40 YEARS OF CHANGING THE WORLD
Intel Developer FORUM
Invent the new reality.

From Peta FLOPS to Milli Watts

Patrick P. Gelsinger
Sr. Vice President
Co-General Manager
Digital Enterprise Group
Intel Architecture

Moore’s Law

“The number of transistors per sq. in of IC doubles about every year.” circa 1965
Dr. Andy Grove

“Software spiral is the dynamics of this industry where software evolves to take advantage of the hardware capabilities and hardware rises to the occasion, and this cycle repeats”
Intel Architecture

Metcalfe's Law
“The systemic value of compatibly communicating devices grows as the square of their number”
Reed's Law

“The number of possible sub-groups of network participants is $2^n - n - 1$"
Intel Architecture

Internet

Embedded
MID
Smartphone
Netbook
Server
Desktop PC
Mobile PC
Workstation

Intel Architecture Value

Moore’s Law,
Grove’s SW Spiral,
Metcalfe’s Law,
Reed’s Law

= f
Intel Architecture

Internet

Peta FLOPs

Milli Watts

Compatible and Scalable
Intel: The Architecture for Life

Internet

Compatible and Scalable

Milli Watts

Peta FLOPs

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Intel: The Architecture for Life

Internet

Anand Chandrasekher

Compatible and Scalable

Milli Watts

Peta FLOPs

Intel: The Architecture for Life

Anand Chandrasekher
Intel: The Architecture for Life

Internet

Dadi Perlmutter

Compatible and Scalable

Milli Watts

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Internet

Milli Watts

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Peta FLOPs

Intel Developer FORUM

Invent the new reality.
High Performance Computing

Insatiable Demand for Performance

Weather Prediction
Oil Exploration
Design Simulation
Genomics Research
Financial Analysis
Medical Imaging
HPC Needs Decades of Moore’s Law

Medical Imaging
HPC Needs Decades of Moore’s Law

Medical Imaging

Genomics Research
HPC Needs Decades of Moore’s Law

- Weather Prediction
- Medical Imaging
- Genomics Research

1 ZFlops
100 EFlops
10 EFlops
1 EFlop
100 PFlops
10 PFlops
1 PFlop
100 TFlops
10 TFlops
1 TFlop
100 GFlops
10 GFlops
1 GFlop
100 MFlops
100 MFlop

Intel’s Commitment to HPC

- Reference Platform
- Software Tools and Libraries
- HPC Division
- Developer Relations
- Research
- Silicon
- Boards and Systems
- Storage

Intel Based Supercomputers Powering Research Breakthroughs
Leading HPC Deployments

New Mexico Computing Applications Center
126.9 T FLOPs
R&D Projects, Weather Research

*Source: www.top500.org
Leading HPC Deployments

Tata CRL- EKA Supercomputer
India
117.9 T FLOPs
Govt Scientific R&D, WW Services

*Source: www.top500.org
Leading HPC Deployments

National Defence Radio Establishment
Sweden
102.8 T FLOPs

*Source: www.top500.org
Leading HPC Deployments in 2007

Intel Supplied About 4 Out of 5 CPUs into HPC
354 Systems of Top 500* Built on IA

*Source: www.top500.org
IA in PRC's Top 10 HPC Systems*

4. China Meteorological Administration, National Satellite Meteorological Center
5. Gaming Company B Shanghai 1
6. Gaming Company B Chengdu
7. Gaming Company B Shanghai 2
8. Gaming Company B Shanghai 3
9. Gaming Company B Beijing
10. Game Company B Xi’an

*Source: http://www.samss.org.cn
IA in PRC’s Top 10 HPC Systems*

1. SINOPEC
4. China Meteorological Administration, National Satellite Meteorological Center
5. Gaming Company B Shanghai 1
6. Gaming Company B Chengdu
7. Gaming Company B Shanghai 2
8. Gaming Company B Shanghai 3
9. Gaming Company B Beijing
10. Game Company B Xi’an

*Source: http://www.samss.org.cn
Sinopec
IA Powers Next Generation Petroleum Exploration

• SINOPEC Shengli Geophysical Institute
• 4X Improvement of Seismic Processing
Li Jun

President
Dawning Information Industry Co., Ltd
Chairman
High Performance Computing Standard Committee
Tukwila for the World’s Most Demanding Computers

- Quad-core with 30 MB cache
- 2 billion transistors
- Multi-threading technology
- Intel QuickPath interconnect
- Dual integrated memory controllers
- Estimate >2X* performance
- Mainframe-class RAS

“HP has already successfully booted four key operating systems (Linux, Windows, HP-UX and OpenVMS) on our Tukwila-based Integrity servers…and have found the initial silicon to be robust and of high quality.”

—Martin Fink, Senior VP & GM, Business Critical Systems, HP

*Compared to Dual-core Itanium® Processor 9100 series
Intel: The Architecture for Life

Internet

Server

Peta FLOPs

Compatible and Scalable

Milli Watts

Intel: The Architecture for Life

Invent the new reality.
Dunnington with 6 Cores

- 45nm high-k technology
- 1.9B transistors
- 16 MB L3 cache
- Caneland socket compatible
- Latest Intel virtualization technologies
- 2H’08

Caneland Gets Better with Dunnington
Enterprise Need for Virtualization

Virtualization 1.0
- Test and Development
- Consolidation

Virtualization 2.0
- Availability & Continuity
- Dynamic Data Center
- Fault Tolerance
- Test and Development
- Consolidation
Intel® Virtualization Technology Evolution

Hardware Enhanced VMMs
- Intel® VT-x and VT-i

2005

Enhanced Stability and Reliability
- Intel® VT for Directed I/O

2007 and Beyond

Enabling New Usage Models
- Intel® VT FlexMigration

Performance Acceleration
- Intel® VT for Connectivity
- Intel® VT FlexPriority
New Hardware Compatibility Problem

Virtual Infrastructure
New Hardware Compatibility Solution

Virtual Infrastructure

Intel® Virtualization Technology FlexMigration
New Hardware Compatibility Solution

Virtual Infrastructure

- 65nm DP Woodcrest (2 Core)
- 45nm DP Harpertown (4 Core)
- 65nm MP Tigerton (4 Core)
- 45nm MP Dunnington (6 Core)

Intel® Virtualization Technology FlexMigration
Quad-Core Intel® Xeon® Processor 5400

Virtualization
Energy Efficiency
Performance

*Other names and brands may be claimed as the property of others
Delivering Performance and Energy Efficiency...
On the Field, Behind the Scenes.

*Other names and brands may be claimed as the property of others.*
Honglin Zhang
Deputy Chief Director
Ministry of Railways - IT Center
China - Ministry of Railways

2007

- 80,000 KM of track
- 5,000+ stations
- 1.4B passengers
- 3.1B tons of goods

2020

- 120,000 KM track
- 1,200 KM High-speed railway
China Railways: End to End IA Solutions

Mission Critical Train Dispatch
Reliable Monitoring and Operation Control
Cost-effective Services at Stations
Flexible Emergency Response
China Railways: End to End IA Solutions

- Mission Critical Train Dispatch
- Reliable Monitoring and Operation Control
- Cost-effective Services at Stations
- Flexible Emergency Response
Intel: The Architecture for Life

Internet

Energy Efficiency

IA Compatible and Scalable

Milli Watts
Peta FLOPs

Intel: The Architecture for Life

Energy Efficiency

Intel Developer FORUM

Intel: The Architecture for Life
Intel’s Approach to Eco-Technology

- Processor
- Platform
- Rack and Data Center

Industry Leadership

Comprehensive Focus on Energy Efficiency

*Other names and brands may be claimed as the property of others
Impact by 2010

- Improve computing platform energy efficiency by 50% - Save an estimated $5.5 billion in energy costs
- Reduce CO₂ emissions by 54M tons/year. Equivalent to:
  - Removal of 11 million autos
  - Eliminating 20 coal plants from the planet
  - Planting 25,000 sq. miles (~65,000 km²) of trees
Eco-Technology

Liu Rulin

Vice President & Secretary General
China Institute of Electronics

Co-Chair
China Electronics Energy Saving Council
Founding Members of CEESC

*Other names and brands may be claimed as the property of others
CEESC and Climate Savers

- Reached the agreement of cooperation with CSCl
- Bridge together the efforts on saving energy and reducing greenhouse gas emissions
Energy Efficiency: SPECpower*

- Measures server power and performance
  - SPECpower_ssj2008*
- Complete dynamic range across eleven load levels

First Industry Standard Energy Efficiency Benchmark

*Other names and brands may be claimed as the property of others
# Top SPECpower* Results

<table>
<thead>
<tr>
<th>Rank</th>
<th>Sponsor</th>
<th>SPECpower_ssj2008 overall ssj_ops/watt</th>
<th>Platform</th>
<th>Processors (Two Socket)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>IBM</td>
<td>854</td>
<td>X3450</td>
<td>2x Intel®® Xeon®® E5462</td>
</tr>
<tr>
<td>3</td>
<td>HP</td>
<td>778</td>
<td>DL180 G5</td>
<td>2x Intel®® Xeon®® E5450</td>
</tr>
<tr>
<td>4</td>
<td>Dell</td>
<td>719</td>
<td>PE 2950 III</td>
<td>2x Intel®® Xeon®® E5440</td>
</tr>
<tr>
<td>5</td>
<td>Dell</td>
<td>712</td>
<td>PE 1950 III</td>
<td>2x Intel®® Xeon®® E5440</td>
</tr>
<tr>
<td>6</td>
<td>HP</td>
<td>698</td>
<td>DL160 G5</td>
<td>2x Intel®® Xeon®® E5450</td>
</tr>
<tr>
<td>7</td>
<td>FSC</td>
<td>690</td>
<td>RX300 S4</td>
<td>2x Intel®® Xeon®® E5440</td>
</tr>
<tr>
<td>8</td>
<td>Dell</td>
<td>682</td>
<td>PE 2950 III</td>
<td>2x Intel®® Xeon®® E5440</td>
</tr>
<tr>
<td>9</td>
<td>HP</td>
<td>662</td>
<td>DL360 G5</td>
<td>2x Intel®® Xeon®® E5450</td>
</tr>
<tr>
<td>10</td>
<td>Intel</td>
<td>468</td>
<td>6025B-TR+</td>
<td>2x Intel®® Xeon®® L5335</td>
</tr>
</tbody>
</table>

Public SPECpower results from http://www.spec.org/power_ssj2008/results/power_ssj2008.html as of March 27, 2008

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<tr>
<td>1</td>
<td>Inspur</td>
<td>910</td>
<td>NF290D2</td>
<td>2x Intel®® Xeon®® L5420</td>
</tr>
<tr>
<td>2</td>
<td>IBM</td>
<td></td>
<td></td>
<td>2x Intel®® Xeon®® E5462</td>
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<td></td>
<td></td>
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<td>Intel</td>
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</tbody>
</table>

"SPECpower is an important industry benchmark to reflect performance-per-watt and I am very pleased today that Inspur has achieved the #1 result for dual processor systems worldwide."

Wang Endong
President
Inspur Beijing Information Corp


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Intel’s Tick Tock Development Model

- **2005-06**:
  - **TICK**: Intel® Pentium® D, Xeon® processors
  - **TOCK**: Intel® Core™2, Xeon® processors
  - **65nm**

- **2007-08**:
  - **TICK**: PENRYN processors
  - **TOCK**: NEHALEM processors
  - **45nm**

- **2009-10**:
  - **TICK**: WESTMERE processors
  - **TOCK**: SANDY BRIDGE processors
  - **32nm**

All products, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice.
Nehalem: Innovative New Architecture

2, 4 or 8 Cores
Integrated Memory Controller
QuickPath Interconnect
2-way Simultaneous Multi-threading
Microarchitecture Enhancements
Dynamic Power Management
SSE 4.2
Q4’08 Production
ISA Innovation Continues...

**SSE4.2**
Efficient Accelerated String and Text Processing
- Implemented in Nehalem
- 256 compares in one instruction
- Financial Market Data Parser
  - 75% reduction in instructions
  - >3x performance increase

**AES-NI**
Instructions To Accelerate AES Encryption And Decryption
- Implemented in Westmere
- >3x performance improvement
  - Enables broad use of AES
  - Improves security
  - Simplifies software
**Sandy Bridge: Intel® Advanced Vector Extensions**  
256-bit Vector Extension to SSE for FP Intensive Applications

<table>
<thead>
<tr>
<th>New Instructions</th>
<th>Benefits</th>
</tr>
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<tbody>
<tr>
<td><strong>Wider Vectors</strong></td>
<td>Up to 2x Peak FLOPs Output</td>
</tr>
<tr>
<td>Increased from 128 bit to 256 bit</td>
<td></td>
</tr>
<tr>
<td><strong>Enhanced Data Rearrangement</strong></td>
<td>Efficient Data Access</td>
</tr>
<tr>
<td>New 256 bit Primitives for Data Permutes</td>
<td></td>
</tr>
<tr>
<td><strong>Three Operand</strong></td>
<td>Smaller Code Size</td>
</tr>
<tr>
<td><strong>Non Destructive Syntax</strong></td>
<td>Parallel Operations</td>
</tr>
<tr>
<td>Efficient and Extensible</td>
<td></td>
</tr>
</tbody>
</table>
"The Microsoft and Intel UC engagement continues its multi-year history of innovation. Intel processors help enable higher definition video conferencing, better power management, and enhanced security, and we are excited about the additional capabilities that Intel® Advanced Vector Extensions will make possible".

Gurdeep Singh Pall, Unified Communications Group Corporate VP, Microsoft

"Floating point and SIMD processing are important to the performance of Adobe software products," said Hart Shafter, Senior Product Manager for Production Premium at Adobe. "We welcome Intel's ongoing innovation in this space and plan to work with Intel to reap the maximum benefit from the new Intel™ Advanced Vector Extensions".

Microsoft

Adobe

Intel® AVX: Performance, Energy Efficient and Extensible
Intel: The Architecture for Life

Visual Computing

Internet

Milli Watts

IA Compatible and Scalable

Peta FLOPs
Visual Computing: Graphics Re-defined

Traditional Graphics
- Rasterization
- Standard Definition
- Video and Audio
- Inefficient for Computing

Visual Computing
- Photorealistic Rendering
- HD Video and Audio Processing
- Graphics and Model Based Computing
Visual Computing: Graphics Re-defined

Traditional Graphics
- Rasterization
- Standard Definition Video and Audio
- Inefficient for Computing
- Rigid Pipeline Architecture

Visual Computing
- Photorealistic Rendering
- HD Video and Audio Processing
- Graphics and Model Based Computing
- Programmable, Ubiquitous, and Unified Architecture

Looks Real ➔ Acts Real = Feels Real

Photorealistic 3D Rendering

Immersive User Interface

High Definition Audio, Video

Computational Modeling
Visual Computing:
Acquiring, Analyzing, Modeling and Synthesizing Visual Workloads

Photorealistic 3D Rendering
Immersive User Interface
High Definition Audio, Video
Computational Modeling

Programmable, Ubiquitous, and Unified Architecture
Multi-core Helps Ensure Games Act Real

Multi-core based platforms enable high quality vegetation simulation, extremely dynamic game environments, high fidelity animations, realistic AI and more.

“This is the closest thing to a living, breathing world that we’ve seen in a game.”

—GameSpot

*Other names and brands may be claimed as the property of others*
“Multi-threaded processors are enabling ray-tracing to reach new levels of realism, content generation, & quality previously unheard of in our industry.”

—Richard Jones, Vice President of Alias at Autodesk
Processor: Quake Ray-Tracing Vision

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Visual Computing: What Does it Take?

- Multi-threaded High-performance CPU
- High Performance Memory and I/O
- IA Programming, Software Tools, and Support
- Integrated or Discrete Graphics
  - Larrabee: Scalable Many-core IA Architecture
Larrabee Architecture for Visual Computing

- Many IA cores
  - Scalable to TeraFLOPS
- New cache architecture
- Throughput architecture
- New vector instruction set
  - Vector memory operations
  - Conditionals
  - Integer and FP arithmetic
- New vector processing unit / wide SIMD
Intel Software Unleashes Developer Freedom

Industry Leading Intel® Software Tools
Addresses Development and Performance Tuning Needs

Visual Computing Tools & Resources
Extending Intel® Software for Larrabee Architecture
Supports Industry Standard APIs (DirectX* and OpenGL*)

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Intel: The Architecture for Life

Internet

Energy Efficient Performance
Solid Tick-tock Execution

IA Compatible and Scalable

Milli Watts

Peta FLOPs

Intel: The Architecture for Life
Intel: The Architecture for Life
Risk Factors

This 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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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.

Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor series, not across different processor sequences. See http://www.intel.com/products/processor_number for details.

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