IA: The Intelligent Architecture Investment

Pat Gelsinger
Senior Vice President and General Manager
Digital Enterprise Group
Today: Intel Architecture

Clients

Servers

Embedded

Visual
Transitioning Nehalem to Mainstream

**Revolutionary Microarchitecture**
Nehalem Enables Highest Performing DT Microprocessors on the Planet

**Nehalem Platform Re-partition**
Greater Performance and Lower Power via Higher Integration

**32nm Process Technology**
Intel's Most Advanced Process Extends Nehalem Through Mainstream
Intel™ Core™ i7 Processor
The Highest Performing Processor On the Planet

- Revolutionary Nehalem microarchitecture
- Superior energy efficient performance
- Intel™ Hyper-Threading technology
  - 8 threads, 4 cores
- Intel™ Turbo Boost technology
- Intel™ Core™ i7 Launched In Nov 2008
Enabling Nehalem For Every Segment

**High End Desktop**
- Revolutionary Microarchitecture

**2008**
- **Intel CORE i7**
- **Intel CORE i7**

**2009+**
- **4 Cores / 8 Threads**
  - Mainstream Desktop
    - Intel Lynnfield
  - Thin & Light Notebook
    - Intel Clarksfield
  - Platform Re-partition

**45 nm High-K**
Nehalem Platform Re-Partition

Penryn Based 3-chip Solution

- Processor
  - FSB
  - Intel 4 Series Chipset
    - iGFX
    - MC
    - Display
    - DDR2/DDR3
  - ICH
    - Clocks
    - I/O

- PCIe Graphics
- Display

Nehalem Based 2-chip Solution

- Processor
  - iGFX
  - IMC
- PCIe Graphics
  - Intellectual Display Interface
- Display
  - Clock buffer
  - ME
- I/O

Greater Performance and Lower Power via Higher Integration
Maintaining the Pace of Execution: Tick-Tock Microprocessor Development

- 65nm: Core 2 Duo
- 45nm: PERNYR
- 32nm: Westmere
- 32nm: Sandy Bridge

32nm Process Health Enables Acceleration of Westmere Product Ramp
Enabling Nehalem For Every Segment

2008

High End Desktop

Revolutionary Microarchitecture

2009+

4 Cores / 8 Threads

Mainstream Desktop

Lynnfield

Thin & Light Notebook

Clarksfield

Platform Re-partition

2 Cores / 4 Threads with Integrated Graphics

32nm Process Technology

Clarkdale

Arrandale

45 nm High-K

32nm High-K
First 32nm Westmere Products

Key Features

- Intel™ Turbo Boost Technology
- Intel™ Hyper-Threading Technology
- Intel™ Graphics Media Accelerator
- Integrated Memory Controller with 2 Channel DDR3

Not all features are available on every processor line item
Nehalem vPro™ Corporate Platforms
New Levels of Security and Manageability

Lynnfield
Clarksfield
Clarkdale
Arrandale

Smarter, Energy-efficient Performance
Nehalem micro-architecture

Expanded Manageability
Intel™ Active Management Technology

Enhanced, Proactive Security
Intel™ Anti-Theft Technology
PRC Customers Embracing vPro™

- Shanda Interactive
- Guang Anmen Hospital
- AQSIQ
- MOR
- Panyu’s People Hospital
- Shanghai Hongqiao Airport
Intelligent Architecture for Embedded Computing

Arrandale Platform Delivers

**Smarter, energy-efficient Performance**
- Nehalem micro-architecture

**Expanded Manageability**
- Intel® Active Management Technology

**Enhanced, Proactive Security**
- Intel® Anti-Theft Technology

Benefits to Retailers

- **Lower OpEx**
- 70% Power Reduction
- Reduced Truck Rolls

- **Improved Shopping Experience**
- More Secure Transactions
- Richer Visual Compute Experience In Same Footprint

IDF2009

Based on comparison between POS terminals with Intel® Pentium® M processors and POS terminals with Intel® Core™ Duo mobile processors. Source: "Advanced CPUs: The Impact on TCO: Evaluations of Retail Store IT Investments" by Global Retail Insights (an IDC company).
New Retail Experience
Today: Intel Architecture

Clients

Servers

Embedded

Visual
Intel™ Xeon™ Processor 5500 Series: Transforming Computing

Most Important Server Launch Since Pentium™ Pro

15 Billion Connected Devices
Design and Discovery

Intelligent Platform
World’s Most Adaptable Server Platform

Intelligent Choice
Delivers Higher Performance, Lower TCO
Estimated 8 Month Payback For Single-core Server Refresh
Intel™ Xeon™ 5500 Platform

- NEW! Intel® 5520 Chipset
- NEW! Intel® Node Manager
- NEW! Intel® X25-E SSDs

NEW! Intel Data Center Manager
- PCI Express* 2.0
- NEW! Intel® 82599 10GbE Controller

- New Memory Subsystem
- Intel™ QuickPath Interconnect
- Intel™ Intelligent Power Technology
- New I/O Subsystem

Superior Platform Available Today
Intel® Xeon® 5500 Performance Publications

**SPECint* _rate_base2006**
240 score (+71%)
Fujitsu

**SPECpower* _ssj2008**
1860 ssj_ops/watt (+64%)
IBM J9* JVM

**SPECfp* _rate_base2006**
194 score (+125%)
Fujitsu

**SPECjAppServer*2004**
3,975 JOPS (+93%)
Oracle WebLogic* Server

**TPC*-C**
631,766 tpmC (+130%)
Oracle 11g* database

**SAP-SD* 2-Tier**
5,100 SD Users (+102%)
SAP* ERP 6.0/IBM DB2*

**SPECComp*Lbase2001**
234,996 score (+189%)
Intel Compiler 11.0/RHEL 5.3*

**TPC*-E**
800 tpsE (+152%)
Microsoft SQL Server* 2008

**SPECWeb*2005**
71,045 score (+140%)
Rock Web* Server

**Fluent* 12.0 benchmark**
Geo mean of 6 (+127%)
ANSYS Fluent*

**SPECjbb*2005**
604,417 BOPS (+64%)
IBM J9* JVM

**SPECCapc* for Maya 6.5**
7.70 score (+87%)
Autodesk* Maya

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**Over 30 New 2S Server and Workstation World Records!**

*The performance metrics shown are based on comparison to Xeon 5400 series; Performance results based on published/submitted results as of March 30, 2009. Platform configuration details available at https://www.intel.com/pressroom/kits/summary/kits.htm. Other names and brands may be>
**Refresh Benefits**

**2005**

**Performance Refresh**
- 184 Intel Xeon 5500 Based Servers
- Up to 9x Performance
- 18% Annual Energy Costs Estimated Reduction

**Efficiency Refresh**
- 184 Intel Xeon Single Core Servers
- As Low as 8 Month Payback
- 90% Annual Energy Costs Estimated Reduction

*Source: Intel estimates as of Nov 2006. Performance comparison using SPECjbb2005 bops (business operations per second). Results have been estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance. For detailed calculations, configurations and assumptions refer to the legal information slide in backup.*
“We’re very excited about the release of the Intel Xeon 5500 processor, built on the new Intel Nehalem Microarchitecture. The complementary features of Windows Server 2008, Hyper-V, and the Intel Xeon 5500 series processors will provide our mutual customers with exceptional performance, energy efficiency, and flexibility, so they can achieve even greater cost savings.”

Bill Laing
Corporate Vice President
Windows Server
Evolving to the Embedded Internet

Requires Dynamic, Efficient and Scalable Infrastructure
Cloud Architecture Requirements

- Intelligent Performance
- Energy Efficiency
- Dynamic Virtualization
Intel™ Xeon™ 5500: Optimized for the Cloud Architecture

- **Intelligent Performance**: Up To 125% Higher Compute Performance*

- **Energy Efficiency**: Automated Power States, ~50% Lower Idle Power, Higher Operating Temperature

- **Dynamic Virtualization**: Up To 2X Virtualization Performance, Enhanced I/O Virtualization

*Up to 125% higher compute performance, 50% idle power, and up to 2X virtualization performance are based on comparison to previous generation 5400 series. Lower cooling cost based on Intel internal analysis (January 2009). For detailed calculations, configurations, and assumptions refer to the legal information slide in the loop.
“We are excited about the evolutionary road VMware and Intel are helping to pave for our customers by combining the new Intel Xeon Processor 5500 Series with VMware’s forthcoming vSphere generation of products. Together, our products provide a power-efficient, high-performance, platform for the datacenter and the cloud that enables our joint customers to do more with less - providing new levels of efficiency, control and choice for them to run their datacenters effectively.”

— Paul Maritz, CEO, VMware
Intel Optimization in Action

Technology: Intel™ Dynamic Node Manager

Platform: Optimized for Data Center

Performance Optimization

Image Processing: 3X Improvement

Data Center: Design and Consultation
"To enable continuous business growth, we have developed the new generation of distributed search architecture based on Intel Xeon 5500 and Intel SSDs. During search application testing, we're excited to see about 100% performance boost and 120% higher performance per watt. Currently, we're deploying hundreds of Intel Xeon 5500-based servers to meet upcoming rapid traffic growth."

— Zhou Lin, Sohu Senior Technical Director
Intel™ Xeon™ 5500 Series: Advancing Online ERP / SaaS in China

“It’s really amazing for UFIDA Online ERP Service to get 3.37x performance boost and 3.36x performance per watt boost on the new Intel Xeon 5500 EP platform. The amazing results show that the new Xeon 5500 EP is certainly the preferred platform for our online service and high performance will certainly greatly impress our customers.”

— Mr. Chen Shuichao, R&D director
Westmere-EP: Next Generation Xeon™ Processor

- 32 nm High-k Process
- Cache Enhancements
- Improved Energy Efficiency
- Up to 6 Cores
- Available 2010

Socket Compatible with Intel™ Xeon™ 5500 Platform
EX Segment Roadmap

2007: Intel Xeon 7300
2008: Intel Xeon 7400
2009: Nehalem-EX
Future: Westmere-EX

Intel Virtualization Technology FlexMigration
32nm Westmere Generation On Track

Designed for Demanding Apps and Large-Scale Consolidation
Nehalem-EX

- Up to 8 Cores
- 24MB of Shared Cache
- Intel® Hyper-threading
- Integrated Memory Controllers
- 4 High-bandwidth QPI Links
- 2.3B Transistors

The Next Generation Intelligent Expandable Platform
Nehalem-EX: 4-Socket Platform

- 8 Cores/64 Threads
- QPI Architecture
- Intel™ Scalable Memory Interconnect with Buffers
- Next Generation I/O with Virtualization Technology

Enterprise, Virtualization, and HPC Leadership
Nehalem-EX: 8S “Glueless” Capability

- 8 Sockets with 128 threads
- Scalable performance through modularity
- Leadership RAS with MCA recovery

Industry Standard, High-end Enterprise Leadership
Tukwila: Game Changer for Mission Critical

- High platform longevity
- Highest scalability
- RAS: Mainframe-class RAS + MCA recovery
- 2x Performance vs. previous generation
- Leading-edge virtualization capabilities
- Next generation I/O and manageability

Itanium™ Platform: Impressive Strength and Continued Growth
Intel’s Collaboration: Energy

- 3 year build-out of “Smart Grid”

- Cover 80% of China’s mainland and 1 billion people

- Collaboration
  - Joint lab to incorporate HPC, vPro™, and embedded technologies
  - Intel Xeon™ 5500 servers for grid simulation
  - Network Isolation and Power Station Automation
Today: Intel Architecture

Clients  Servers  Embedded  Visual
Intel™ Atom™ Processor: Global Embedded Opportunity

In-Vehicle Infotainment
Handheld terminal
Rugged tablet
DSS Video Server
Wearable PC
Smart shopping cart
Digital signage
Surgery patient monitoring
Portable Sonogram
Smart soldier wearable computer
Unmanned vehicle system
Music Keyboard
TV Camera
Residential Gateway

Automated farm equipment
Portable Point of Sale terminal
Mobile video streamer
Fleet navigation & mgmt system
Kiosk
IP-media phone
Sewing machine
Ocean monitoring equipment
Ruggedized handheld
Home Automation
PLC (Programmable Logic Controller)
HMI (Human Machine Interface)
Smart Camera
Weight Scales

~1,000 Embedded Design Engagements in Progress
New Options for Intel™ Atom™ Processor

Processor Options for Embedded
Two packages (13x14 or 22x22 mm) Industrial or commercial temp

System Controller Options
Two packages (22x22 or 37.5x37.5 mm) Industrial or commercial temp

Improved Power Efficiency
45nm High-K
Enhanced Intel SpeedStep™

Embedded Segment
IA software compatible
7 year extended life cycle support

Adding 4 New Processors and 2 System Controller Hub Options for Embedded
Intel Atom™ Processor: Embedded Growth in PRC

- Industrial
- Education
- In-Vehicle Infotainment
- Digital Security & Surveillance
- Intelligent Transportation
- Medical
- Point of Sale
- Digital Signage

Evoc Group

HPC HUIPU SCIENCE

Shiyuan Electronics

SEEYCO

UP-TECH

Shenzhen ZBJ Technology

DT Research

SBS

Cynovo

Vion-Tech.com
Jasper Forest:
Unparalleled Leadership for Embedded and Storage

Increased Scalability
Quad, Dual, Single Core SKUs
23-85W Options

Integration for Reduced Real Estate
Native PCI Express with Non-transparent Bridging
Native RAID Acceleration

Telecommunications-Grade Reliability
Higher Tcase for NEBs Certification
Today: Intel Architecture

Clients  Servers  Embedded  Visual
Larrabee

- Intel’s first many-core architecture
  - Designed for high throughput applications
  - Expect many derivatives overtime
- A highly differentiated architecture
  - Programmable graphics pipeline enables developer innovation and stunning visual effects
  - IA programmability provides great flexibility
  - Fully coherent cache architecture
  - Standard API support (DirectX*, OpenGL*, OpenCL*)

First Discrete Graphics Products In Late 2009 Or 2010

*Other names and brands may be claimed as property by others
Prototyping on Larrabee

• C++ Larrabee Prototyping Library
  - Released at Game Developer’s Conference, 27 Mar ’09

• Enables early Larrabee code exploration and prototyping
  - Gives developers deep insight into the architecture and efficiency

Now Available on www.intel.com/software/graphics
C++ Larrabee Prototype Library

- 100+ Vector instructions
- Ex: 512 bit SIMD
- Load-op
- Format conversion
- Broadcast/swizzle
- Ternary
- Multiply-add
- Predication
- Gather/scatter support

Developed with Software Developers to Deliver the Programmability they Need most
Ct: Superior Data Parallel Programming Solution

- Avoid parallel programming pitfalls
- Develop readable programs
- Scale from dual-core to many-core

Ct: The Right Way to Do Data Parallelism
Announcing: Ct Technology Going Into Intel Tools

Data Parallel Programming for Multi-core and Many-core Processors

- Productive data parallel programming
  - High level abstraction for ease of use
- Investment protection
  - Performance scaling from dual-core to many-core CPUs
- C++ extended by standard use of templates
  - No changes to standard C++ compilers
- Complements software tools from Intel and others
- Product beta by EOY 2009

Bringing New Capabilities to Data Parallelism
Forward-Scaling Data Parallel Performance

No Recompile Or Processor-specific Coding Required!

CPU Scaling Relative to 1C HTN@3GHz

<table>
<thead>
<tr>
<th>Application</th>
<th>Xeon E5450 at 3.0 GHz</th>
<th>Xeon x5570 at 3.0 GHz</th>
<th>NHM-EX 8C at 3.0 GHz</th>
<th>Future CPU at 3.0 GHz Est.</th>
</tr>
</thead>
</table>

LRB Scaling Relative to 1C LRB

<table>
<thead>
<tr>
<th>LRB Size</th>
<th>LRB x8C***</th>
<th>LRB x16C***</th>
<th>LRB x32C***</th>
<th>LRB x64C***</th>
</tr>
</thead>
</table>

Speedup

www.intel.com/software/data_parallel
Industry Feedback on Ct Technology

“Intel’s Ct technology will help us take full advantage of the power of data parallelism and will help us quickly scale our applications into the future.”
— Xia Zhang, Neusoft CTO

“Ct represents an essential new development for the future of parallel programming and we believe Ct will become one of the cornerstones of CERN’s future programming environment.”
— Prof. Dr. Volker Lindenstruth, Chair of Computer Engineering, Univ of Heidelberg. Head of ALICE High Level Trigger

“Ct is a breakthrough capability. As the underlying hardware platform evolves, we would like to take advantage of Ct’s ability to scale, so we can build high-performance financial algorithms that protect our investment.”
— Jeffrey M. Birnbaum, Managing Director, Bank of America

“We believe Intel’s Ct, is an exciting new technology for data-intensive computing environments such as seismic imaging.”
— Laurent Clerc, VP Technology Services, CGGVeritas

Register for Ct Newsletter at Intel Software Network
www.intel.com/software/data_parallel

*Other names and brands may be claimed as property by others.
Software Support for Many Core

Proven Intel Tools and Development Model
- C++ Auto-vectorizing Compiler
- Intrinsics
- Native Threading
- Ct support planned

Extending Support for Larrabee
- Compiler, debugger, libraries & samples
- Intel Graphics Performance Analyzers extended to Larrabee (DirectX and Native mode)
- Supports standard APIs: DirectX*, OpenGL*, OpenCL*

*Other names and brands may be claimed as property by others
Summary

Intel Nehalem Microarchitecture Products for Mainstream Computing

32nm Based Products In 2010

Intel Xeon™ 5500 Transforms Computing and Provides Great ROI

Nehalem-EX Brings New RAS Capabilities and 4S-8S Scalability In 2009

Atom, Jasper Forest and Arrandale Extend the Reach In Embedded Segment

Larrabee on Track and Rich Set of Developer Tools for Scalability

IA: The Intelligent Architecture Investment

Accelerate Design Of Nehalem Micro-architecture Based Products
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/performancedata/limits.htm or call (U.S.) 1-800-628-9686 or 1-916-356-3104.

Relative performance is calculated by assigning a baseline value of 1.0 to one benchmark result, and then dividing the actual benchmark result for the baseline platform into each of the specific benchmark results of each of the other platforms, and assigning them a relative performance number that correlates with the performance improvements reported.


Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

Hyper-Threading Technology requires a computer system with a processor supporting HT Technology and an HT Technology-enabled chipset, BIOS and operating system. Performance will vary depending on the specific hardware and software you use. For more information including details on which processors support HT Technology, see here.

Intel® Turbo Boost Technology requires a Platform with a processor with Intel Turbo Boost Technology capability. Intel Turbo Boost Technology performance varies depending on hardware, software and overall system configuration. Check with your platform manufacturer on whether your system delivers Intel Turbo Boost Technology. For more information, see http://www.intel.com/technology/turbo.

Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. See http://www.intel.com/products/processor_number for details. Intel products are not intended for use in medical, life saving, life sustaining, critical control or safety systems, or in nuclear facility applications. All dates and products specified are for planning purposes only and are subject to change without notice.

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Benchmark configuration details

- All comparisons based on published/submitted/approved results as of March 30, 2009
- SPECint_rate_base2006:
  - Baseline Intel® Xeon* processor X5470 based platform details: Fujitsu Siemens PRIMERGY® RX200 S4 server platform with two Intel Xeon processors X5470 3.33GHz, 12MB L2 cache, 1333MHz FSB, 1600MHz 6x2GB DDR2 PC2-5300, 2xraid, 1x5.5k, with ECC, SUSE Linux Enterprise Server 10 SP2 x86_64 Kernel 2.6.16-50.421-smp, Intel C++ Compiler for Linux 32* and Linux64* version 11.0 build 20090730. For more information see http://www.spec.org/cpu2006/results/2009/20090730/11c0900010100c04.html.
  - Intel® Xeon* processor X5670 based platform details: Fujitsu PRIMERGY® TX800 S8 server platform with two Intel Xeon processors X5670 2.93GHz, 8MB L3 cache, 6.4GT/s QPI, 48 GB memory (6x8 GB PC3-10600R, 2xraid, 1x5.5k, with ECC, SUSE Linux Enterprise Server 10 SP2 x86_64 Kernel 2.6.16-50.421-smp, Intel C++ Compiler for Linux32 and Linux64 version 11.0 build 20090131. Submitted to www.spec.org for review at 240 as of March 30, 2009.
- SPECint_rate_base2006:
  - Baseline Intel® Xeon* processor X5482 based platform details: Hewlett-Packard ProLiant DL160 G5 server platform with two Intel Xeon processors X5482 3.20GHz, 12MB L2 cache, 1333MHz FSB, 1600MHz 6x2GB DDR2 CL5 FB DIMM), S4-BIT SUSE Linux Enterprise Server 10 SP1, Intel C++ Compiler for Linux 32* and Linux64* version 10.1 build 20090876. Referenced as published at 664. For more information see http://www.spec.org/cpu2006/results/2009/20090876/11c0900010100c04.html.
  - Intel® Xeon* processor X5670 based platform details: Fujitsu PRIMERGY® TX800 S8 server platform with two Quad-Core Intel Xeon processors X5570 2.93GHz, 8MB L3 cache, 6.4GT/s QPI, 24 GB memory (6x16 GB PC3-10600R, 2xraid, 1x5.5k, with ECC, SUSE Linux Enterprise Server 10 SP2 x86_64 Kernel 2.6.16-50.421-smp, Intel C++ Compiler for Linux32 and Linux64 version 11.0 build 20090131. Submitted to www.spec.org for review at 194 as of March 30, 2009.
  - Intel® Xeon* processor X5670 based platform details: Cisco B200 M1 server platform with two Quad-Core Intel Xeon processors X5570 2.93GHz, 8MB L3 cache, 6.4GT/s QPI, 16 GB memory (8x4 GB PC3-10600R, 2xraid, 1x5.5k, with ECC, SUSE Linux Enterprise Server 11 x86_64 2.6.27.15-2-default, Intel C++ Compiler for Linux32 and Linux64 version 11.0 build 20090131. Result measured at 194 as of March 30, 2009.
- SAP-SD 2-Tier
- TPCC
  - Baseline Intel® Xeon* processor X5460 based platform details: HP ProLiant ML370 G5 platform with Intel Xeon processor X5460 3.16GHz (2 processors / 8 cores / 8 threads), 2x8MB L2 cache, 1333 MHz system bus, 64GB memory, Microsoft SQL Server 2005 x64 Enterprise edition SP2, Microsoft Windows Server 2003 Enterprise x64 Ent R2. Referenced as published at 275,149 tpcc/m and 31.44 tpmC available data January 7, 2008. For more information see: http://www.spec.org/tpcc/results/2008/20080107/11c0900010100c04.html.
  - Intel® Xeon* processor X5670 based platform details: HP ProLiant DL180 G6 platform with two Intel Xeon processors X5570 2.93GHz (2 processors / 8 cores / 16 threads), 8MB L3 cache, 6.4GT/s QPI, 144 GB memory (18x8 GB DDR3), Oracle 11g database* with Oracle Enterprise Linux OS*. Result submitted to www.spec.org as of March 30, 2009.
Benchmark configuration details

- All comparisons based on published/submitted/approved results as of March 30, 2009.
- TPCE

SPEChipt2005
- Baseline Intel® Xeon® processor X5460 based platform details: Fujitsu-Siemens PRIMERGY RX600 S4 server platform* with two Intel Xeon processors X5460 3.33GHz, 12MB L2 cache, 1333MHz FSB, 16GB memory, Microsoft Windows Server 2008 Enterprise x64 Edition*, Oracle (R) Real Application Express 3.2.0.18.0.1, 4 VM Instances. Referenced as published at 348,034 BOPS. For more information see http://www.spec.org/2005 Results/s2005p1/2/2292010-0002581.html.
- Intel® Xeon® processor X5570 based platform details: IBM BladeCenter HS22 Server platform* with two Intel Xeon processors X5570 2.93GHz, 8MB L3 cache, 6.4GT/s QPI, 24GB memory (6x4GB DDR3-1333MHz), Microsoft Windows Server 2008 Enterprise x64 Edition, IBM J9 2.4.1.4 (build pvs/38458sr5-200903201411580555), run with 4 VM Instances. Result measured at 604417 BOPS - March 30, 2009.

SPEWeb2005
- Baseline Intel® Xeon® processor X5460 based platform details: HP ProLiant DL380 G5 server platform with two Intel Xeon processors X5460 3.16GHz, 12MB L2 cache, 32GB memory (8x4G 667MHz DDR2 FB-DIMM), Red Hat Enterprise Linux 5.4 (24 x86_64), RockWeb Server v1.46 x86_64, referenced as published at 26591i. For more information see http://www.spec.org/2005 Results/s2005p1/2/2292010-0002581.html.
- Intel® Xeon® processor X5570 based platform details: HP ProLiant DL380 G5 platform* with two Intel Xeon processors X5570 2.93GHz, 8MB L3 cache, 6.4GT/s QPI, 144GB memory (12x8GB DDR3), Red Hat Enterprise Linux 5.2, RockWeb Server v1.4.7 (x86_64). Result submitted to www.itz.org for review at 71,045 as of March 30, 2009.

Fluent:
- Baseline Intel® Xeon® processor X5462 based platform details: Supermicro X7DB9+-* server platform with two Intel Xeon* processors X5462 3.20GHz, 12MB L2 cache, 1600MHz FSB, 64GB memory (4x16GB DDR2 FB-DIMM), 64-bit Red Hat Enterprise Linux 5.3*. Performance measured using Fluent Version 12.0 Beta Version 12.0.1.3*. Six individual benchmarks are shown as a measure of single node performance. *Overall performance is the geometric mean of the six individual benchmarks.
- Intel® Xeon® processor X5570 based platform details: SG Alto ICE 820EX* server platform with two Intel Xeon processors X5570 2.93GHz, 8MB L3 cache, QPI 6.4 MT/s, 24GB memory (12x2GB DDR3), 64-bit Suse Linux Enterprise Server® 10 SP2 with ProPack* SP2*. Performance measured using Fluent Version 12.0 Beta. Version 12.0.3) Six individual benchmarks are shown as a measure of single node performance. *Overall performance is the geometric mean of the six individual benchmarks.
Benchmark configuration details

- All comparisons based on published/submitted/approved results as of March 30, 2009
- SPECComp 2001
  - Baseline Intel® Xeon® processor E5472 based platform details: Supermicro X7DB8+ server platform with two Intel® Xeon® processors E5472 3.00GHz, 12MB L2 cache, 1600MHz FSB, 32GB memory (8x1GB DDR2-667MHz), 512KB L2 cache, Linux 10.1* (X86-64) (Linux 2.6.16.13-4-mp), Binaries built with Intel® Compiler 10.1. Referenced as published at 17197. (SPECCompBase2001). For more information see http://www.spec.org/comp_tests/results/2007/cmp2007-20071107-00274.html.
  - Intel® Xeon® processor X5570 based platform details: Acer B-200 M1 server platform with two Intel® Xeon® processors X5570 2.93GHz, 8MB L3 cache, 64GT/s QPI, 24GB memory (6x4GB DDR3-1333MHz), Red Hat EL 5.3, Linux Kernel 2.6.18.128.65 SMP x86_64, Binaries built with Intel® C/C++ Compiler 11.0 for Linux. Result submitted to SPEC for review as 43593 (SPECCompBase2001) as of March 30, 2009.

SPECpower_ssj2008
- Baseline Intel® Xeon® processor L5430 based platform details: PowerEdge R2510 M1 server platform with two Intel® Xeon® processors L5430 3.33GHz, 12MB L2 cache, 1333MHz FSB, 8GB memory, Oracle JRockit (build P28-0-9-14-1410948-1.6.0_05-200903031-1104-windows-x86_64, compiled mode) published at 1135 Watts. For more information see http://www.spec.org/power_ssj2008/results/power_ssj2008/2009-09-28/1110948-00088.html.
- Intel® Xeon® processor X5570 based platform details: Veranal Systems, Inc. VME 305 server platform with two Intel® Xeon® processors X5570, 2.93GHz, 8GB (4x2), Microsoft Windows Server 2008 Enterprise Service Pack 2 OS. Oracle JRockit (build P28-0-9-14-1110948-1.6.0_05-200903031-1104-windows-x86_64, compiled mode) published at 1143 Wats provided by Veranal as of 3/30/2009.

SPECappServer 2004
- Baseline Intel® Xeon® processor X5460 based platform details: HP ProLiant BL460c G1 server platform with two Intel® Xeon® processors X5460 3.16GHz, 12MB L2 cache, 1600MHz FSB (4x2) and 667MHz EDO DDR2 (8x4GB), Oracle Application Server 10G Release 10.1.3.4 - Java Edition, BEA JRockit(R) 5.0.1 JDK (R27.30.106) (Linux x86 32bit), Oracle Database Enterprise Edition Release 11.1.0.6. Referenced as published at 2006. For more information see http://www.spec.org/app_server/results/app_server/2006-01-20/1110928-00065.html.
- Intel® Xeon® processor X5570 based platform details: Dell PowerEdge R610 server platform with two Intel® Xeon® processors X5570 2.93GHz, 8MB L3 cache, 64GT/s QPI, 24GB memory (12x2 GB DDR3), Oracle WebLogic Server Standard Edition Release 10.3.3, Oracle JRockit(R) 5.0.1 JDK (R27.6.0.50) (Linux x86 32bit), Oracle Database Enterprise Edition Release 11.1.0.7. Result submitted to SPEC for review at 3972 as of March 30, 2009.

VMmark
- Baseline Intel® Xeon® processor X5570 based platform details: HP ProLiant ML370 G5 server platform with two Intel® Xeon® processors X5450 3.33GHz, 2x6GB L2 cache, 1333MHz FSB, 48GB memory, VMware ESXi v3.5. Update 3 Published at 31.5g7Tiles. For more information see http://www.spec.org/vmmark/results/vmmark/2010-03-31/open-source-ml370-g5-dual-xeon.html.
- Intel® Xeon® processor X5570 based platform details: Dell PowerEdge R710 Server platform with two Intel® Xeon® processors X5570 2.93GHz, 8MB L3 cache, 64GT/s QPI, 86 GB memory (12x8 GB DDR3-1066MHz), VMware ESXi beta built 150817. Submitted to VMware for review at 23.55g16Tiles.
Xeon 5500 Refresh Slides (System Configurations)

- 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 Intel Performance Benchmark Limitations.

- Single Core to Xeon 5500 Refresh Configuration Details
  - Source: Intel internal measurements 2005 – 2008 comparing 2S Xeon 3.8GHz (Irwindale), 8x1GB DIMMs, 1 HDD, 382W power under load to 2S Xeon X5570 (Nehalem 2.93GHz), 6x2GB DIMMs, 1 HDD, 315W power under load.

- Dual Core Xeon 5100 to Xeon 5500 Refresh Configuration Details
  - Source: Intel internal measurements 2005 – 2008 comparing 2S Xeon 5160 (Woodcrest 3.0GHz), 8x2GB DIMMs, 1 HDD, 354W power under load to 2S Xeon X5570 (Nehalem 2.93GHz), 6x2GB DIMMs, 1 HDD, 315W power under load.
# Single Core Energy Efficient Refresh Calculation Details

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2009</th>
<th>Delta / Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Intel® Xeon® 3.8GHz with 2M cache</td>
<td>Intel® Xeon® X5570 (2.93GHz)</td>
<td></td>
</tr>
<tr>
<td><strong>Performance per Server</strong></td>
<td>1</td>
<td>8.7x increase</td>
<td>Intel internal SPECjbb2005® measurements as of Feb 2009</td>
</tr>
<tr>
<td><strong>Server Power Idle / Active Power</strong></td>
<td>228W idle / 382W active</td>
<td>174W idle / 312W active</td>
<td>Server idle for 16 hours per day and active for 8 hours per day</td>
</tr>
<tr>
<td># Servers needed</td>
<td>184</td>
<td>21</td>
<td>~ 9:1 server consolidation</td>
</tr>
<tr>
<td># Racks needed</td>
<td>9 racks</td>
<td>1 rack</td>
<td></td>
</tr>
<tr>
<td><strong>Annual Server kWhr</strong></td>
<td>451,474</td>
<td>42,515</td>
<td><strong>90% lower energy costs</strong></td>
</tr>
<tr>
<td><strong>Total Annual Energy Costs</strong></td>
<td>$90,294</td>
<td>$8,502</td>
<td>$81,792 electricity costs per year. Assumes $0.10/kWhr and 2x cooling factor</td>
</tr>
<tr>
<td><strong>Operating System Licensing Costs</strong></td>
<td>$165,600</td>
<td>$18,900</td>
<td>$146,700 less per year. Assumes a RHEL 5yr license at $900</td>
</tr>
<tr>
<td><strong>Annual Cost Savings of</strong></td>
<td>$220,954</td>
<td>$220,954</td>
<td>Source <a href="http://www.dell.com">www.dell.com</a> as of 12/10/08</td>
</tr>
<tr>
<td><strong>Cost of new HW</strong></td>
<td>n/a</td>
<td>$147,000</td>
<td>Assume $6,900 per server</td>
</tr>
</tbody>
</table>

**Payback Period of 8 months**
<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2009</th>
<th>Delta / Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Intel Xeon single core (3.8Ghz w/ 2M cache)</td>
<td>Intel Xeon 5500 series (2.93GHz)</td>
<td>bops = business operations per second</td>
</tr>
<tr>
<td><strong>Performance per Server</strong></td>
<td>50,970 bops SPECjbb2005*</td>
<td>447,000 bops SPECjbb2005*</td>
<td>Server active 24hr per day (assuming HPC application)</td>
</tr>
<tr>
<td><strong>Power Consumption per Server</strong></td>
<td>382W active</td>
<td>315W active</td>
<td>Data Center Capability = 1 MW</td>
</tr>
<tr>
<td><strong>DC Cooling Factor</strong></td>
<td>1.6 PUE</td>
<td>1.6 PUE</td>
<td><strong>Same Design</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PUE = Power Usage Effectiveness.</td>
</tr>
<tr>
<td><strong># of Servers</strong></td>
<td>1,637</td>
<td>1,637</td>
<td><strong>Same Footprint</strong></td>
</tr>
<tr>
<td><strong>Data Center Performance</strong></td>
<td>83,437,890 bops</td>
<td>731,739,000 bops</td>
<td><strong>Up to 8.8x Performance Increase</strong></td>
</tr>
<tr>
<td><strong>Data Center Power</strong></td>
<td>1,000 KW</td>
<td>825 kW</td>
<td><strong>Estimated 18% Lower Power</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td># of Servers * Svr Power * PUE</td>
</tr>
</tbody>
</table>
For 50% Lower Platform Idle Power

Configuration details for 50% lower idle power: Intel internal measurements of 221W at idle with Supermicro 2xE5450 (3.0GHz 80W) processors, 8x2GB 667MHz FBDIMMs, 1x700W PSU, 1x320GB SATA hard drive vs. 111W at idle with Supermicro software development platform with 2xE5540 (2.53GHz Nehalem 80W) processors, 6x2GB DDR3-1066 RDIMMs, 1x800W PSU, 1x150GB 10k SATA hard drive. Both systems were running Windows 2008 with USB suspend select enabled and maximum power savings mode for PCIe link state power management. Measurements as of Feb 2009.

For Virtualization Performance

• Up to 2.10x Virtualization performance compared to Xeon 5400 series claim supported by performance results on VMmark* benchmark. Xeon X5470 data based on published results. Xeon X5570 Intel internal measurement. (Feb 2009)
• Configuration details: - VMmark benchmark
• Baseline Quad-Core Intel Xeon processor X5470 based platform details: HP Proliant ML370 G5 server platform with two Quad-Core Intel Xeon processors X5470 3.33GHz, 2x6MB L2 cache, 1333MHz FSB, 48GB memory, VMware ESX V3.5. Update 3 Published at 9.15@7 tiles.
• New platform: Intel repreduction server platform with two Quad-Core Intel Xeon processor X5570, 2.93 GHz, 8MB L3 cache, 6.4QPI, 72GB memory (18x4GB DDR3-800), VMware ESX Build 140815. Performance measured at 19.51@13 tiles.