IT@Intel Brief

Intel Information Technology

Computer Manufacturing

64-Bit Computing

May 2007

Quad-Core Intel® Xeon® Processor Benefits for Silicon Design

Intel IT and Synopsys conducted a joint performance assessment of Intel® 64-bit multi-core platforms running Synopsys Proteus* application for optical proximity correction (OPC). We found that the Quad-Core Intel® Xeon® processor improves throughput as much as 4.8x compared to the first-generation 64-bit Intel Xeon processor with a single core, and up to 1.68x compared to the Dual-Core Intel Xeon processor (see Figure 1). The quad-core processor increases performance and capacity, running more jobs in parallel to achieve higher throughput without increasing the server footprint or data center costs.

Profile: Quad-Core Intel Xeon Processor

- Increases compute capacity within the same server footprint
- Up to 4.8x improved throughput over Intel Xeon processor with a single core
- Up to 1.68x improved throughput over Dual-Core Intel Xeon processor

We conducted the performance assessment on 2-socket 64-bit servers based on the Quad-Core Intel Xeon processor, the Dual-Core Intel Xeon processor, and the Intel Xeon processor with a single core running one Synopsys Proteus OPC job per processing core with same input datasets.

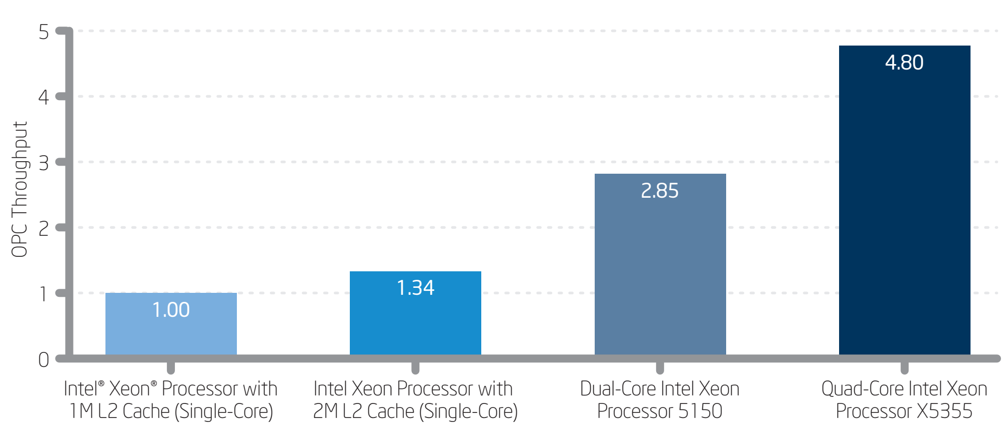


Figure 1. Quad-Core Intel® Xeon® processors boost the performance of Synopsys Proteus* application for optical proximity correction (OPC) 4.8x over Intel Xeon processors with a single core, and up to 1.68x over Dual-Core Intel Xeon processors. Intel internal measurements, May 2007.

Design Environment Challenges

Silicon chip design engineers at Intel have to meet ongoing challenges: integrating more features into ever-shrinking silicon chips, bringing products to market faster, and keeping engineering design and manufacturing costs low. As design complexity increases, the requirements for compute capacity also increase, so refreshing servers and workstations with higher performing systems is cost effective and offers a competitive advantage.

Intel IT launched a performance assessment to quantify and analyze the potential performance benefits of the new Quad-Core Intel Xeon processor as compared to previous-generation processors in our electronic design automation (EDA) computing environment. While this assessment focused on an EDA application, the benefits of quad-core processor throughput could apply to other applications in high-performance computing (HPC) environments where simulation and verification are large parts of the workflow, including:

- Computational fluid dynamics (CFD) and simulation in the aeronautical and automobile industries
- Synthesis and simulation applications in the life sciences
- Simulation in the oil and gas industries

Test Methodology

We ran Synopsys Proteus OPC on 2-socket servers based on the Quad-Core Intel Xeon processor, the Dual-Core Intel Xeon processor, and the first-generation 64-bit Intel Xeon processor with a single core. Table 1 shows our specifications.

Synopsys Proteus OPC is a distributed application used in semiconductor design. We tested throughput by running one input dataset, dataset A, processed by multiple OPC application instances (one job per processing core on each server).

The Quad-Core Intel Xeon processor-based server ran eight jobs in parallel, as compared to four jobs on the Dual-Core Intel Xeon processor-based server, and two jobs on the Intel Xeon processor-based server (single-core).

To determine the scalability of the performance increase, we also measured throughput using a second dataset, dataset B. We ran tests on one, two, and four 2-socket servers based on Quad-Core Intel Xeon processor X5355 and Dual-Core Intel Xeon processor 5150 using the same methodology.

Table 1. Two-Socket 64-Bit Server Platform Specifications Running SUSE Linux Enterprise Server 9* from Novell

Processor	Cores per 2-Socket Server	Clock Speed	L2 Cache per Socket	Front-Side Bus	Random Access Memory
Intel® Xeon® Processor with 1M L2 Cache (Single-Core)	2	3.6 GHz	1 MB	800 MHz	16 GB DDR2-400
Intel Xeon Processor with 2M L2 Cache (Single-Core)	2	3.8 GHz	2 MB	800 MHz	16 GB DDR2-400
Dual-Core Intel Xeon Processor 5150	4	2.66 GHz	4 MB	1333 MHz	16 GB DDR2-667/FB-DIMM
Quad-Core Intel Xeon Processor X5355	8	2.66 GHz	2x 4 MB	1333 MHz	16 GB DDR2-667/FB-DIMM

Key: DDR double data rate
FB-DIMM fully buffered dual in-line memory module

Results

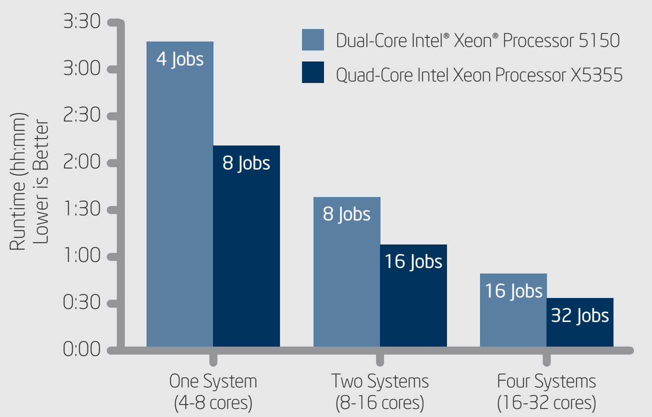
As shown in Figure 1 and Table 2, the runtime performance comparisons on single 2-socket servers demonstrate that Quad-Core Intel Xeon processors improved throughput significantly: up to 4.8x compared to Intel Xeon processors with a single core and up to 1.68x for Dual-Core Intel Xeon processors. This test was conducted using input dataset A.

Our performance comparisons on multiple servers showed that the runtime and throughput advantage for Quad-Core Intel Xeon processor-based servers scales as the numbers of servers and cores increase in HPC clusters. Figure 2 shows runtime performance results across multiple servers and Figure 3 shows throughput results. This test was conducted using input dataset B.

Table 2. Runtime Performance for Synopsys Proteus* Application for Optical Proximity Correction (OPC) on a Single 2-Socket Server Using Dataset A

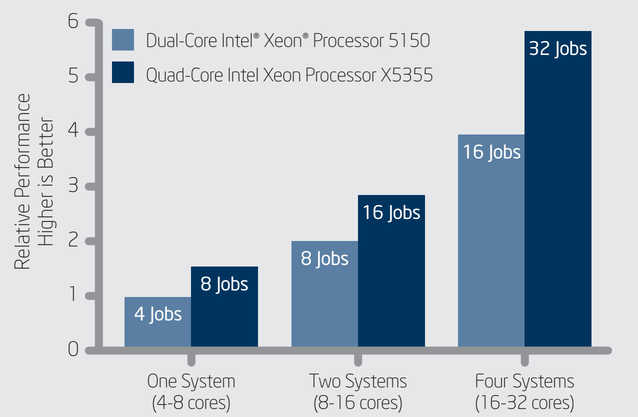
Processor	OPC Jobs[1]	Runtime (hours:minutes:seconds)	Relative Throughput
Intel® Xeon® Processor with 1M L2 Cache (Single-Core)	2	10:40:12	1.00
Intel Xeon Processor with 2M L2 Cache (Single-Core)	2	7:58:31	1.34
Dual-Core Intel Xeon Processor 5150	4	3:44:20	2.85
Quad-Core Intel Xeon Processor X5355	8	2:13:29	4.80

[1] One OPC job per core



Number of Servers	Core Ratio[2]	Runtime (hours:minutes:seconds) Dual-Core Intel® Xeon® Processor 5150	Quad-Core Intel Xeon Processor X5355
One	4 to 8	3:18:09	2:11:30
Two	8 to 16	1:39:16	1:07:56
Four	16 to 32	0:49:55	0:33:58

Figure 2. Synopsys Proteus* application for optical proximity correction (OPC) runtimes decrease as the number of servers increase, maintaining a consistent Quad-Core Intel® Xeon® processor advantage over Dual-Core Intel Xeon processors. Intel internal measurements, May 2007.



Number of Servers	Core Ratio[2]	Relative Throughput Dual-Core Intel® Xeon® Processor 5150	Quad-Core Intel Xeon Processor X5355
One	4 to 8	1.00	1.51
Two	8 to 16	2.00	2.92
Four	16 to 32	3.97	5.83

Figure 3. The Quad-Core Intel® Xeon® processor throughput advantage scales as the total number of processors increases within a high-performance computing (HPC) cluster. The Quad-Core Intel Xeon processor demonstrated a consistent ability to run twice as many jobs as the Dual-Core Intel Xeon processor and delivered faster runtimes, dramatically improving throughput by 1.5x. Intel internal measurements, May 2007.

[2] Core ratio: Quad-Core Intel Xeon processor-based 2-socket servers have twice as many cores available as Dual-Core Intel Xeon processor-based 2-socket servers.

Conclusions

As we've concluded our performance assessment, we are beginning to deploy Quad-Core Intel Xeon processor-based servers in our data centers to achieve greater performance and significantly increase compute capacity within the existing data center footprint.

We anticipate lower overall maintenance and operation costs proportional to increased throughput gains; more cores in the Quad-Core Intel Xeon processor boosts capacity in the same 2-socket server footprint, which means we'll need to operate and maintain fewer machines to address our computing demand. With significantly increased performance and pricing similar to Dual-Core Intel Xeon processors, Quad-Core Intel Xeon processors are the right choice for silicon design environments, and may also benefit other HPC computing applications.

Acronyms

CFD	computational fluid dynamics
DDR	double data rate
EDA	electronic design automation
FB-DIMM	fully buffered dual in-line memory module
HPC	high-performance computing
OPC	optical proximity correction

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