# High Performance Computing for Silicon Design


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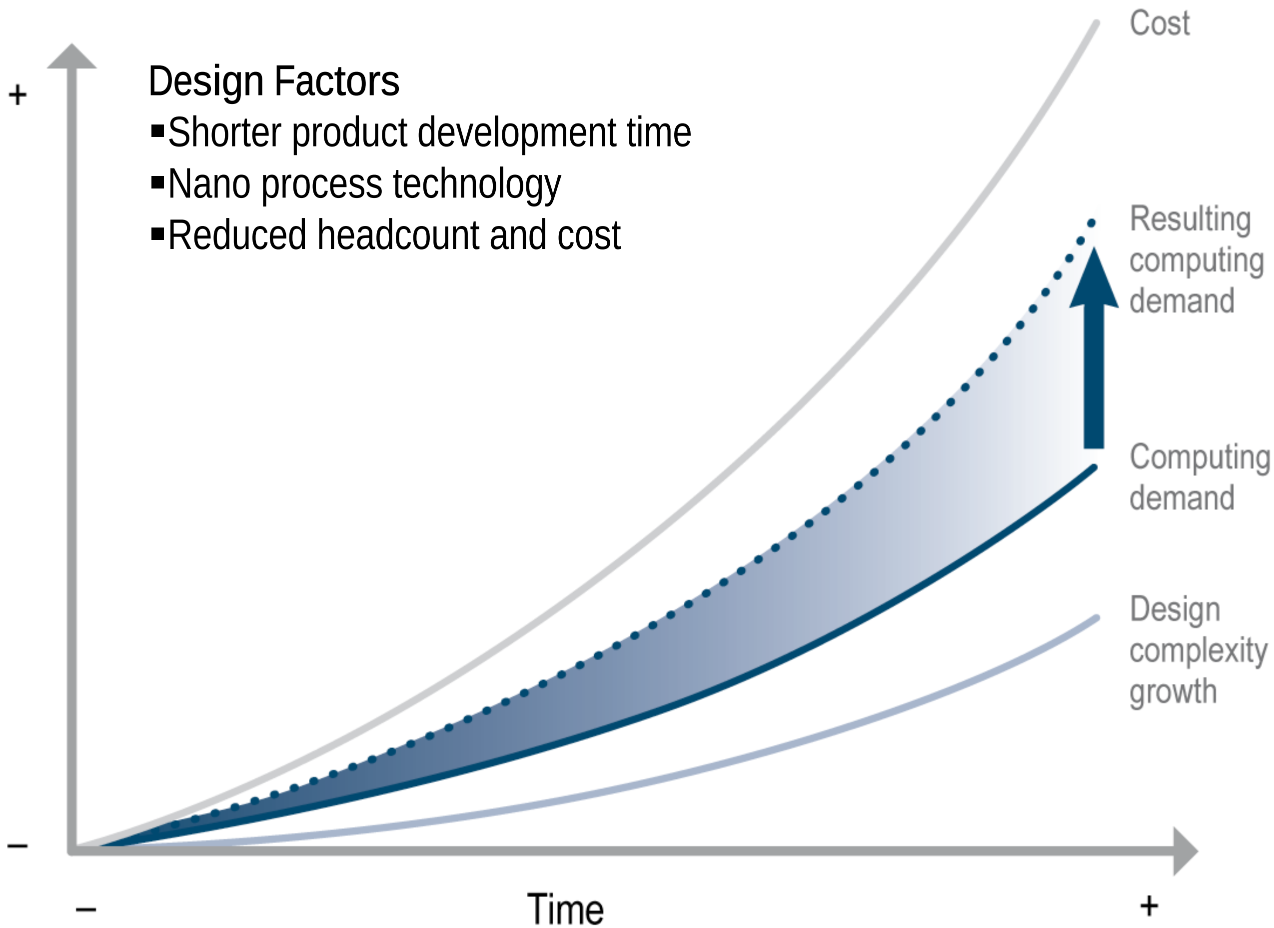
# Intel Computing Environment and Computing Demand

# Design Team Challenges




- Increased pre-silicon verification
- High degree of design automation
- Global design team and collaboration

# Intel Data Center Profile

- Intel has four major groups currently driving individual data center requirements (DOME):
  - (**D**esign) Design Computing: Support the chip design community and they have most of the servers within Intel
  - (**O**ffice) General Purpose: Supporting typical IT and customer services
  - (**M**anufacturing) FAB/ATM: Manufacturing computing supporting fabrication and assembly
  - (**E**nterprise) Enterprise applications supporting eBiz

70% of servers in Intel are in "D"
30% of servers are in "OME"

# Design Computing Env Overview

- Classification by server type in “D” environment
  - 65,000 Servers running Linux
  - 52% Blades (Xeon 2S) – All multi-core servers are at 4GB-8GB per core
  - 42% 1U (Xeon 2S, Few 1S) – Multi-core servers are at 8GB per core
  - 6% Rest (Xeon MP) – 128GB to 1TB per server
- Classification by use model in “D” environment
  - Batch servers (70%)
  - Interactive & large memory batch servers (30%)
- High Performance Mega Data Centers:
  - Each data center has multiple modules design to handle over 500+ watts/SF
  - 6000 sq ft/ per module with ~3MW of useable power
  - ~200 cabinets/racks per module
  - 15-22KW power allocation per rack (48-64 blades per rack)
  - Some data centers support 30KW (Up to 84 blades per rack)

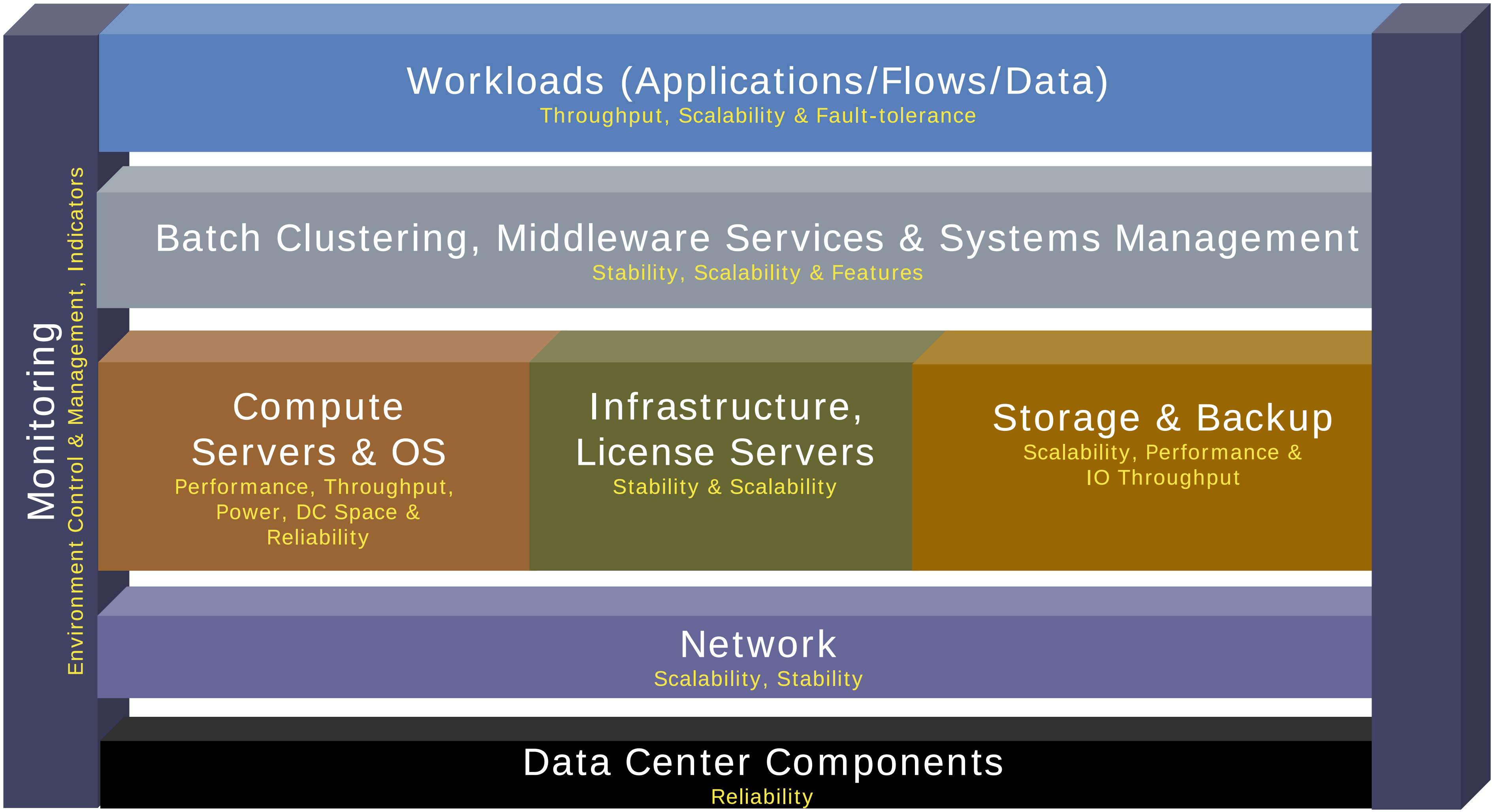
# Compute Demand Drivers inside Intel

- Pre-Silicon Design Computing
  - More than 100,000 simulation jobs per chip design each week for several quarters till tape-in
  - Small, Medium, Large memory workloads
  - Many chip designs in flight at a given time
  - Primarily CPU, and Physical Memory Bound – Lately Storage is of concern

- Tape-out Computing
  - 16,000 Optical Proximity Correction (OPC) jobs for each of the complex silicon layer
  - Small, Large, Very Large memory workloads
  - CPU, Network, and Storage Bound

# Intel HPC Environment

# HPC Solution Stack



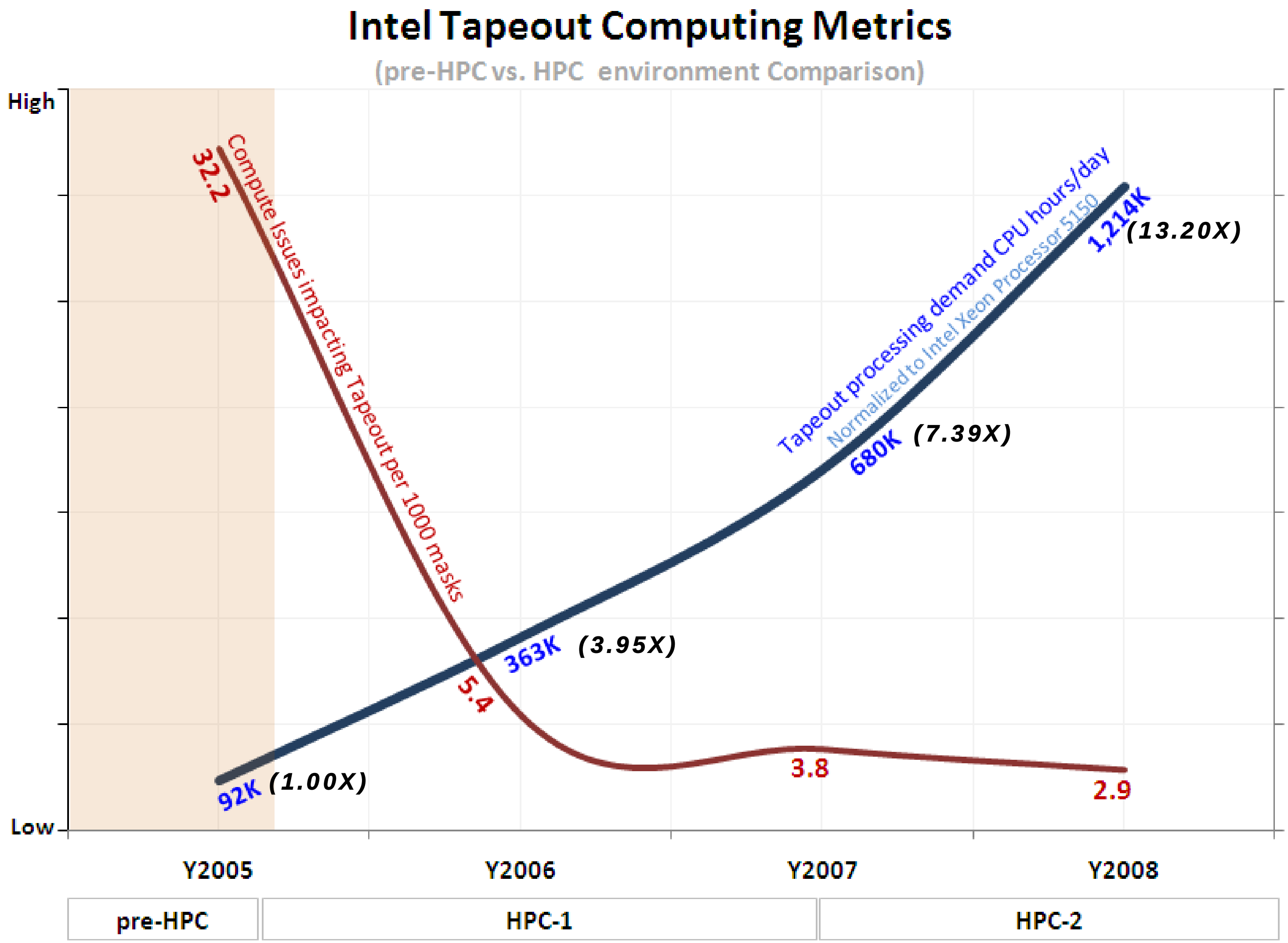
# HPC Capability and Target Use Roadmap

| | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|

| HPC Technology Areas | HPC-1<br>Optimize for 45nm, Support >=65nm | HPC-2<br>Optimize for 32nm, Support >=45nm | HPC-3 Target Additions<br>Optimize for 22nm, Support >=32nm |
|---|---|---|---|
| **Batch Clustering**<br>Stability, Scalability, Features | Systems/Pool: 8.5K (**1.3x**) | 11K (**1.3x**) | 11K (**1x**) |
| | Jobs/Pool: 20K+ (**1.5x**) | 30K+ (**1.5x**) | 60K+ (**2x**) |
| | Scheduling: Preferential | Smart Class | Support for Virtualization |
| **Storage & Backup**<br>Scalability, Performance<br>IO Throughput | IO Spec TP#: 5,120 (**10x**)*<br>HVM IO TP# : 3,200+MBps<br>Volume Size : 3.2TB (**8x**) | 5,120<br>3,500+ MBps (**1.1x**)<br>6.4TB (**2x**) | 14,080 (**2.75x**)<br>5,300+ MBps (**1.5x**)<br>TBD |
| | Single-Stream Perf*:70MBps (**1x**) | 160 MBps (**2.3x**) | 240 MBps (**1.5x**) |
| | HW/SW: Parallel-Storage-Gen1$ | Parallel-Storage-Gen2$ | Parallel-Storage/Open-Standard |
| **Network**<br>Scalability, Stability | Storage: 40Gbps (**10x**) | 40Gbps (**1x**) | 11x1x10Gbps (**2.75x**) |
| | Master: 1Gbps (**10x**) | 2x1Gbps (**1x**, **Redundancy**) | 10Gbps (**5x**) |
| | Slave: 100Mbps (**1x**) | 100Mbps (**1x**) | 100Mbps/1Gbps (**1x/10x**) |
| **Compute**<br>Optimized for Perf, Throughput, Capacity<br>Power & DC Space | Large RAM: **512GB** (**4x**) (Based on Intel Architecture)<br>Perf. TP#: 1.6-5x | **1TB** (**2x**) (Based on Intel Architecture)<br>1.7x | TBD |
| | Batch Node: 2S/**Dual**-Core/16GB<br>Perf. TP: **2.1x** *(With Intel® Xeon® Processor 5150)* | 2S/**Quad**-Core/32GB<br>**2.3x** *(With Intel® Xeon® Processor E5450)* | 2S/**Quad**-Core/48GB<br>**1.74x** *(With Intel® Xeon® Processor X5570 – No HT)* |
| **OS**<br>New HW Feature Support, Scalability, Stability, Perf. | Enterprise Feature: **Stable,**<br>Inter-System **NUMA** Support | **Multi-Core** Optimized | **Virtualization** Optimized |
| **License Servers**<br>Stability, Scalability | Platform: IA Based (**3x** over RISC) | Latest IA based solution | Latest IA based solution |
| **Apps Tuning**<br>Throughput | Tuning: CPU Prefetch (**1.2x**)<br>Enablement: **512GB Support** | SSE4 | Hyper-Threading |

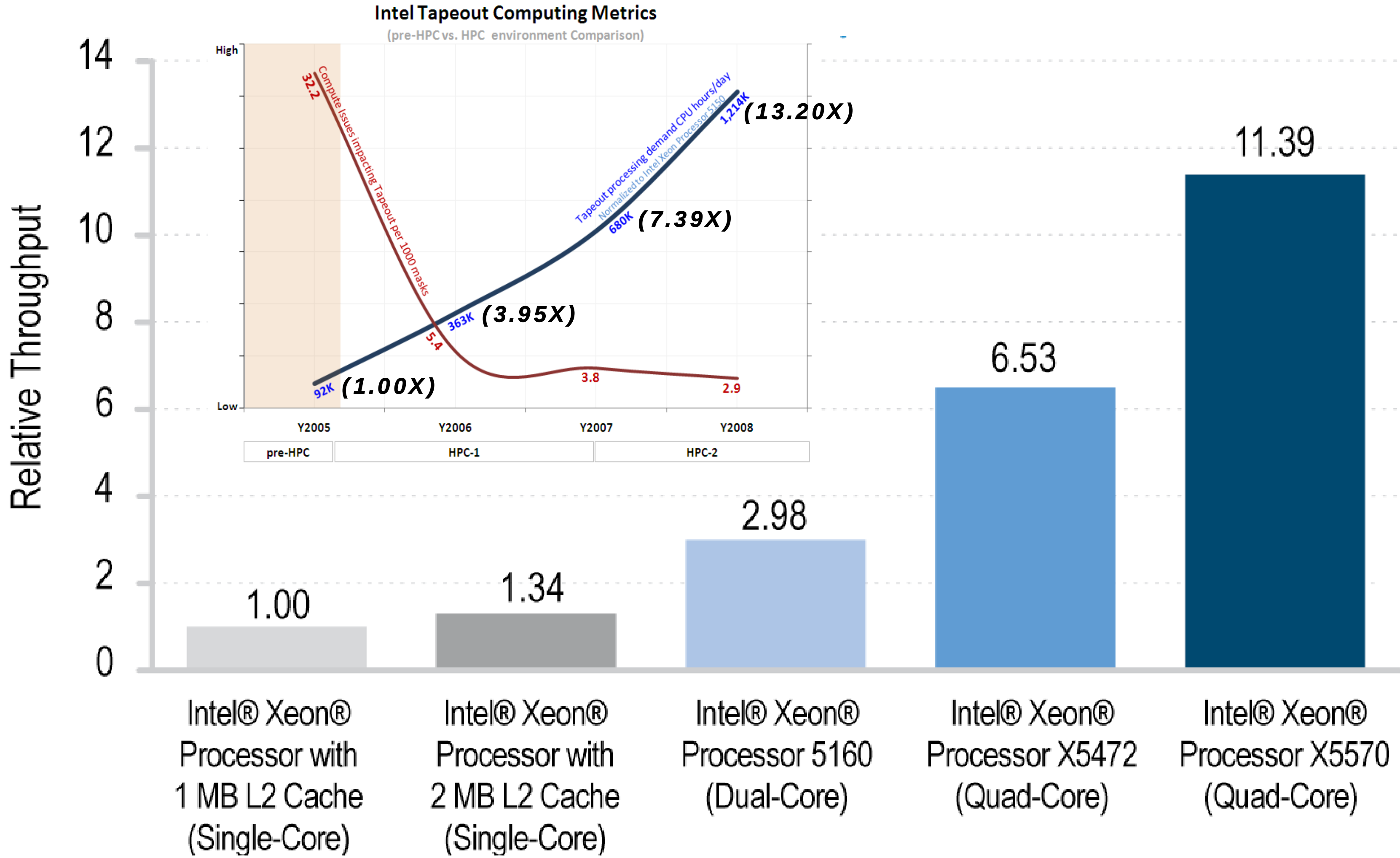
(10x)* = 10x Spec Limit improvement over prior gen. solution (5120 MBps vs. 512MBps);
"Single-Stream Performance" is relevant for Backup & Vol. size; $ Proprietary Software
# TP – Throughput; HWA – Hardware Acceleration

# HPC Demand & Benefits for Intel Tapeout



# EDA Performance Improvement with Intel® Xeon® Processor Generations

# Intel® Architecture Performance Improvement for OPC




Intel internal measurements May 2007, November 2007, and February 2009.

# Runtime Performance for OPC Application

| Processor | OPC Jobs§ | Runtime (HH:MM:SS) | Relative Throughput |
|---|---|---|---|
| 64-bit Intel® Xeon® Processor with 1 MB L2 Cache (3.6 GHz) | 2 | 10:40:12 | 1.00 |
| 64-bit Intel® Xeon® Processor with 2 MB L2 Cache (3.8 GHz) | 2 | 07:58:31 | 1.34 |
| Intel® Xeon® Processor 5160 (3.0 GHz) | 4 | 03:34:39 | 2.98 |
| Intel® Xeon® Processor X5472 (3.0 GHz) | 8 | 01:37:58 | 6.53 |
| Intel® Xeon® Processor X5570 (2.93 GHz) | 8 | 00:56:11 | 11.39 |

§ One OPC job per core.

Intel internal measurements May 2007, November 2007, and February 2009.

# Intel Xeon processor 5500 series offers Higher Density, Superior Performance, and Lower Power for OPC

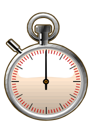
**30 Dual-Core** Intel® Xeon® 5150 based servers

**16GB** RAM per server (4GB RAM/core)

Total Power Consumed **9360** Watts

**120** Distributed OPC jobs

**11** minutes and **41** seconds



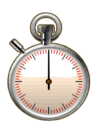
**15 Quad-Core** Intel® Xeon® X5355 based servers

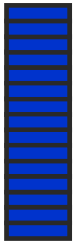
**32GB** RAM per server (4GB RAM/core)

Total power consumed **6450** Watts

**120** Distributed OPC jobs

**11** minutes and **04** seconds





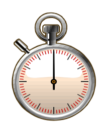
**10 Quad-Core** Intel® Xeon® E5450 based servers

**32GB** RAM per server (4GB RAM/core)

Total power consumed **3200** Watts

**80** Distributed OPC jobs

**11** minutes and **36** seconds



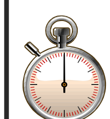
**6 Quad-Core** Intel® Xeon® X5570 based servers

**24GB** RAM per server (3 GB RAM/core)

Total power consumed **2250** Watts

**78** Distributed OPC jobs

**10** minutes and **25** seconds



Intel quad-core server solution shows OPC throughput advantages

Intel internal measurements May 2006, November 2006, November 2007, and February 2009.

# Profile: Intel® Xeon® Processor 5500 Series

- Up to 13.14x improved performance over single-core processors for simulation workloads
- Up to 11.39x improved performance over single-core processors for OPC workloads
- Up to 13:1 server consolidation ratio for simulation workloads and 11:1 for OPC workloads


IT@Intel Brief
Intel Information Technology

Improving EDA Batch Application Performance

Intel® Xeon® processor 5500 series has demonstrated a substantial performance multiple when compared to prior generation Intel® quad-core processors in high-performance computing applications.

Dr. Howard Ko

Profile: Intel® Xeon® Processor 5500 Series

Intel® Architecture Performance Improvement for Simulation

Intel® Architecture Performance Improvement for Optical Proximity Correction

Figure 1. Servers based on Intel® Xeon® processor 5500 series improved Synopsys VCS* application performance for simulation.[1]

Figure 2. Servers based on Intel® Xeon® processor 5500 series improved Synopsys Proteus* application performance for optical proximity correction (OPC).[1]

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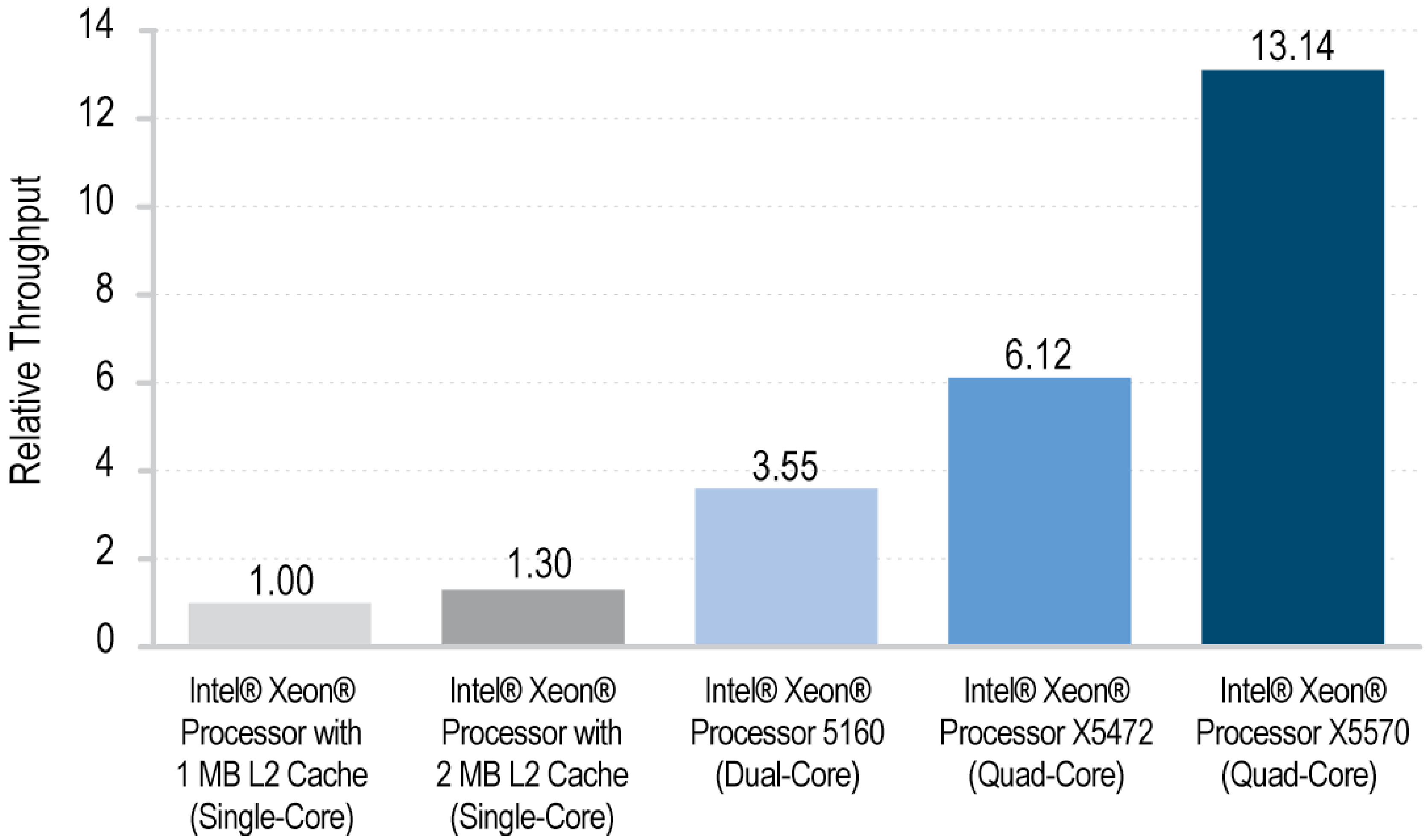
# Intel® Architecture Performance Improvement for Simulation




Intel internal measurements May 2007, November 2007, and February 2009.

# Runtime Performance for Simulation Application

| Processor | Simultaneous Simulation Jobs | Runtime (HH:MM:SS) | Relative Throughput |
|---|---|---|---|
| 64-bit Intel® Xeon® Processor with 1 MB L2 Cache (3.6 GHz) | 2 | 93:51:07 | 1.00 |
| 64-bit Intel® Xeon® Processor with 2 MB L2 Cache (3.8 GHz) | 2 | 72:23:11 | 1.30 |
| Intel® Xeon® Processor 5160 (3.0 GHz) | 4 | 26:26:16 | 3.55 |
| Intel® Xeon® Processor X5472 (3.0 GHz) | 8 | 15:20:01 | 6.12 |
| Intel® Xeon® Processor X5570 (2.93 GHz)[Δ] | 16 | 07:08:36 | 13.14 |

[Δ] Tests run on Intel Xeon Processor X5570 series had Intel® Hyper-Threading Technology and Intel® Turbo Boost Technology enabled.

Intel internal measurements May 2007, November 2007, and February 2009.

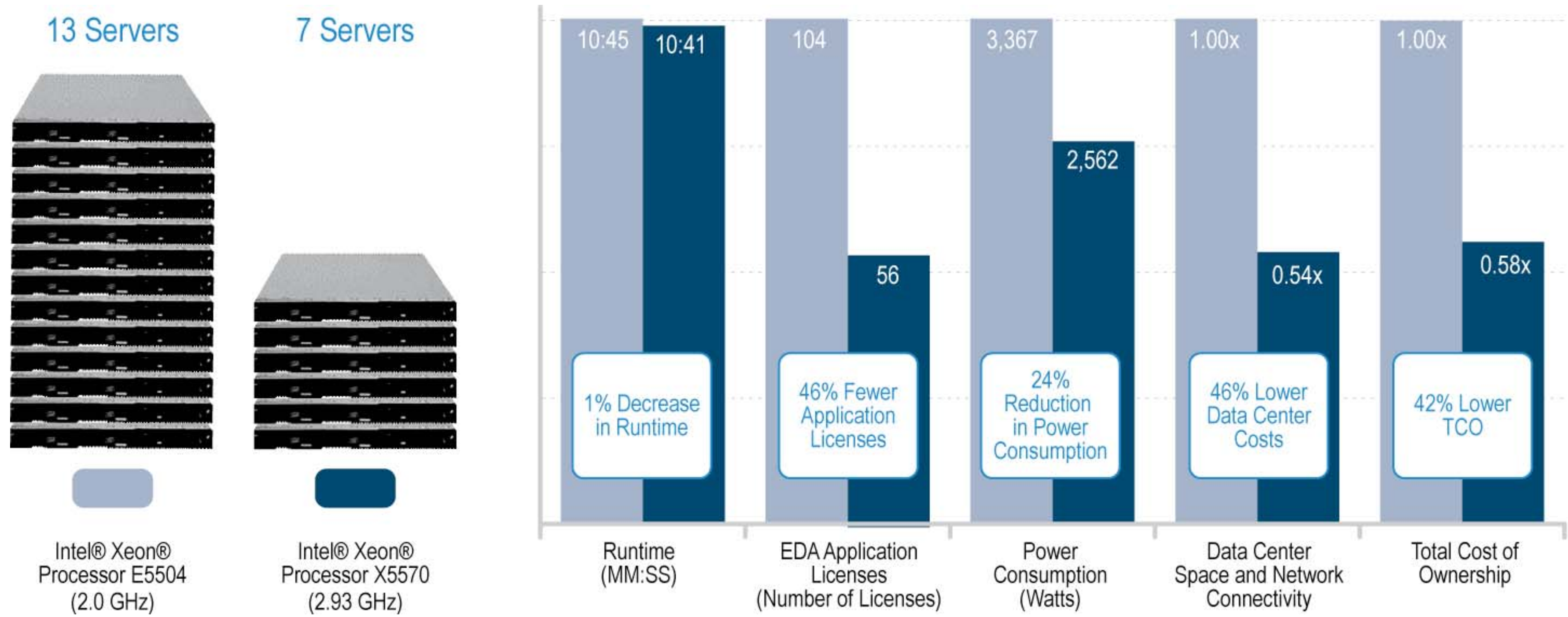
# Mainstream Intel® Xeon® Processor 5500 Series Segments

| | Basic | Standard | Advanced |
|---|---|---|---|
| CPU Frequency | 2.0 GHz to 2.13 GHz | 2.26 GHz to 2.53 GHz | 2.66 GHz to 2.93 GHz |
| CPU Power | 80 W | 80 W | 95 W |
| QPI | 4.8 GT/S | 5.86 GT/S | 6.4 GT/S |
| CPU Cache Size | 4 MB | 8 MB | 8 MB |
| Memory Speed | 800 MHz | 800/1066 MHz | 800/1066/1333 MHz |
| Intel® Turbo Boost Technology | No | Yes | Yes |
| Intel® HT Technology | No | Yes | Yes |

GT/S – Gigatransfers/Second; Intel® HT – Intel® Hyper-Threading Technology; QPI – Intel® QuickPath Interconnect

# EDA Throughput and Total Cost of Ownership

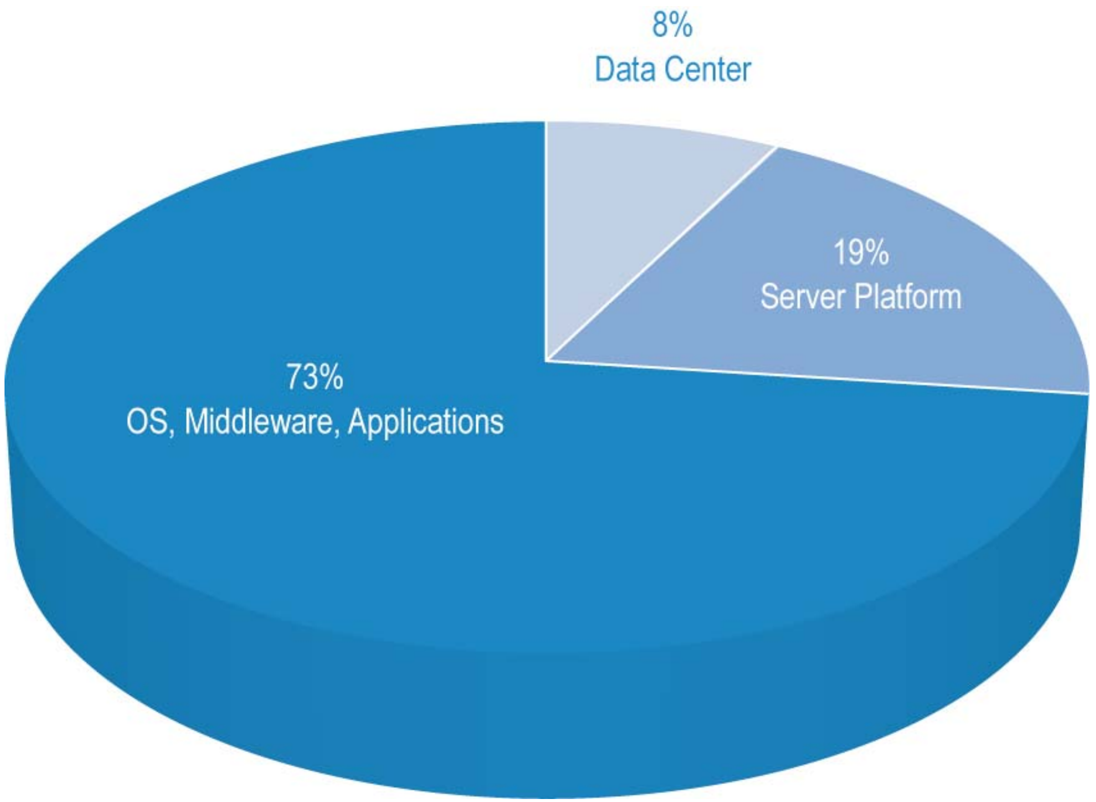
- In tests with real Intel EDA workloads, we required fewer servers based on high-end processors to achieve the same performance. This resulted fewer EDA application licenses; reduced data center power, space, and connectivity requirements; and substantially lower estimated TCO.




Intel internal measurements, February 2009.

# Server TCO

- The hardware platform accounts for a small proportion of server total cost of ownership (TCO). TCO calculations based on Intel® Xeon® processor X5570 (2.93 GHz).




Intel internal measurements, February 2009.

# Profile: Intel® Xeon® Processor 5500 Series

- High-end processors reduce server TCO by 42 percent compared to low-end processors
- High-end processors deliver up to 87 percent faster performance

IT@Intel Brief

Intel Information Technology

## Selecting Server Processors to Reduce Total Cost

With the introduction of the Intel® Xeon® processor 5500 series-based platforms, the benefits we are seeing from our IT strategy to standardize on higher-end processors for our servers purchases is even more compelling and results in a significantly lower TCO.

— Diane Bryant

**Profile: Intel® Xeon® Processor 5500 Series**

- High-end processors reduce server TCO by 42 percent compared to low-end processors
- High-end processors deliver up to 87 percent faster performance

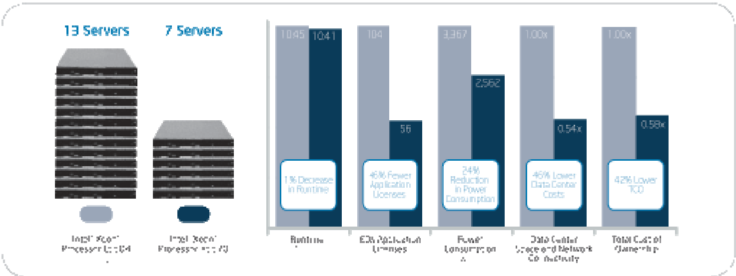



Figure 1. Electronic design automation (EDA) throughput and total cost of ownership (TCO).

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# HPC-1 to HPC-2 Storage Performance

HPC-2 Generation Limit: ~**15K** OPC jobs accessing one Parallel-Storage

| Category | Parallel-Storage-Gen1 | Parallel-Storage-Gen2 |
|---|---|---|
| **Meta Data Server Load** | **~100%** | **~80%** |
| **Interactive Latency** | **Unacceptable** | **Acceptable (no impact)** |
| **Write (sec)** | **25.00** | **4.00 (6.25x)** |
| **Read (sec)** | **25.00** | **0.47 (53x)** |
| **File listing (sec)** | **17.00** | **0.7 (24x)** |
| **File removal (sec)** | **25.00** | **0.36 (69x)** |
| **Event: Storage Vol Offline** | **Yes** | **No** |