The Power Behind Demanding Workstation Applications

Intel® Pentium® III Xeon™ Processor
Intel® 840 Chipset

October 1999
Intel Corporation

Table of Contents

Executive Summary . . . 3

Intel® Pentium® III Xeon™ Processor Microarchitecture and Workstation Benefits . . . 3

Management Features . . . 4
Advanced Transfer Cache . . . 5
Advanced System Buffering . . . 5
Intel® Internet Streaming SIMD Extensions . . . 5
P6 Dynamic Execution Microarchitecture . . . 5
Features for Testing and Performance Monitoring . . . 5

Benefits of Multiprocessing Intel® Pentium® III Xeon™ Processors . . . 6

Multitasking . . . 6
Multithreading . . . 6

Intel® 840 Chipset and Workstation Benefits . . . 6

Processor Support . . . 7
I/O . . . 7
Memory . . . 8
Graphics . . . 8
The Intel® 840 Chipset Architecture . . . 8

Intel® Pentium® III Xeon™ Processor Benchmarks . . . 10

Accelerating Creation, Design, Visualization and Analysis for e-Business . . . 10
Design . . . 10
Creation . . . 13
Visualization and Analysis . . . 13
Multiprocessing . . . 14

The Nature of Benchmarks . . . 15

Benchmark System Configurations . . . 17

References . . . 18

Disclaimers and Restrictions . . . 19

Performance Report Notice . . . 19
SPEC Benchmark Test Notice . . . 19

List of Figures

Figure 1. Effective e-Business collaboration with Intel® Architecture-based workstations, the e-Creation Vehicle of Choice . . . 3
Figure 2. The new Intel® Pentium® III Xeon™ .18 micron microarchitecture . . . 4
Figure 3. The Intel® 840 Chipset system architecture design . . . 9
Figure 4. APC Pro/ENGINEER benchmark . . . 10*
Figure 5. MSC/NASTRAN benchmark . . . 11*
Figure 6. ANSYS benchmark . . . 11*
Figure 7. Verilog-XL benchmark . . . 11*
Figure 8. SPECviewperf benchmark . . . 12*
Figure 9. STREAM benchmark . . . 13*
Figure 10. CERN benchmark . . . 13*
Figure 11. The new dual Intel® Pentium® III Xeon™ processor-based 733 MHz Compaq SP750 workstation—actual data . . . 14*

Executive Summary

e-Business growth demands that companies outpace competitors in new product and service development. Doing this requires the fastest possible workstations on designers' and analysts' desktops to speed creativity, design, visualization, and analysis. Intel-based workstations based on the new Intel® Pentium® III Xeon™ processor with advanced transfer cache, advanced system buffering, and multiprocessing give companies the performance and productivity they need to stay ahead. With AGP Pro graphics and the Intel® Scalable Bandwidth Technology of the Intel® 840 Chipset, workstation users are able to meet ever more stringent time-to-market pressures for efficient designs, attention-grabbing creativity, complex data visualizations, and in-depth analysis.

Delivering high memory bandwidth, mid-range to high-end Intel Pentium III Xeon processor-based workstations support rapid prototyping and digital design activities. For example, the new Pentium III Xeon processor provides an average 46 percent performance boost over legacy systems as measured by the SPECapc* for Pro/ENGINEER* benchmark (see Figure 4).

In the Internet economy, products and services are being introduced at ever shorter intervals. No longer can a company make a product or provide a service in isolation. Collaboration is key to success. Intel-based workstations are driving down the cost of workstation ownership and becoming the creation and collaboration vehicles of choice. By using intranets and extranets, businesses are able to do rapid prototyping in a virtual, collaborative environment. This leads to better products produced faster. With powerful, cost-effective workstations on designers' desks, suppliers can provide digital designs rather than just mockups. Once a product or service is designed, companies can use an integrated supply chain to get customers the right information while reducing overhead and increasing forecast accuracy.

Intel-based workstations are being used to bring many of these new products and services to market faster, with higher quality and reduced costs. Companies using Intel-based workstations get faster prototyping, faster virtual designs, and the ability to manage their supply system online. High-performance Pentium III Xeon processor-based workstations shorten the distance from thinking to seeing, from idea to success.

Intel® Pentium® III Xeon™ Processor Microarchitecture and Workstation Benefits

Today's new high-performance Intel Pentium III Xeon processor-based workstation allows Internet developers, product designers, and financial professionals to create, design, visualize, analyze, and collaborate with colleagues faster and more clearly than ever before. Processing speeds of up to 733 MHz, a new advanced transfer cache with advanced system buffering, and an enhanced front-side bus are among many features designed to accelerate performance for all workstation market segments.

The Intel Pentium III Xeon processor is designed to bring tremendous processing power from mid-range to high-end

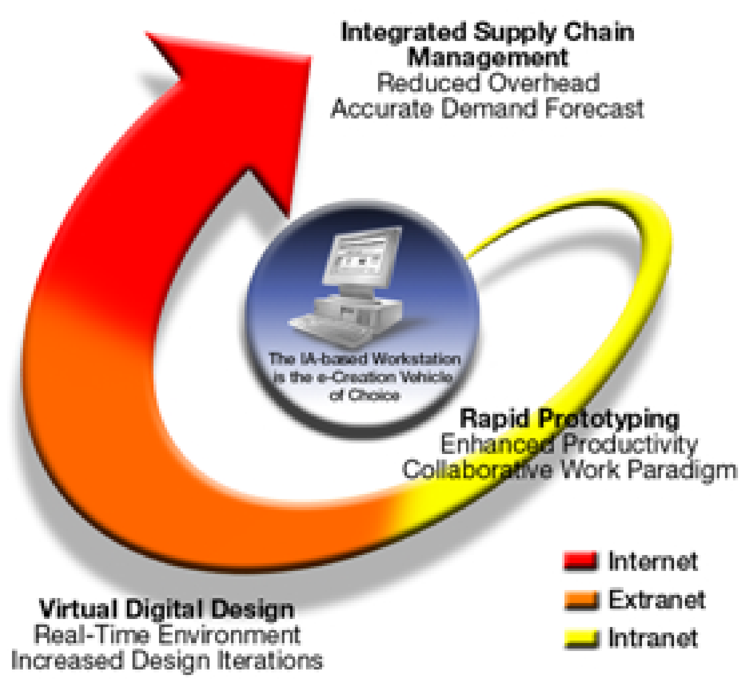


Figure 1. Effective e-Business collaboration with Intel® Architecture-based workstations, the e-Creation Vehicles of Choice

workstations. Design objectives included optimizing the use of Intel's new 0.18 micron semiconductor process, which provided significant performance improvements and headroom. Key design features include:

- Management Features
- Speeds of up to 733 MHz
- 133 MHz system bus designed to support the Intel 840 Chipset
- Advanced 256 KB Transfer Cache
- 32 KB non-blocking Level 1 cache to provide fast access to heavily used data
- Advanced System Buffering
- P6 Dynamic Execution micro-architecture including multiple branch prediction, data flow analysis, and speculative execution
- Internet Streaming SIMD Extensions, consisting of 70 new instructions that enable advanced imaging, 3D, streaming audio and video, speech recognition, and an enhanced Internet experience
- Dual Independent Bus (DIB) architecture increases bandwidth and performance

Some of these features are discussed here in detail.

Management Features

The Pentium III Xeon processors provide a variety of advanced features that enhance the ability of a workstation platform to monitor and protect the processor and its environment and to help customers create a robust IT environment, maximize system uptime, and ensure optimal configuration and operation of their servers

- **Thermal Sensor.** To provide thermal protection, this device continuously monitors core temperatures (via an on-core thermal diode) and combines with platform manageability features to enable the system to actively manage thermal conditions.
- **Error Checking and Correction.** ECC helps protect mission-critical data. ECC is performed on the data signals for all L2 cache bus and system bus transactions, automatically correcting single-bit errors and alerting the system to any double-bit errors. All errors are logged, and the system can track error rates to identify failing system components.
- **System Management Bus.** The Intel Pentium III Xeon processor adds several manageability functions to the Intel® product line. Inside the cartridge, two new components (in addition to the thermal sensor described above) use this interface to communicate with other system management hardware and software:
  1. *Processor Information ROM* (P.I. ROM) contains information about the specific processor in which it resides. This information includes robust addressing headers to allow for flexible programming and forward compatibility, core and L2 cache electrical specifications, processor part and S-spec numbers, and an electronic signature.
  2. *Scratch EEPROM* ships empty and gives system manufacturers or processor resellers the option to use this EEPROM to include whatever data they wish. It can also be used by a system to track various information about the system or the processor, including system specifications, inventory and service tracking, installation defaults, environment monitoring, and usage data. Its contents can be write protected by the system as well.

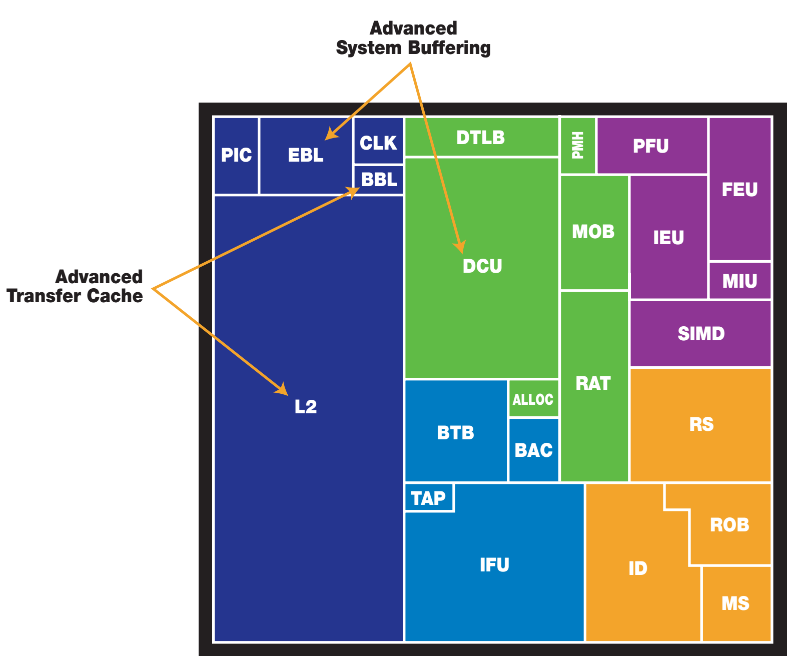


Figure 2. The new Intel® Pentium® III Xeon™ 0.18 micron microarchitecture

- **Processor Number.** Extends the concept of processor identification by providing a 96-bit software accessible processor number which may be used by applications to identify a system. Applications include membership authentication, data backup/restore protection, removable storage data protection, and managed access to files.

Advanced Transfer Cache

The advanced transfer cache—previously known as the Level 2 cache—consists of micro-architectural improvements to provide a higher data bandwidth interface into the processor core. The advanced transfer cache performance is also completely scalable with the processor core frequency. The advanced transfer cache features:

- Full-speed 256 KB on-die Level 2 cache
- 8-way set associativity
- 256-bit data bus to the Level 2 cache
- Reduced latency interface to cache data (as compared to discrete caches)

The advanced transfer cache delivers significant performance benefits to workstation users. The increased bandwidth delivers 32 Bytes every two clocks (11.7 GB/sec at 733 MHz), is fully scalable with the core processor frequency, and enables full system bus utilization. There is a greater than four times reduction in CPU clock latency over the previous Pentium III Xeon processor version, which decreases the penalty of L1 cache misses and reduces snoop stalls. Lastly, the 8-way set associativity increases cache performance for real applications, providing a benefit for integer and workstation workloads.

Advanced System Buffering

Advanced System Buffering increases the utilization of the available bandwidth on the 133 MHz system bus, thus optimizing the fast system bus. It delivers a balanced increase in buffers to minimize bottlenecks. Advanced System Buffering provides:

- Six (6) fill buffers, providing a 50 percent increase in concurrent non-blocking data cache operations
- Eight (8) bus queue entries, allowing more outstanding memory/bus operations
- Four (4) writeback buffers, which reduce blocking during cache replacement operations and faster de-allocation times for multiple fill buffer

Intel® Internet Streaming SIMD Extensions

The Intel® Internet Streaming SIMD Extensions consist of 70 instructions, such as single instruction, multiple data for floating point, and additional SIMD-integer and cacheability control instructions. Streaming SIMD Extensions bring several benefits to workstation users and Internet applications:

- Higher resolution and quality images can be viewed and manipulated
- Higher quality audio, MPEG2 video, and simultaneous MPEG2 encoding and decoding
- Reduced CPU utilization for speech recognition, as well as higher accuracy and faster response times

Dozens of independent software vendors support the Intel Streaming SIMD Extensions, using it to achieve significant application performance improvements.

P6 Dynamic Execution Microarchitecture

The Pentium III Xeon processor is built on the P6 Dynamic Execution microarchitecture delivering great performance to workstation users. Multiple branch prediction forecasts program execution through several branches, accelerating the flow of work to the processor and eliminating wait time. Data flow analysis finds data dependencies between instructions and creates an optimized, reordered schedule of instructions. Again, the result is less wait time for processors and more productive processing. Speculative execution allows this optimized schedule of instructions to execute randomly, ensuring that the processor's superscalar execution units remain busy and boosting overall performance.

Features for Testing and Performance Monitoring

The Intel Pentium III Xeon processor includes a number of features that facilitate performance monitoring and testing. The Built-In Self Test (BIST) provides single stuck-at fault coverage of the microcode and large logic arrays, as well as testing of the instruction cache, data cache, Translation Lookaside Buffers, and ROMs. The IEEE 1149.1 Standard Test Access Port and Boundary Scan mechanism enables testing of the Pentium III Xeon processor and system connections through a standard interface.

There are internal performance counters for performance monitoring and even counting.

Benefits of Multiprocessing

The Pentium III Xeon processor utilizes a GTL+ bus that provides glueless support for up to two processors. This enables system integrators to use Pentium III Xeon processors to provide low-cost, two-way symmetric multiprocessing systems that deliver significant performance gains for multitasking systems and multithreaded applications. Benchmarks show that you can improve productivity up to 88 percent by configuring your Intel-based workstation with two processors (see Figure 11). The benefits of multiprocessor workstations come from multitasking and multithreading.

Multitasking

Multitasking is nothing more than running multiple applications at the same time on a computer. It could be multiple copies of an application or several different applications, but the important factor is that these applications run at the same time. At present, most people using workstations do this every day. The extent to which users benefit depends on how much time is spent doing concurrent execution of applications. With workstations based on the Intel Architecture, it doesn't take much time to cost-justify a dual-processor workstation. In many cases, the incremental Intel processor can be cost-justified in as little as four to eight work weeks. For more information, go to http://www.intel.com/go/workstations/, then click on "Multiprocessing" and check out the cost-justification calculator.

Multiprocessing capability is important to users of multiple, concurrently executing single-threaded applications. With long-running engineering simulations, analyses, graphics, image processing, and software compilations running on one processor in the background, multiprocessor workstation users can prepare reports, do spreadsheet calculations, and prepare presentations on a second processor in the foreground. Alternatively, multiple simulation or analysis runs can be done simultaneously on a multiprocessor workstation.

The Pentium III Xeon processor provides excellent multitasking workload performance, since its large advanced transfer cache allows large amounts of data to be stored locally and accessed quickly. Also, the high bandwidth, split-transaction system bus allows multiple processors to effectively share the system bus, increasing bus utilization and minimizing bus contention.

Multithreading

Multithreading is a programming technique that enables an application to take advantage of the processing power of a multiple-processor system configured as a single computer system. This allows applications to run parts of their workload in parallel, where possible. There are many different ways to exploit parallelism. Some of these include performing the same operation on different sets of data in parallel, performing various operations on independent sections of data, or separating the "number-crunching" part of an application from user-interface operations (which provides noticeable improvement in user interaction with the system). Multithreaded applications provide significantly more flexibility and efficiency in the allocation of resources to application software, and they represent the direction in which an increasing number of applications are moving.

Many applications are being written specifically to take advantage of multiple processors to provide the dramatic performance gains that help companies maintain their competitive edge. Currently, applications from such diverse disciplines as image processing, mechanical design automation, chemistry, fluid dynamics, finance, and video editing all have the capability of executing multiple threads using the multiprocessing capabilities of Pentium III Xeon processor-based workstations. As even more applications are developed to exploit the benefits of multithreading, multiprocessor workstations will provide an even more critical performance edge.

Intel® 840 Chipset and Workstation Benefits

If Intel only increased the performance of the processor, the CPU engine would outstrip the rest of the system-I/O, memory, graphics. To make sure that workstation users take full advantage of the power of the Pentium III Xeon processor, Intel has increased the bandwidth of its chipsets.

The Intel 840 Chipset manages traffic from I/O drives, memory, graphics, and the processor(s). The Intel 840 Chipset delivers a performance leap in each of these categories for workstation users. It supports dual processors, a 133 MHz front-side bus, two memory channels for 3.2 GB/s throughput, AGP 4X graphics with the AGP Pro 50/110 graphics card, and dual PCI bus. It delivers significantly increased system bandwidth over its predecessors in the key areas of memory, I/O and graphics subsystems. This bandwidth delivers outstanding performance in multiprocessor systems, while also enabling the use of high-bandwidth peripherals through a 533 MB/sec PCI-64 bus and a high performance AGP port.

Processor Support

The Intel 840 Chipset supports the latest Pentium III Xeon processors. It can support dual-processing configurations using a 133 MHz system bus.

I/O

The Intel 840 Chipset embodies a new interconnect architecture (Intel® Accelerated Hub Architecture) that transitions the PCI bus to a peripheral role in favor of the use of high-speed low pin-count buses. This new architecture doubles or quadruples aggregate bandwidth in every critical area over that of its predecessor, the 440GX. The Accelerated Hub Architecture provides up to 800 MB/sec of I/O bandwidth, supporting both 32-bit and 64-bit PCI segments. It also supports the 133 MHz processor system bus introduced on the Pentium III Xeon processor; the Pentium III Xeon has an enhanced bus interface and is capable of fully exploiting this bandwidth.

The bandwidth of the Intel 840 Chipset, coupled with the option to support dual Pentium III Xeon processors, will allow Intel 840 Chipset-based systems to compete with traditional workstations. The introduction of PCI 64 to the platform will give Intel-based workstations standard access to the most advanced and sophisticated peripheral cards available.

AGP Pro Graphics

The AGP Pro specification enables high-performance graphics cards that contain larger numbers of specialized components. AGP Pro 50 supports cards that draw up to 50 watts of power, and AGP Pro 110 supports power requirements of up to 110 watts. Some of the performance components typically integrated into these board designs include:

- Larger memory for texture, depth, and display data
- Faster geometry processors for calculating transform movements, set-up data, and lighting values of polygons
- Faster rasterizers for filling in polygons with texture data
- Higher resolution frame buffers for output display

AGP Pro defines the electrical/mechanical/thermal specification, not AGP bus speed. AGP Pro cards can be either AGP 2X or AGP 4X. The AGP bus is scalable-1X, 2X and now 4X, independent of AGP Pro. The AGP bus bandwidth increases from PCI at 132 MB/sec to AGP 4X at 1GB/sec.

Memory

The Intel 840 Chipset supports the next-generation memory technology, Direct Rambus* DRAM (RDRAM*). Two Rambus channels provide the highest memory bandwidth in any high-volume Intel-based platform. The Direct Rambus interface represents a new approach to memory interfacing. The 12 address bits, 4 control bits and 64 data bits of a conventional memory array are replaced by a single 16-bit bi-directional bus, clocked on both edges of a high-speed 400 MHz clock and providing maximum data transfer rates of 1.6 GB/sec per device. The bus now carries commands to the memory, and transfers data in both directions in response to these commands. The lower pin count of the Rambus interface allows designers to accept a more challenging electrical design task in exchange for relatively simple, easily-manufactured designs that can deliver high data rates with a minimum component count. The low pin count allows channels to be easily added to a controller, providing a practical method to scale bandwidth for several generations of chipset. This is manifested in the Intel 840 Chipset, which uses two memory channels.

Initial Direct Rambus memory modules will be available with transfer rates of 600, 700 and 800 MHz and will be designated as PC600 and PC800 memory respectively. The Intel 840 Chipset supports PC600 & PC800 to enable system and memory manufacturers to optimize performance, yield and cost.

Graphics

AGP Pro, an extension of the AGP specification, provides more power and cooling capability to the graphics subsystem. This support system enhancement permits the design of graphics cards with powerful processors and large memory capacities; otherwise, the signals and the protocols remain identical to those in the original AGP specification.

The AGP architecture was developed to address the ever-increasing bandwidth needs of graphics accelerators. The initial implementation, AGP 2X, delivered double the bandwidth of PCI. Consequently, it was connected directly to the memory controller to avoid total overload of the PCI bus. AGP Pro supports the transfer rates supplied by the AGP 2X or AGP 4X specification and power requirements up to 110 Watts. The additional graphics bandwidth provided by AGP 4X demands a corresponding increase in main memory bandwidth, delivered by the use of the 3.2 GB/sec Direct Rambus interface. In conjunction with the Pentium III Xeon processor with Internet Streaming SIMD Extensions and AGP Pro, the Intel 840 Chipset opens up new opportunities for advanced graphics systems.

The Intel® 840 Chipset Architecture

Previous generation chipsets used the PCI bus to connect the north and south bridges of the chipset. However, with the Intel 840 Chipset, the PCI bus has been moved to become an extension of the I/O Controller Hub. The Intel Accelerated Hub Architecture is used to connect the Memory Controller Hub to the I/O Controller Hub and PCI-64 Controller Hub. The hub architecture partitions the system into three major components. It is distinguished by its use of a very high-bandwidth, reduced pin-count interface called the hub interface. The hub interfaces provide increased bandwidth of 266 MB/sec and 533 MB/sec with just 16 pins and 25 pins, respectively. Its bandwidth and architecture allows the chipset to deal effectively with isochronous data without the bottlenecks associated with the PCI protocols. This bandwidth is achieved through the use of very high clock rates, differential signaling on the strobe line, a reference voltage signal that guarantees reliable switching, and a compensation signal that allows the chip to match its buffer characteristics to those of the printed circuit board.

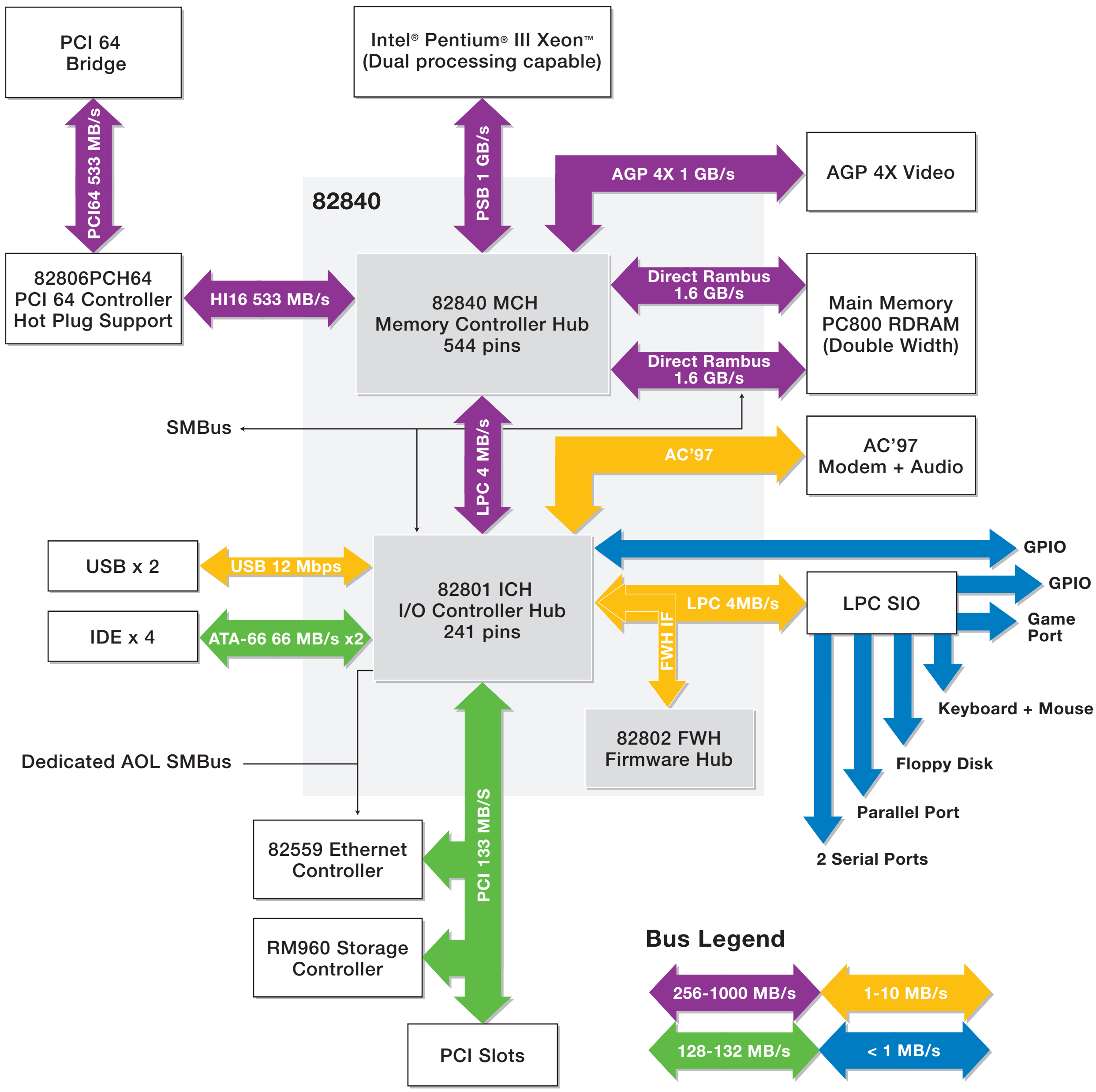


Figure 3. The Intel® 840 Chipset system architecture design

Intel® Pentium® III Xeon™ Processor Benchmarks

Accelerating Creation, Design, Visualization and Analysis for e-Business

Design

- **SPECapc* for Pro/ENGINEER***

  Parametric Technology Corporation's Pro/ENGINEER is a suite of integrated application-specific software products that automate the mechanical design-through-manufacturing process. This unique, fully-associative suite of mechanical design automation software includes application-specific products that address the complete spectrum of product development activities.

  SPEC/GPC's Application Performance Characterization (SPECapc) project group offers performance results and free downloads for a benchmark based on Pro/ENGINEER Rev. 20. The model used in the benchmark is a realistic rendering of a complete photocopy machine consisting of approximately 370,000 triangles.

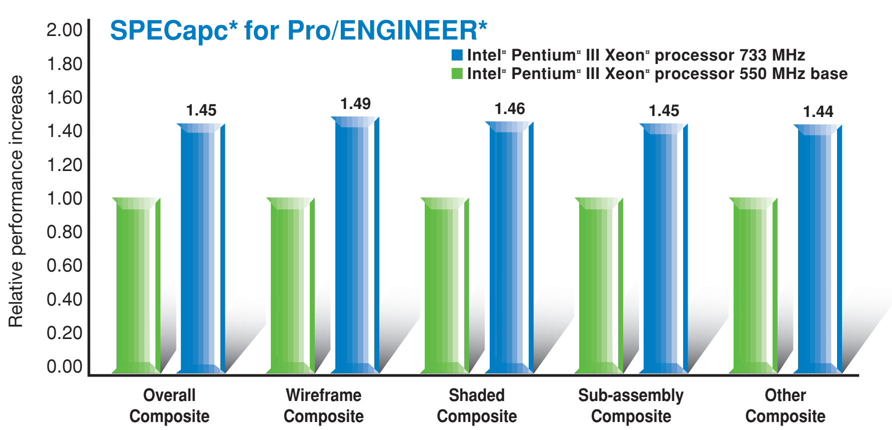
  The benchmark comprises 17 tests. Startup and initialization time is measured, but given no weight (0.0) within the composite score for the benchmark. There are 16 graphics tests, each of which measures a different rendering mode or features.

  The first three graphics tests measure wireframe performance using the entire model. The next four measure different aspects of shaded performance, using the same model. Each of these tests executes exactly the same sequence of 3D transformations to provide a direct comparison of different rendering modes. The next four tests use a sub-assembly, and compare the two FASTHLR modes, the default shading mode, and shaded with edges. These tests also execute a common sequence of 3D transformations. The last five graphics tests use two different instances of the model—the first three without its outer skins (to illustrate the effect of FASTHLR and level-of-detail operations), and the last two to illustrate complex lighting modes and surface curvature display. The last test is an aggregate of all time not accounted for by the previous 16 tests, and is a mix of CPU and graphics operations.

  Scores are generated for all 17 tests. Composite numbers are provided for each set of graphics tests (shaded, sub-assembly, wireframe and other) and there is an overall composite score for graphics and CPU operations. Start-up and initiation time is not included in the composite score.

- **MSC/NASTRAN***

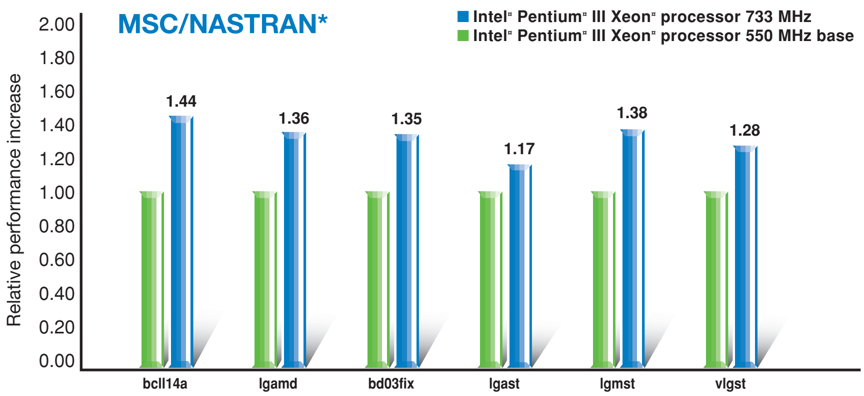
  MSC/NASTRAN* is a leading Finite Element Analysis (FEA) program from MacNeal-Schwendler Corporation (MSC). It offers a wide variety of analysis types, including linear statics, normal modes, buckling, heat transfer, dynamics, frequency response, transient response, random response, response spectrum analysis and aeroelasticity. MSC's solutions have played a key role in the design of virtually every major automobile, aircraft and space vehicle developed in the past decade. MSC products have helped ensure the product performance, safety, and reliability of a broad spectrum of products.



SPECint95 and SPECfp95 benchmark tests reflect the performance of the microprocessor, memory architecture and compiler of a computer system on compute-intensive, 32-bit applications. SPEC benchmark test results for Intel® microprocessors are determined using particular, well-configured systems. These results may or may not reflect the relative performance of Intel® microprocessors in systems with different hardware or software designs or configurations (including compilers). Buyers should consult other sources of information, including system benchmarks, to evaluate the performance of systems they are considering puchasing. For more information about SPEC95, including a description of the systems used to obtain these test results, and other information about microprocessor and system performance and benchmarks, visit Intel's World Wide Web site at www.intel.com or call 1-800-628-8686.

Figure 4. The new Intel® Pentium® III Xeon™ processor 733 MHz on a new Intel® 840 Chipset-based platform compared to the Intel® Pentium® III Xeon™ processor 550 MHz on a 440GX AGPset-based Intel validation platform—projected results.

Source: Results performed by Intel. Please refer to the SPEC Benchmark Test Notice and other performance notices in the Performance Report Notice at the end of this document. For system configuration, see Benchmark System Configurations at the end of this document.



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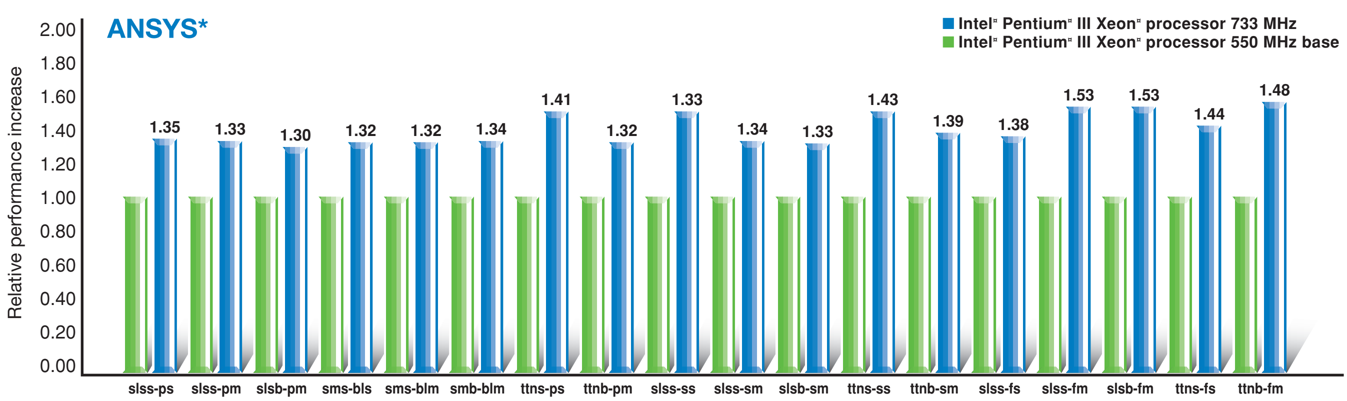
Like other memory-intensive applications, MSC/NASTRAN is sensitive not only to processor speed but also to memory throughput and access times.

MSC/NASTRAN version 70.5.3 has been optimized to use Streaming SIMD Extensions for improved memory throughput when running on Pentium III Xeon processors. The benchmark shows the added performance Streaming SIMD Extensions provide to the Pentium III Xeon processor.



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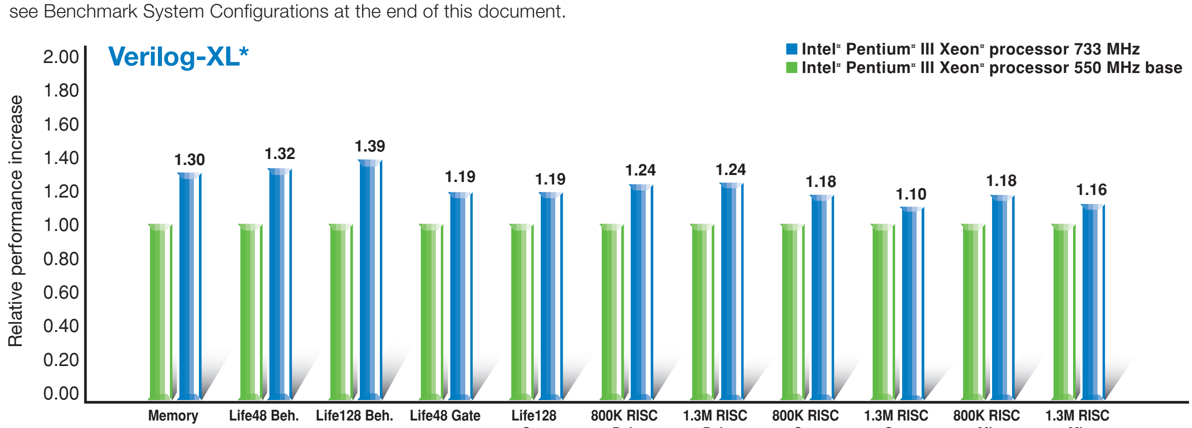

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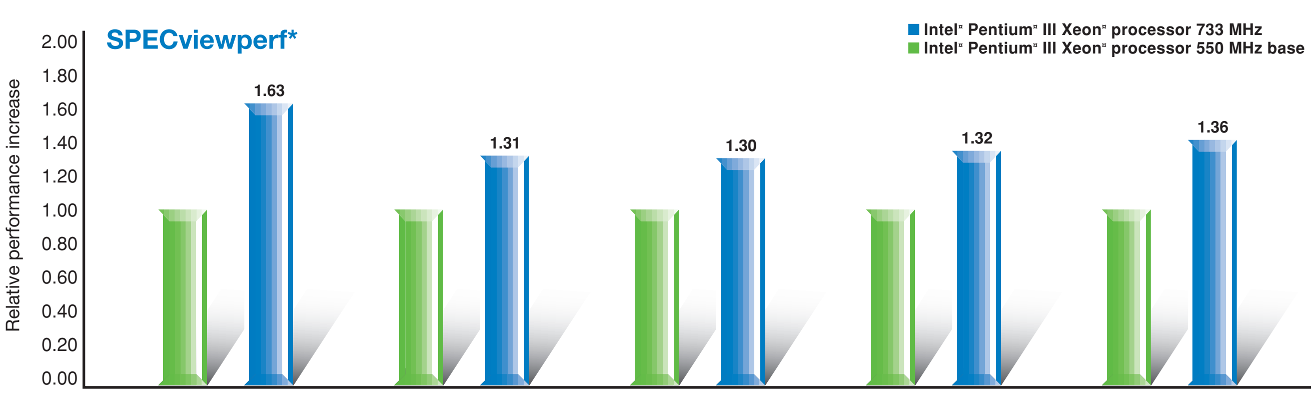
- **ANSYS***

  ANSYS* version 5.5.3 is a major finite element analysis software product from ANSYS Corporation. There are several benchmarks available for ANSYS: each consists of a different model which has 10,000 to almost 200,000 degrees of freedom and exercises a particular equation solver such as Gaussian, sparse matrix and Block Lanczos modal solvers. The ttns-fs benchmark operates on flood tank and tubes modeled with 3D thin shell elements. It uses the frontal (Gaussian) equation solver, and has 10,000 to 50,000 degrees of freedom, which refers to the number of equations being solved. It produces a time-history solution for temperature, accounting for temperature-dependent thermal material properties. ANSYS sms-bls and ANSYS slsb-sm executes two copies of ANSYS, described above. The slsb-sm benchmark operates on a disk brake rotor modeled with 3D hexahedron elements. It uses the sparse matrix equation solver, and has 50,001 to 200,000 degrees of freedom. It produces a steady-state solution for deflection and stress, not accounting for geometric or material nonlinearities. The sms-bls benchmark operates on a fuel rail modeled with 3D thin shell elements. It uses the Block Lanczos modal solver, and has 10,000 to 50,000 degrees of freedom, which refers to the number of equations being solved. It produces a dynamic solution for vibratory mode shapes and frequencies.

- **Verilog-XL***

  Electronic Design Automation (EDA) simulation is an activity that manipulates very large data sets, and therefore requires an extraordinary level of memory throughput backed by solid integer performance. The ISD Magazine* EDA Platform Benchmark. The benchmark results are reported in percentage improvement (higher is better), and cover simulation of circuits ranging in size from 800 KB to 1.3 MB gates. The benchmark components include simulations of a Re-configurable Architecture Workstation and a RISC microprocessor core. The benchmarks were developed by Integrated Systems Design (ISD) Magazine (http://www.isdmag.com/) and SEVA Technologies. The Benchmark measures the performance of a leading EDA simulation application from Cadence Design Systems, Inc. (http://www.cadence.com/software/ verilog.html). Cadence's Verilog-XL* version 2.7.2 digital logic simulator is the core of the industry's most production-proven and highest-performing top-down design environment. Supporting the design of complete systems, printed circuit boards, ASICs and custom ICs, Verilog-XL delivers unmatched simulation performance that has been tested on thousands of designs worldwide.

It is used to simulate advanced digital circuits at either the gate or behavior level.



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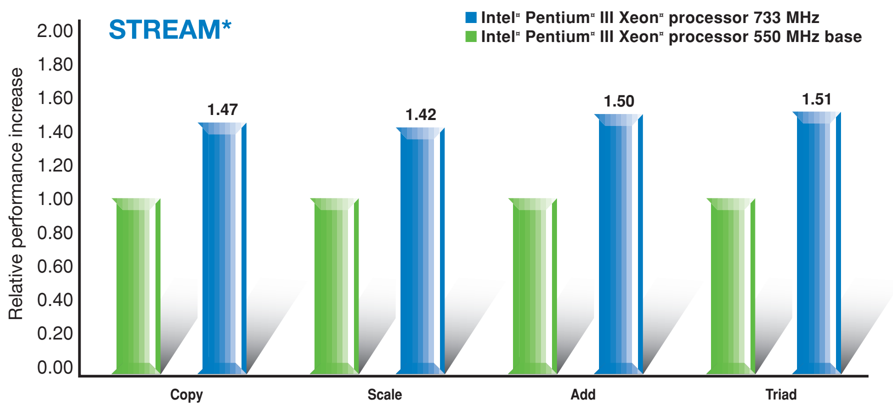

Figure 9. The new Intel® Pentium® III Xeon™ processor 733 MHz on a new Intel® 840 Chipset-based platform compared to the Intel® Pentium® III Xeon™ processor 550 MHz on a 440GX AGPset-based Intel validation platform—projected results.

Source: Results performed by Intel. Refer to Performance Report Notice at the end of this document. For system configuration, see Benchmark System Configurations at the end of this document.

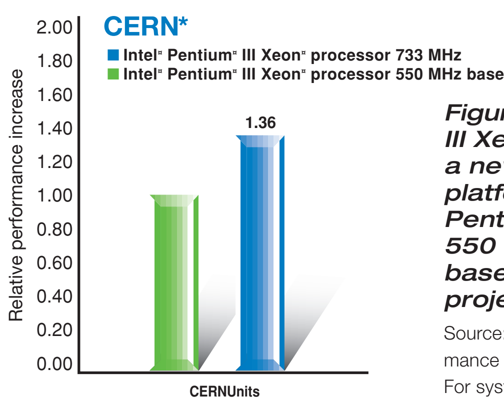

Figure 10. The new Intel® Pentium® III Xeon™ processor 733 MHz on a new Intel® 840 Chipset-based platform compared to the Intel® Pentium® III Xeon™ processor 550 MHz on a 440GX AGPset-based Intel validation platform—projected results.

Source: Results performed by Intel. Refer to Performance Report Notice at the end of this document. For system configuration, see Benchmark System Configurations at the end of this document.

Creation

- **SPECviewperf***

  SPECviewperf* version 6.1.1 is a portable OpenGL performance benchmark program written in C. It was developed by IBM, with updates and significant contributions by SGI, Digital and other OpenGL Performance Characterization (OPC) project group members. Viewperf* provides a vast amount of flexibility in benchmarking OpenGL performance. The OPC group joined the Graphics Performance Council (GPC) in 1994, and has since become part of the Standard Performance Evaluation Corporation (SPEC). The Graphics Performance Characterization (GPC) Group, a part of the SPEC organization develops and maintains Viewperf.

Visualization and Analysis

- **STREAM***

  STREAM* is a synthetic benchmark which measures the maximum sustainable memory bandwidth. It uses 4 long vector operations to generate four different mixes of processor-to-memory read and write transactions. The size of each vector is defined larger than the cache size so that data re-use (either inside the cache or in registers) is eliminated. Bandwidth measurements in MB/s are obtained by simply dividing the size of all data transferred over the bus during a particular vector operation by the amount of time it takes to carry out that operation.

  STREAM is not designed to model a real workstation application, but rather to evaluate a particular architectural feature of the machine, but no workstation benchmark exercises the memory system as much as STREAM does. Improvement in STREAM performance does not automatically mean that a similar improvement will be measured for workstation applications in general. This is because memory bandwidth requirements vary substantially from one workstation benchmark to another In addition, workstation applications which rely heavily on access to main memory can be much more sensitive to memory latency than they are to memory bandwidth.

- **CERN***

  The CERN* benchmark was developed by the “Conseil European pour la Recherché Nucleaire” (CERN) in Geneva, Switzerland and has been used for over a decade for measuring the performance of computers of interest to CERN. The tests consists of a suite of FORTRAN programs used to determine the CPU power of a computer system for running High Energy Physics applications. It has four test jobs, two Monte Carlo simulations and two event analysis jobs. Individual results are reported as a ratio relative to the VAX 8600 system timings provided by CERN. The final result, CERNUnits, is the geometric mean of the four individual results.

Multiprocessing

- **DGauss***

  Oxford Molecular Group is an international supplier of software and services for discovery research with computational chemistry. Their software is installed at all the major chemical and pharmaceutical companies. DGauss* is an Oxford Molecular Group application originally developed for Cray supercomputers. Parallel Intel Architecture workstations now enable chemists to effectively reduce time to solution in the development of new chemicals and drugs. DGauss version 4.0 is a quantum chemistry program used for studying electronic, magnetic, and structural properties of molecules and clusters. The workload used in the benchmark computes the energy and forces of a zeolite fragment, Si8O7H18.

- **FLUENT***

  Fluent Inc. is a leading ISV developing computational fluid dynamics (CFD) software that is used worldwide for a broad range of engineering analyses by major industrial companies. FLUENT,* one of their key applications, has run successfully on processor Intel and Windows NT* systems for several years.

  UGM2 simulates swirling turbulent flow in a curved duct with a sudden expansion inlet. Mixer simulates laminar two-phase flow through a static mixer. STANCAS simulates turbulent flow in a duct elbow .The first problem is a standard test case that runs in about 5 minutes on about 40,000 cells. The last two represent typical uses of FLUENT by engineers. They execute sequentially for less than one hour on the Intel Architecture workstations running Windows NT using 200 KB to 300 KB cells.

- **LS-DYNA***

  LS-DYNA* is a robust, multifaceted MCAE analysis tool that is used extensively by both commercial and educational/ research engineering clients. Applications of LS-DYNA have expanded, in part due to its availability on Intel Architecture workstations, to include aerospace, biomedical, and electrical component drop testing applications, as well as automobile crashworthiness and metal forming. LS-DYNA routinely performs complex analyses with relative ease, due to its user-friendly Windows NT operational environment, command line mode, and online manuals.

- **VISAGE***

  VIPS Limited is a UK-based company that develops and markets The VISAGE* System, an advanced and comprehensive finite element program for solving geomechanical, rock mechanical, environmental and petroleum engineering problems. The program has been used on supercomputers and high-end servers and recently was ported to and parallelized on Intel Architecture-based workstations. Using VISAGE, engineers can solve for and design mines, foundations, dams, bridges, and buildings. The same system can also be used for environmental studies in order to track down the flow of contaminants through porous media. Petroleum engineers can use the VISAGE software for the compaction and subsidence of black oil reservoirs, design for the location of injection/production wells or study the initiation and propagation of fractures as VISAGE is the world's first three-phase, gas-oil-water-, stress-dependent reservoir simulator which includes thermal fracturing capabilities. The software can also be used in structural geology for determining the modern stress state between complex fault and fracture networks.

  Two one-hour demonstrations were run with VISAGE. The first example, 1slp01, idealizes a slope stability problem in 2-D commonly encountered in geotechnical engineering. A 10 m high embankment with a 22.5° slope is

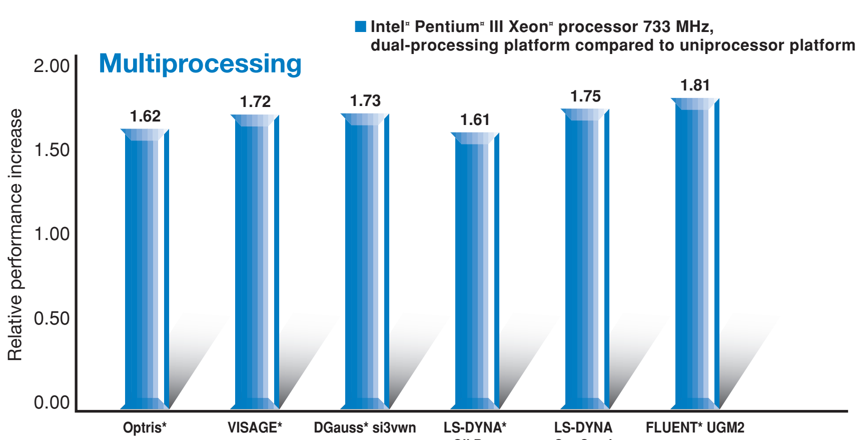

Figure 11. The new dual Intel® Pentium® III Xeon™ processor-based 733 MHz Compaq Professional Workstation SP750*—actual data

Source: Results performed by Intel. Refer to Performance Report Notice at the end of this document. For system configuration, see Benchmark System Configurations at the end of this document.

constructed in soft clay, and the resulting slip surface is calculated. The second example, 1fot3d, models a foundation resting on a 3-D mass of stiff clay. The footing is loaded to represent the weight of a building above, and the deformations around the footing are calculated.

- **Optris***

  Dynamic Software develops and markets Optris.* Optris is used internationally by auto manufacturers, tool makers, steel suppliers, and others to simulate the entire metal stamping process. In order to detect ruptures, wrinkles and other stamping problems before tool manufacturing and production begins, Optris is used to validate the results of a CAD design. As a virtual press, Optris replaces the try-out phase on a real press. This reduces costs and lead times, and by optimizing designs it also increases the resulting product quality. Optris is based on an explicit finite element method. Incremental stamping simulation can now run on PC with excellent Intel Architecture performance.

  Optris was run on the top part of a Renault Twingo front suspension tower. The computation involved adaptive meshing with a model that began with 6.4 KB elements and ended with 12.5 KB elements. The blank undergoes an increase of nearly an order of magnitude in elements. A total of over 18 KB cycles were used in the simulation.

The Nature of Benchmarks

The advantages of the Intel Pentium III Xeon processor are borne out in the performance of systems running standard benchmarks. Benchmarks provide a means of comparing the performance of different systems, their goal being to provide insight into how an application will run on a given system.

Two types of benchmarks are important in evaluating performance:

- Component benchmarks measure the performance of specific elements in a computing system: the processor, hard drive, or geometry accelerator. These benchmarks exercise particular system components by executing programs which themselves utilize mainly one component. For example, processor speed benchmarks are processor-bound programs, which make little use of memory and I/O resources. Since applications utilize all system components to varying degrees, it's important to take care in making application performance assumptions from component benchmark results.
- Application benchmarks measure the performance of applications that are run by users. Because application bench marks measure the overall performance of the various components of a system working together, they can be a more accurate predictor of the performance that users will see with their applications. Although application benchmarks are better predictors of application performance, it is important to carefully evaluate the similarities and differences between the real workload and that executed by the benchmark.

Performance as reported by standard benchmarks is likely to vary from the observed performance on real workloads for two reasons:

- Benchmark results published by Intel are measured on specific systems and components using specific hardware and software configurations. Differences between Intel's configurations and other configurations will yield varying results. Differences in application and benchmark software revisions, compilers, and operating system versions may also affect measured performance.
- Application benchmarks may or may not exercise the system and the application in ways that are representative of the way an application is actually used. This includes not only the application features that are executed, but also the size and the nature of the data sets they manipulate as well. The best way to predict performance is to run the actual application and workload on the target system.

The Pentium III Xeon processor is designed for demanding workstation applications. Many workstation application benchmarks utilize small data sets compared to what can be expected in real workloads. When the same benchmark applications are executed with more realistic data sets, one can usually expect a greater performance advantage. This ensures growing room for both future releases of workstation applications as well as for their data sets.

Benchmark System Configurations

Hardware

Processor	Intel® Pentium® III Xeon™ Processor 550 MHz	Intel® Pentium® III Xeon™ Processor 733 MHz	Intel® Pentium® III Xeon™ Processor 733 MHz
L2 Cache	512 KB	Advanced Transfer Cache of 256 KB	
Board or System	MS440GX	Intel® Validation Board	Compaq Professional Workstation SP750*
Memory Size and Type	PC100 SDRAM, 512 MB, ECC Enabled	PC800 RDRAM, 512 MB, ECC Enabled	256 MB
Graphics Adapter (2D/3D)	3D Labs Oxygen VX1 32 MB AGP 2X (Internet Streaming SIMD optimized) E&S Tornado 3000 for SPECviewperf* and SPECapc* for Pro/ENGINEER*—10 x 12 x True		Intense 3D Wildcat 4110
Graphics driver for Windows NT* 4.0	VX1: 2.14-0919 driver for Windows NT 4.0 with NT service pack 4 installed		
Resolution /Colors	1024 x 768 true color (60 Hz) for all benchmarks except SPECviewperf and SPECapc for Pro/ENGINEER—10 x 12 x True		SPECviewperf and SPECapc Pro/ENGINEER 12 x 10 x True
Hard Disk	Seagate Cheetah* ST39102LW 10,000 rpm SCSI, 9.1 GB		Quantum Atlas 10K, Ultra 3 SCSI Wide, 10,000 rpm, 18.2 GB
Disk Controller	Adaptec AHA2940U2W SCSI/PCI		
CD ROM Drive	Toshiba 32X XM-6201B SCSI CD-ROM Drive		
Network Interface Card	Intel® Pro 100b PCI Ethernet LAN Adapter		

Operating System / Software

Windows NT 4.0	Windows NT 4.0 build 1381 NTFS partition with Service Pack 4 installed

References

The following Web sites provide further information on the various benchmarks whose results are reported in this paper:

- **SPECapc* for Pro/ENGINEER,* SPECviewperf***
  http://www.spec.org
- **MSC/NASTRAN***
  http://www.macsch.com
- **ANSYS***
  http://www.ansys.com
- **Verilog-XL***
  http://www.isdmag.com
- **CERN***
  http://wwwinfo.cern.ch
- **Optris***
  http://www.dynamic-software.com
- **VISAGE***
  http://www.vips.co.uk
- **DGauss***
  http://www.oxmol.com
- **LS-DYNA***
  http://www.kbs2.com
- **Fluent***
  http://www.fluent.com
- **STREAM***
  http://www.cs.virginia.edu/stream

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