45nm Product Press Briefing

Stephen L. Smith
Corporate Vice President
Director of Group Operations
Digital Enterprise Group
Risk Factors

• Today’s presentation contains forward-looking statements. All statements made that are not historical facts are subject to a number of risks and uncertainties, and actual results may differ materially. Please refer to our most recent Earnings Release and our most recent Form 10-Q or 10-K filing available on our website for more information on the risk factors that could cause actual results to differ.
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How can Intel achieve 10X performance over time?

- Deliver Parallel Computing
- Design Power Efficient Architectures
- Focus on Platform and Usage Models

From 2004 press briefing... already exceeded

13.90 in 2006

5.25 In 2005

Source: Intel
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See http://www.spec.org for more information
Estimates as of September 2007
Agenda

- Intel® 45nm Manufacturing Technology
- Enhanced Intel® Core™ Microarchitecture
- Intel® 45nm Products & Platforms
- Summary
45nm Status

- 1st generation revolutionary high-k + metal gate transistors for improved performance and reduced leakage power
- Working “Penryn” microprocessors were first demonstrated in January ’07 and “Silverthorne” microprocessors in April ’07
- Intel’s 45nm processors are 100% lead-free
- Intel 45nm CPUs will convert to halogen-free packaging technology by the end of 2008
- Intel’s 45nm process technology will be described in more detail at the International Electron Devices Meeting (10-12 Dec’07)
Yield on Track for 45nm Production
CPU Shipments (65nm vs. 45nm)

65 nm

45 nm

Source: Intel Internal
45nm Advantage

Intel® Xeon® Processor 5300 series (Clovertown) 65nm
143 mm²
582m Transistors
8 MB Cache

Intel® Xeon® Processor 5400 series (Harpertown) 45nm Hi-k
107 mm²
820m Transistors
12 MB Cache

*Source: Intel
Die image size proportion is approximate
Enhanced Intel® Core™ Microarchitecture

Today's 65nm Intel Core Microarchitecture

- Intel® Wide Dynamic Execution
- Intel® Advanced Smart Cache
- Intel® Smart Memory Access
- Intel® Advanced Digital Media Boost
- Intel® Intelligent Power Capability

45nm Enhanced Intel Core Microarchitecture (Penryn)

- Fast Radix-16 Divider
- Faster OS Primitive Support
- Enhanced Intel Virtualization Technology

- Larger L2 Cache: up to 12MB
- 24 Way Set Associativity

- Improved Store Forwarding
- Higher bus speeds

- Intel SSE4 instructions
- Super Shuffle Engine

- Deep Power Down Technology *
- Enhanced Dynamic Acceleration Technology *

* Mobile only features

New Levels of Energy-Efficient Performance
Enhanced Intel® Core™ Microarchitecture – Details Covered In These IDF Sessions

- **TCHS001** [Tuesday, 2pm, Room 2001-2003]
  *Buckle Up: It is Penryn inside* **Speakers:** Steve Pawlowski & Ofri Wechsler
  - in depth on Penryn and high-level view of Nehalem next gen microarchitecture

- **IPTC001** [Tuesday, 5:10pm, CT-1]
  *45nm Next-Generation Intel® Core™ Microarchitecture (Penryn) and Intel® SSE4 - Chalk Talk* **Speakers:** Stephen Fischer, Kiefer Kuah, Karthik Krishnan

- **IPTS001** [Tuesday, 3pm, Room 2001-2003]
  *Technical Overview of the 45nm Next-Generation Intel® Core™ Microarchitecture (Penryn)* **Speaker:** Stephen Fischer

- **IPTS002** [Tuesday, 5:10pm, Room 2001]
  *Tuning for Intel® SSE4 on the 45nm Next-Generation Intel® Core™ Microarchitecture (Penryn)* **Speakers:** Karthik Krishnan & Jeremy Saldate

- There are more tracks & sessions focused on High Performance Computing, Workstations, Server, and Desktop segment platforms
Sustained Leadership

New product architecture

New process generation

TICK Pentium® D, Xeon®, Core™ processor

TOCK Core 2 processor, Xeon processor

TICK PENRYN Family

TOCK NEHALEM

TICK WESTMERE

TOCK SANDY BRIDGE

2 YEARS process life

65nm

2 YEARS process life

45nm

2 YEARS process life

32nm

TICK

TOCK
Intel® Notebook / Desktop Roadmap

4Q’07 □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ □ Future

**Desktop Extreme segment processors**

**Desktop Performance / Mainstream segment processors**

**Mobile Extreme segment processors**

**Mobile Performance / Mainstream segment processors**

**45nm Desktop Intel® Core™2 Extreme processors** *(Intel shipments and OEM availability in 4Q’07)*

- Intel® X38, P35 Express & OEM Chipsets
- Future Chipset

**45nm Desktop Intel® Core™2 Quad, Duo processors** *(Intel shipments in 4Q’07, OEM availability in 1Q’08)*

- Intel® 3 Series & OEM Chipsets
- Future Chipset

**45nm Mobile Intel® Core™2 Extreme processors** *(Intel shipments in 4Q’07, OEM availability in 1Q’08)*

- Intel® & OEM Chipsets
- Future Chipset

**45nm Mobile Intel® Core™2 Duo processors** *(Intel shipments in 4Q’07, OEM availability in 1Q’08)*

- Intel® & OEM Chipsets
- Future Chipset

**45nm Intel® Silverthorne processors** *(available beginning in 1H’08)*

Intel®
Intel® Xeon® Enterprise Roadmap

4Q’07  ●  Future

Intel® Xeon® MP 7000 Sequence (Expandable)
- Intel® Xeon® 7300 Series (65 nm)
- Intel® 7300 Chipset & OEM

Future Platform
- Nehalem Processors
- Future Chipset

Intel® Xeon® DP 5000 Sequence (Efficient Performance)
- Xeon® 5100
- Xeon® 5300 (65 nm)
- 45nm Quad- & Dual- Intel® Xeon® Processor
- Intel® 5000 P/V Chipsets

Future Platform
- Nehalem Processors
- Future Chipset

Intel® Xeon® DP 5000 Sequence (Workstation & HPC)
- 45nm Quad- & Dual- Intel® Xeon® Processor
- Intel® 5400 Chipsets

Future Platform
- Nehalem Processors
- Future Chipset

Intel® Xeon® UP 3000 Sequence (Entry)
- Xeon® 3200
- Xeon® 3000 (65 nm)
- 45nm Quad- & Dual- Intel® Xeon® Processor
- Intel® 3000 P/V Chipsets

Future Platform
- Nehalem Processors
- Future Chipset

45nm Intel® processors ramp first in Enterprise
Intel® Penryn Family

**Server**

**Intel Xeon® processor families**
- *Quad-Core Harpertown*
  - 12 MB Cache
  - 120W, 80W, 50W
  - Available: 4Q’07
- *Dual-Core Wolfdale-DP*
  - 6 MB Cache
  - 80W, 65W, 40W
  - Available: 4Q’07
- *Dunnington*
  - Socket compatible with Intel Xeon 7300 series
  - Available: 2H’08

**Desktop**

**Intel Core™ 2 Extreme & Intel Core 2 Quad Processors** (*Yorkfield*)
- Quad Core
  - Up to 12MB Cache
  - 95W (MS)
  - 130W (XE)
  - Available:
    - 4Q’07 = Extreme
    - 1Q’08 = Mainstream

**Intel Core 2 Duo Processors** (*Wolfdale*)
- Dual Core
  - Up to 6MB Cache
  - 65W
  - Available: 1Q’08

**Mobile**

**Intel Core 2 Extreme & Intel Core 2 Duo Processors** (*Penryn*)
- Next evolution of dual-core power efficiency
- Up to 6MB L2 Cache
- Variety of wattages
- Available: 1Q’08

Shipping 45nm Products in All Segments 4Q’07
Energy Efficient Enterprise Platforms

Blackford MCH

Configurable set of PCIe Gen1 ports

ESB2 I/O Bridge

Seaburg MCH

Dual 1600 MT/s Point to Point Bus

Configurable PCIe ports up to Dual x16 Gen2 (gfx)

Zoar

Dual x16 Gen2 (gfx)

SAS/SATA platform only

Bridge

Bensley Platform

Server Platform

Stoakley Platform

Workstation and HPC Platform

† 1600 MT/s limited to Stoakley platform only

* not all features are supported on all SKUs
45nm Hi-k Intel® Xeon® Quad-Core Processor Performance Comparisons

Extending Server Performance Leadership

- Quad-Core Intel Xeon X5365 3.0GHz
- SPECint® rate 2006: 1
- SPECint® 2006: 1.19*

- Quad-Core Intel Xeon 5400 Series 3.16GHz
- SPECint® 2006: 1.25

- Quad-Core Intel Xeon 5400 Series 3.16GHz

Workstation Multitasking Enhancements

- Quad-Core Intel Xeon X5365 3.0GHz
- SPECapc* solidWorks® 2005 and Fluent® 6.3.26 L1/L2, 5x concurrently: 1.23

- Quad-Core Intel Xeon 5400 Series 3.20GHz

Leadership on Bandwidth Intensive Applications

- Quad-Core Intel Xeon X5365 3.0GHz / 1333 FSB
- SPECfp®_rate2006: 66.9

- Quad-Core AMD Opteron 2360 2.5GHz
- SPECfp®_rate2006: 86.3

- Quad-Core Intel Xeon 5400 Series 3.20GHz / 1600 FSB
- SPECfp®_rate2006: 89.8*

Extending Performance Leadership!
Paradigm Benchmark\textsuperscript{1} with Intel\textregistered Xeon\textregistered Processors

Relative Jobs/Day

Up to 1.96X Faster!

Dual Core

Intel\textsuperscript{®} Xeon\textsuperscript{®}
5160 3.0 GHz

Quad Core

45nm Hi-k Intel\textsuperscript{®} Xeon\textsuperscript{®}
5400 3.0 GHz

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DATA SOURCE: Intel\textregistered Corporation Internal Measurement results as of September 1, 2007. See back up for configuration details.

Relative performance for each benchmark is calculated by taking the actual benchmark result for the first platform tested and assigning it a value of 1.0 as a baseline. Relative performance for the remaining platforms tested was calculated by 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® Core™2 Extreme QX9650**  
Next Gen 45nm Quad-Core

- **Quad-Core:**  
  4 cores / 4 threads

- **3.0 GHz Core Frequency**  
  *(initial offering)*

- **Larger 12MB L2 Cache**

- **Enhanced Intel® Core™ Microarchitecture**
  - 45nm process technology:  
    - Higher Performance at same TDP

- **Technologies*:**  
  - Intel® 64  
  - Enhanced Intel SpeedStep® Tech  
  - Execute Disable Bit  
  - Intel® Virtualization Tech

- **1333 MHz FSB**

- **LGA 775 socket**

- **FMB: 130W**

- **Supported by the Intel® X38 and P35 Express Chipsets**

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1 WARNING: altering clock frequency and/or voltage may (i) reduce system stability and useful life of the system and processor; (ii) cause the processor and other system components to fail; (iii) cause reductions in system performance; (iv) cause additional damage; and (v) affect system data integrity. Intel has not tested, and does not warranty, the operation of the processor beyond its specifications.*

*Certain features may be available only on particular SKUs.
Intel® X38 Express Chipset

**Performance**
- PCI Express 2.0 Dual x16
- DDR3 1333
- Intel® Fast Memory Access
- Intel® Turbo Memory†

**Technology**
- Support for existing 65nm & new 45nm Intel® Core™2 Extreme processors as well as mainstream Intel Core 2 Quad, Duo processors
- Greater performance in the same power envelope

**Tuning**
- Intel® Extreme Memory
- Intel® Extreme Tuning Utility
- Flexible (unlocked) bus ratios

The Intel® X38 Express Chipset has been shipping for some time & will be broadly available from OEMs soon

QX9650 + X38 Express Extends Existing Performance Leadership

† Some features may not be available at launch.
Microarchitecture improvements combined with a 12MB L2 cache and SSE4 improve upon Intel® Core™2 processor performance even at the same clock speed.

Source: Intel. Configuration: Intel® Core™2 Extreme QX6850 (8MB L2, 3.0 GHz, 1333MHz FSB) and Pre-Production 45nm Intel Core™2 Processor (12MB L2, 3.0 GHz, 1333MHz FSB) on Intel DX38BT board, Intel Chipset INF 08.30.1013, 2x1GB Dual Channel Corsair* DDR3-1333 9-9-9-24, Seagate* 320GB Barracuda* NCQ Serial ATA 7200 RPM, Windows® Vista* Ultimate 32bit. Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance. Buyers should consult other sources of information to evaluate the performance of systems or components they are considering purchasing. For more information on performance tests and on the performance of Intel products, visit http://www.intel.com/performance/
**Intel® Server Board X38ML**

- X38 Express chipset, 1333 FSB
- Single PCI-Express Gen 2 x16 connector
- Up to 4 DIMMs (8GB)
- DDR2 667/800 memory w/ ECC
- Integrated 4 port SATA
- 3.0Gb/s with RAID 0,1,10
- Integrated Dual Gigabit Ethernet (Zoar)

**Intel® Server System SR1520ML**

shown with included heat sinks, PCI-E x16 risers, 2.5” drive carriers
“45nm Tock”—Nehalem

### Dynamic Scalability for Efficient Performance on Demand

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Unlocks</td>
<td>Leverages 4 Issue Intel® Core™ Micro-architecture Technology</td>
</tr>
<tr>
<td>Intel 45 nm High-k Silicon Benefits</td>
<td>Dynamically Managed Cores/Threads/Caches</td>
</tr>
<tr>
<td>Design Scalability Optimizes for Each Market Segment</td>
<td>Simultaneous Multi-threading</td>
</tr>
<tr>
<td>Performance Enhanced Dynamic Power Management</td>
<td>Multi-level Shared Cache Architecture</td>
</tr>
</tbody>
</table>

### Design Scalability Optimizes for Each Market Segment

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>New System Architecture</td>
<td>Scalable &amp; Configurable Cache, Interconnects &amp; Memory Controllers</td>
</tr>
<tr>
<td>Includes QuickPath Architecture</td>
<td>Optional High Performance Integrated Graphics For Client</td>
</tr>
<tr>
<td>Initial Products in Production in ‘08</td>
<td>Scalable Performance: 1 to 16+ Threads &amp; 1 to 8+ Cores</td>
</tr>
</tbody>
</table>

All product information and dates are preliminary and subject to change without notice.
Nehalem Based System Architecture

- 2, 4, 8 Cores, 4, 8, 16 Threads
- Intel® QuickPath Architecture
- Buffered or Unbuffered Memory
- Optional Integrated Graphics
- Integrated Memory Controller
Nehalem Based 4S System Architecture

Nehalem

I/O Hub

PCI Express*

Intel QuickPath Interconnect

Intel
Summary

• New generation 45nm process technology enhanced Intel® Core™ Microarchitecture shipping in 4Q’07 across all segments

• New Stoakley DP server segment platform & 45nm processors provide boost for High Performance Computing

• New Intel® X38 Express chipset based platform with new 45nm quad-core Intel® Core™2 Extreme processor hits new heights of performance in the same power envelope

• 45nm Hi-k advances allow Intel to address multiple diverse segments from low power IA Silverthorne to Nehalem

Customers benefit from Intel leadership in manufacturing, micro-architecture, and product development
Thank You
45nm Hi-k Intel® Xeon® Quad-Core Processor
Performance and Energy Efficiency Comparisons configuration details

- Extending Server Performance Leadership
  - SPECint_rate2006
  - Quad-Core Intel Xeon processor X5365 based platform details: Supermicro® X7DB8 with two Quad-Core Intel Xeon processors X5365 3.0GHz, 16 GB memory (8x2GB), 1333 FSB, O/S 64-Bit SUSE Linux Enterprise Server 10, Kernel 2.6.16.21-0.8-smp for x86_64, Intel C++ Compiler for Linux version 10.1 & Smart Heap Library Version 8.1. Published at www.spec.org as of September 4th 2007.
  - 45nm Hi-k Intel Xeon Quad-Core processor 3.16Ghz based platform details: Intel pre-production platform with two 45nm Hi-k Intel Xeon Quad-Core processors 3.16GHz, 1333 FSB, 16 GB memory (8x2GB), O/S 64-Bit SUSE Linux Enterprise Server 10, Kernel 2.6.16.21-0.8-smp for x86_64, Intel C++ Compiler for Linux version 10.1 & Smart Heap Library Version 8.1.
  - Java (Server side Java* benchmark)
    - Quad-Core Intel Xeon processor X5365 based platform details: Intel pre-production platform with two Quad-Core Intel Xeon processors X5365 3.0GHz, 16 GB memory (8x2GB), 1333 FSB, Microsoft Windows Server* 2003 Enterprise x64 Edition + SP1 (64-bit), BEA* JRockit* 5.0 P27.2.0. Result measured with 4 JVM instances.
    - 45nm Hi-k Intel Xeon Quad-Core processor 3.16Ghz based platform details: Intel pre-production platform with two 45nm Hi-k Intel Xeon Quad-Core processors 3.16GHz, 16 GB memory (8x2GB), 1333 FSB, Microsoft Windows Server* 2003 Enterprise x64 Edition + SP1 (64-bit), BEA* JRockit* 5.0 P27.2.0. Result measured with 4 JVM instances.

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45nm Hi-k Intel® Xeon® Quad-Core Processor
Performance and Energy Efficiency Comparisons configuration details

- Leadership on Bandwidth Intensive Application
  - SPECfp_rate2006
  - Quad-Core AMD Opteron 2350 based platform details: Result published at [www.amd.com](http://www.amd.com/us-en/Processors/ProductInformation/0,30,118,8726,8800,~T19102.00.html). x Quad-Core AMD Opteron™ processors Model 2360 SE in Supermicro H8DMU+ motherboard, 16GB (8x2GB DDR2-667 memory), 250GB Seagate SATA disk drive, SuSE Linux Enterprise Server 10 SP1 64-bit kernel as of Sept 13, 2007. Result published at 86.3.
  - Quad-Core Intel Xeon processor X5365 based platform details: Supermicro* X7DB8 with two Quad-Core Intel Xeon processors X5365 3.0GHz, 16 GB memory (8x2GB), 1333 FSB, O/S 64-Bit SUSE Linux Enterprise Server 10, Kernel 2.6.16.21-0.8-smp for x86_64, Intel C++ Compiler for Linux version 10.1 & Smart Heap Library Version 8.1. Published at [www.spec.org](http://www.spec.org) as of September 4th 2007 at 66.9.
  - 45nm Hi-k Intel Xeon Quad-Core processor 3.20Ghz based platform details: Intel pre-production platform with two 45nm Hi-k Intel Xeon Quad-Core processors 3.20GHz, 1600 FSB, 16 GB memory (8x2GB), O/S 64-Bit SUSE Linux Enterprise Server 10, Kernel 2.6.16.21-0.8-smp for x86_64, Intel C++ Compiler for Linux version 10.1 & Smart Heap Library Version 8.1. Result measured at 89.8.

- Workstation Multi-Tasking Enhancements - Manufacturing “Working Differently” scenario SPECapc* SolidWorks* 2005 and Fluent* 6.3.26 L1/L2 workloads running 5x concurrently
  - 2x Quad-Core Intel® Xeon® Processor 5400-series (3.20 GHz, 1600 MHz FSB, 12 MB cache, formerly “Harpertown”) on “SunCity Stoakley” pre-production workstation compared to 2x Quad-Core Intel Xeon Processor X5365 (3.00 GHz, 1333 MHz FSB, 8 MB cache) on SuperMicro* X7DA8 workstation, COMMON: 8 GB FBD-667 memory, WDC WD740GD HDD, Windows XP* Professional x64 SP1, NVIDIA* Quadro* FX 4500 PCIe* x16 video card driver 91.36.

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## Processor Microarchitecture Comparison

<table>
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<tr>
<th></th>
<th>65nm Intel® Core™ Microarchitecture</th>
<th>45nm Hi-k Penryn</th>
<th>AMD K8</th>
<th>Barcelona</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Date</strong></td>
<td>1H 2006</td>
<td>2H 2007</td>
<td>2003</td>
<td>2H 2007</td>
</tr>
<tr>
<td><strong>Clock Frequency</strong></td>
<td>3GHz</td>
<td>Up to &gt;3GHz Demo’d 3.33GHz</td>
<td>3GHz</td>
<td>&gt;2Ghz Demo’d ?</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Intel 65nm</td>
<td>Intel 45nm Hi-K+Metal Gate</td>
<td>90nm/65nm</td>
<td>65nm</td>
</tr>
<tr>
<td><strong>Cache</strong></td>
<td>Shared L2 Higher BW 256bit data width</td>
<td>24 way Shared L2 Higher BW 256bit data width</td>
<td>Dedicated L2 64 bit data width</td>
<td>Shared L3 128 bit data width</td>
</tr>
<tr>
<td><strong>Total L2/L3 Cache</strong></td>
<td>Up to 8MB</td>
<td>Up to 12MB</td>
<td>Up to 2MB</td>
<td>Up to 4MB</td>
</tr>
<tr>
<td><strong>Issue Width</strong></td>
<td>4 Issue</td>
<td>4 Issue</td>
<td>3 Issue</td>
<td>3 Issue</td>
</tr>
<tr>
<td><strong>Pipeline Efficiency</strong></td>
<td>14 Stage Speculative OOO Loads/Stores Macro &amp; Micro Fusion</td>
<td>14 Stage Speculative OOO Load/Store Macro &amp; Micro Fusion</td>
<td>12 Stage No load/store re-ordering</td>
<td>12 Stage No load/store re-ordering</td>
</tr>
<tr>
<td><strong>System Bus</strong></td>
<td>Up to 1333 MHz</td>
<td>Up to 1600 MHz</td>
<td>1000 MHz</td>
<td>1000MHz</td>
</tr>
<tr>
<td><strong>SSE</strong></td>
<td>Intel SSSE3 ISA 128 Bits/Cycle</td>
<td>Intel SSE4 ISA 128 Bits/Cycle</td>
<td>SSE3 (Equiv) 64Bits/Cycle</td>
<td>SSE3 (Equiv) 128Bits/Cycle</td>
</tr>
</tbody>
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