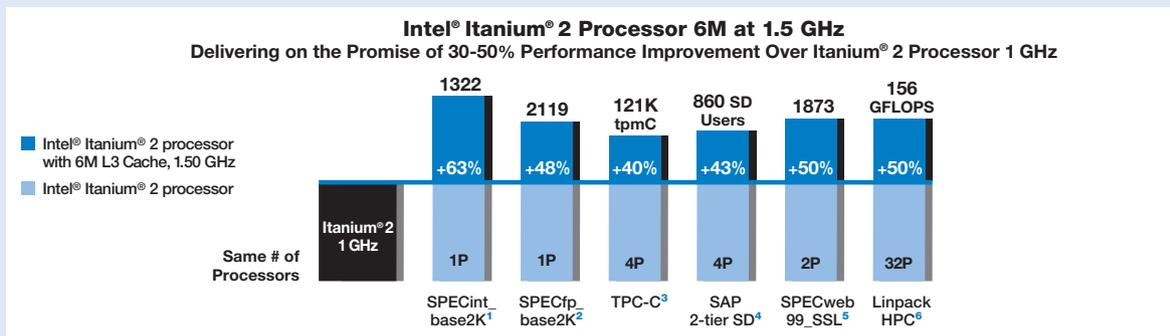
2. 4P TPC-C (Database) -38% scaling from Itanium® 2 processor to Itanium® 2 processor (6M): HP rx5670* server, 121,065 tpmC at \$4.97/tpmC, 96,000 users, with four (4) Intel Itanium 2 processors, each at 1.50 GHz with 6M L3 cache, running Microsoft Windows* Server 2003 Enterprise Edition and Microsoft SQL* Server 2000 Enterprise Edition 64-bit, with 64GB RAM. TPC-C Availability date: Aug. 1, 2003 vs. HP rx5670 server, 87,741 tpmC at \$5.037/tpmC, 70,000 users, with four (4) Intel® Itanium® 2 processors, each at 1 GHz with 3M L3 cache, running Microsoft Windows* Server.NET Enterprise Server 2003 and Microsoft SQL Server 2000 Enterprise Edition 64-bit, with 48GB RAM. TPC-C Availability date: Feb. 12, 2003.

2P SPECweb99_SSL (secure Web serving) -52% scaling from Itanium 2 processor to Itanium 2 processor (6M): HP rx2600* server, 1873 Conforming Simultaneous Connections with two (2) Intel Itanium 2 processors, each at 1.50 GHz with 6M L3 cache, running HP-UX* 11i v2, Zeus* 4.2r2i, with 4GB of main memory. Test date: April, 2003 vs. HP rx2600 server, 1230 Conforming Simultaneous Connections with two (2) Intel Itanium 2 processors, each at 1 GHz with 3M L3 cache, running HP-UX 11i v1.6, Zeus 4.2r2i, with 4GB of main memory. Test date: Feb. 2003.



- Source www.spec.org: Itanium® 2 processor results measured on HP Server rx2600 using Itanium® 2 processor 6M at 1.5 GHz, 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+ 1.7 GHz processor.
- Source www.spec.org: Itanium® 2 processor results measured on HP Server® rx2600 using Itanium® 2 processor 6M at 1.5 GHz, Red Hat® 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+ 1.7 GHz processor.
- Source www.tpc.org: Itanium® 2 processor results of 121,065 tpmC and \$4.97/tpmC on HP Server® rx5670 using 4 Itanium® 2 processors 1.5 GHz 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 1.25 GHz, 32GB memory, availability 09/27/02.
- Source www.sap.com/benchmark: Itanium® 2 processor results measured on HP Server® rx5670 using 4 Itanium® 2 processors 1.5 GHz with integrated 6MB L3 cache, 24GB of memory, HP-UX 11i, SAP rev 4.6 C, Oracle9i®. Best RISC result of 420 from www.sap.com/benchmark on AlphaServer ES45 1000 MHz.
- Source www.spec.org: Itanium® 2 processor result of 1873 on HP Server® rx2600 using 2 Itanium® 2 processors 1.5 GHz with 6MB L3 cache, 12GB memory, HP-UX, Zeus® 4.2r2, published 5/03. Best RISC result on Sun Fire® 280R result of 1008 with 2 UltraSPARC® III Cu processors at 1.2 GHz with 8MB L2 cache (off chip), Solaris® 9, Sun ONE Web Server® 6.0 SP5, 32GB RAM, published 4/03.
- Source www.spec.org for Best published RISC result of 96,377 on eServer pSeries IBM® 655 using 4 Power4+ 1.7 GHz 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 116,466 measured by HP on HP Server® rx5670 using 4 Itanium® 2 processors 6M at 1.5 GHz with integrated 6MB L3 cache, 4GB 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.
- Source: Dell Computer for Itanium® 2 processor 6M results on a cluster of 16 Dell® PowerEdge® Servers, each with 2 Itanium® 2 processors 6M at 1.5 GHz, 4GB RAM, Red Hat® Linux® AS 2.1. Source: http://www1.ibm.com/servers/eserver/pseries/hardware/system_perf.pdf for Best RISC result of 143.3GFLOPs on IBM eServer® p690 with 32 Power 4+ processors at 1.7 GHz.
- Source www.tpc.org: HP Superdome Server®, 707,102 tpmC at \$9.13/tpmC, with 64 Intel® Itanium® 2 processors, each at 1.5 GHz with 6MB of L3 cache, running Microsoft® Windows® Server 2003 Datacenter Edition and Microsoft® SQL Server® 2000 Enterprise Edition 64-bit, with 512 GB RAM. TPC-C Availability date: Oct. 23, 2003. Best single system RISC using IBM eServer® pSeries 690 Turbo 7040-681, 680,613 tpmC, \$11.13/tpmC, with thirty two (32) IBM Power4+ processors at 1.7 GHz, running IBM AIX® 5L V5.2, IBM DB2® UDB 8.1, 512GB RAM, Available: 11/08/2003.

Figure 1. Industry Leading Performance. Platforms using the new Intel Itanium 2 processor (6M) have taken a substantial performance lead in a variety of major industry benchmarks.



- Source www.spec.org: Itanium® 2 processor 6M results measured on HP Server® rx2600 using Itanium® 2 processor 6M at 1.5 GHz, HP-UX operating system and submitted to SPEC. SPECint® is a trademark of SPEC®. Itanium® 2 processor result of 810 measured on HP Server rx2600 using Itanium® 2 processor 1 GHz with integrated 3MB L3 cache, HP-UX operating system.
- Source www.spec.org: Itanium® 2 processor 6M results measured on HP Server® rx2600 using Itanium® 2 processor 6M at 1.5 GHz, Red Hat® Linux® AS2.1 operating system and submitted to SPEC. SPECfp® is a trademark of SPEC®. Itanium® 2 processor result of 1431 on HP Server® rx5670 using Itanium® 2 processor 1 GHz with 3MB L3 cache, Red Hat® Linux® 2.1.
- Source www.tpc.org: Itanium® 2 processor 6M results of 121,065 tpmC and \$4.97/tpmC on HP Server® rx5670 using 4 Itanium® 2 processors 1.5 GHz 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. Itanium® 2 processor results on HP Server rx5670, 87, 741 tpmC at \$5.03/tpmC, with 4 Itanium® 2 processors at 1 GHz with 3MB L3 cache, Microsoft® Windows® .NET Advanced Server, Microsoft SQL Server 2000 Enterprise Edition 64-bit, 48GB memory, availability date 2/12/03.
- Source www.sap.com/benchmark: Itanium® 2 processor 6M result measured on HP Server® rx5670 using 4 Itanium® 2 processors 1.5 GHz with integrated 6MB L3 cache, 24GB of memory, HP-UX 11i, SAP rev 4.6 C, Oracle9i®. Itanium® 2 processor result of 600 SD users on HP Server rx5670 using 4 Itanium® 2 processors 1 GHz with 3MB L3 cache, 16GB memory, Windows® Advanced Server LE 1.2, SAP rev 4.6 C, SQL Server Enterprise Edition 64-bit.
- Source www.spec.org: Itanium® 2 processor 6M result of 1873 on HP Server® rx2600 using 2 Itanium® 2 processors 1.5 GHz with 6MB L3 cache, 12GB memory, HP-UX, Zeus® 4.2r2, published 5/03. Itanium® 2 processors result of 1230 on HP Server rx2600 using 2 Itanium® 2 processors 1 GHz with 3MB L3 cache, 8GB memory, HP-UX, availability 9/02.
- Source: Dell Computer for Itanium® 2 processor 6M results on a cluster of 16 Dell® PowerEdge® Servers, each with 2 Itanium® 2 processors 6M at 1.5 GHz, 4GB RAM, Red Hat® Linux® AS 2.1. Itanium® 2 processor measurement of 101.77GFLOPs done on a NEC Server TX719510 using 32 Itanium® 2 processors 1 GHz with integrated 3MB L3 cache, 128GB memory, Linux® OS.

Figure 2. Rapid Performance Scaling. The newly released Intel Itanium 2 processor (6M) has delivered significant performance increases for the Itanium architecture, and comparable advances are expected in future processor releases.

Ready for Broader Enterprise Deployment

Enterprise customers need more than leading performance. They need flexible platform configurations, strong software support and clear evidence that the new architecture can be integrated effectively with their existing solutions.

All these pieces are falling into place for the Itanium architecture (Figure 3).

Flexible Platform Configurations

The Itanium architecture has seen more than 100% growth in system availability in the past year. Over 50 Itanium 2 processor-based platforms are being developed by manufacturers for planned release in 2003, including systems from major vendors such as Hewlett Packard, IBM, Dell, Unisys, SGI and Bull. Servers with 2, 4 and 8 processors are widely available, and several vendors currently offer systems with 16, 32 or 64 processors. A system with 128 processors is expected in 2003, and larger systems are in development. Most of these servers are priced well below comparable RISC-based systems.

This wide vendor support drives performance, innovation and competitive pricing at the platform level. Customers have considerable flexibility for choosing vendors and configurations that match their specific requirements. Since virtually all of these vendors also offer 32-bit Intel® Xeon™ processor family-based servers, customers can expect

a high degree of consistency among management tools and interfaces for both server families.

A Choice of Major Operating Systems

The Intel Itanium architecture is now supported by more major operating systems than any other architecture (Table 1). Current choices include Microsoft Windows Server 2003 (64-bit), HP-UX, and multiple flavors of Linux.

This broad support simplifies integration into both 32-bit and 64-bit environments, enabling IT organizations to take advantage of existing tools and skill sets. Depending on internal requirements, businesses may choose to support multiple Operating Systems (OS) on a single hardware architecture. Alternatively, they can migrate toward a single operating environment for all their business applications. The ability to support both strategies offers exceptional flexibility for managing growth and containing costs.

Table 1.
Availability of Key Operating Systems for the Itanium architecture

Windows* Server 2003	Available today
HP-UX* 11i	Available today
Red Hat Linux*	Available today
SuSE Linux*	Available today
MSC.Linux*	Available today
United Linux*	Available today

Figure 3: Itanium® 2 Processor Ecosystem

Performance	Itanium® 2 processor is setting new records in performance across application segments.
OEMs/Hardware	Platform breadth is growing with a full line-up of Itanium® 2-based OEM offerings available in '03.
Operating Systems	Windows Server 2003*, multiple versions of Linux,* and HP-UX* are in production.
Tools	Robust set of development tools for commercial and custom applications are available now.
Applications	Broad array of applications are in production and availability of new applications is growing quickly.
End Users	Design wins and deployments are progressing across application segments.

Source: Intel Corporation

Hundreds of Optimized Applications

Over 400 of the Itanium architecture-compatible applications and tools are currently available, and many more production releases are scheduled for 2003. Solutions have come to market most rapidly for high-performance computing applications, databases (Table 2), Enterprise Resource Planning (ERP), Supply Chain Management (SCM), mechanical computer-aided engineering (MCAE), electronic design automation (EDA), digital content creation (DCC), compute-intensive custom applications and security transactions.

Major enterprise ISVs have embraced the Itanium architecture, and many smaller vendors have followed suit. Production applications are available now from BEA, IBM, Microsoft, Oracle, SAP, and SAS. In key application categories, it is already possible to deploy comprehensive production solutions using proven, off-the-shelf components. Success breeds success, and vendor support continues to accelerate as OS, application and tool availability increases. For the latest information, visit the Intel Web site at: www.intel.com/eBusiness/products/itanium

Major Enterprise Deployments

Adoption of the Itanium architecture has followed the classic trend demonstrated by other high-end computing innovations. It has been adopted by leading customers in three essential tiers, and is now positioned for widespread deployment by mainstream businesses.

- **Tier 1: High-performance computing** – Scientific research teams have always been among the earliest adopters of important new technologies. The Itanium architecture has been chosen for some of the world’s largest computing systems, including projects by the European Organization for Nuclear Research (CERN), the National Center for Supercomputing Applications (NCSA) and the Pacific Northwest National Laboratory (PNNL).
- **Tier 2: Commercial technical applications** – Commercial research and development teams also have high-end performance needs, but deployment costs must be closely managed. In this arena, the Itanium architecture has already been adopted by a variety of industry leaders, including BMW, DreamWorks Animation, Airbus, Sony Imageworks and ChevronTexaco.
- **Tier 3: Enterprise applications** – Cost-effective and reliable integration support is essential for mainstream enterprise deployment. Companies such as VeriSign, JetBlue Airways, Liberty, Reuters, Wells Fargo and many others have deployed or are now deploying the Itanium architecture-based solutions.

The success of these implementations is confirming the value of the Itanium architecture, and enabling new customers to take advantage of proven solutions and key learnings. For specific case studies touching on all three tiers, visit the Intel Web site at: www.intel.com/eBusiness/casestudies/ss_product.htm

Table 2: Availability of Databases for Itanium® 2 Processors

Oracle9i* for HP-UX*	Available now
Oracle9i for Linux*	Available now
Oracle9i for Microsoft Windows* Server 2003	Available now
Microsoft SQL Server 2003* Enterprise Edition (64-bit) for Microsoft Windows Server 2003	Available now
IBM DB2* UDB v.8.1 for Microsoft Windows Server 2003	Available now
IBM DB2 UDB v.8.1 for Linux	Available now

Investment Protection through Broad Industry Support

The long-term value of a major computing architecture depends on its staying power. Will it remain a viable, cost-effective solution into the future, so current solutions can grow to support next-generation needs?

The answer is a clear yes for the Itanium architecture, which is now supported by the largest combined investment of any 64-bit architecture. The broad network of collaborating and competing vendors includes many of the most respected names in the industry. This level of support helps to ensure rapid and simultaneous innovation on multiple fronts, and an exceptional level of industry momentum. It also helps customers avoid the risks of vendor lock-in. In a volatile industry, there is no better guarantee of long-term value.

Driving Toward the Future

Intel® processor advances will continue to drive rapid advances for the Itanium architecture, fueling comparable advances at the platform, OS and application levels. Multiple next-generation processors are already in development. As one example, a low-voltage Intel Itanium 2 processor will be released before the end of 2003. This processor will deliver performance that compares favorably with the original Intel Itanium 2 processor operating at 1 GHz, but will consume less than half the power. It will be ideal for high-density environments.

Other advances include:

- **Multi-core processors** – Multiple cores with a large, high-performance cache boost performance while reducing power consumption.
- **Enhanced multithreading technology** – Multithreading has already demonstrated its value in the Intel Xeon processor family, increasing performance by up to 30% for multithreaded applications.

- **Larger cache** – Cache stores data and instructions on-die for exceptionally fast retrieval. Larger caches will continue to reduce memory latencies and improve performance for data-intensive applications.
- **Higher frequencies** – Intel will continue to scale clock frequencies, providing customers with very direct performance gains across virtually all applications.
- **Enhanced microarchitecture** – Smaller process generations will enable ongoing enhancements to increase parallelism, execution resources and processing efficiency.

Conclusion

With record-breaking performance, comprehensive hardware and software options, and widespread support for integration and migration, the Itanium architecture is now ready for more mainstream enterprise deployment. For businesses, this means the key advantages of Intel® architecture – performance, value, compatibility and choice – can now be realized when deploying or scaling their most demanding enterprise applications. Affordable, industry standard components can be used in place of more expensive and complex proprietary systems, to drive down total costs and provide a more agile foundation for growth.

The advantages of the Itanium architecture can be expected to increase steadily in the months and years ahead. It is already supported by the largest combined investment of any 64-bit architecture, and increasing success will undoubtedly bring more vendors into the marketplace with compatible systems and solutions. Intel's strong processor roadmap will continue to drive performance gains, while providing a wider range of processors to meet diverse needs more cost-effectively.

In simplest terms, the Itanium architecture has come of age. If you are not already exploring its potential in your own environment, now is the perfect time to start.

A Scalable Architecture for Long-term Growth

The Itanium® architecture was designed from the ground up for long-term performance scaling. Based on Explicitly Parallel Instruction Computing (EPIC), the Itanium architecture supports highly parallel processing, large memory addressability, and innovative, compiler-based optimization. The parallel architecture includes a large number of execution registers that enable efficient, simultaneous processing for up to six instructions.

Since the compiler optimizes the software for parallel throughput, the processor can focus all its resources on fast execution, making optimal use of advanced features such as predication, which reduces branch delays, and speculation, which preloads essential data for faster processing. The enhanced role of the compiler also opens additional avenues for performance scaling, enabling compiler-based optimizations that will continue to extend and support hardware advances.

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