IT@Intel Brief

Intel Information Technology

Computer Manufacturing

Data Center Management

Server Virtualization

February 2007

Boosting Server Virtualization Performance

Using a performance-driven methodology to compare the operating costs of server virtualization platforms, Intel IT demonstrated an average 1.6x performance improvement and up to a 30 percent cost reduction with the Quad-Core Intel® Xeon® processor X5355 running at 2.66 GHz as compared to its predecessor, the Dual-Core Intel Xeon processor 5160 running at 3.0 GHz.

Profile: Server Virtualization

- Average 1.6x performance improvement
- Up to 38% reduction in number of servers
- Up to 30% reduction in TCO

We approximated the total cost of ownership (TCO) of each platform by measuring workload performance, platform performance, and power consumption. Figure 1 shows our test results.

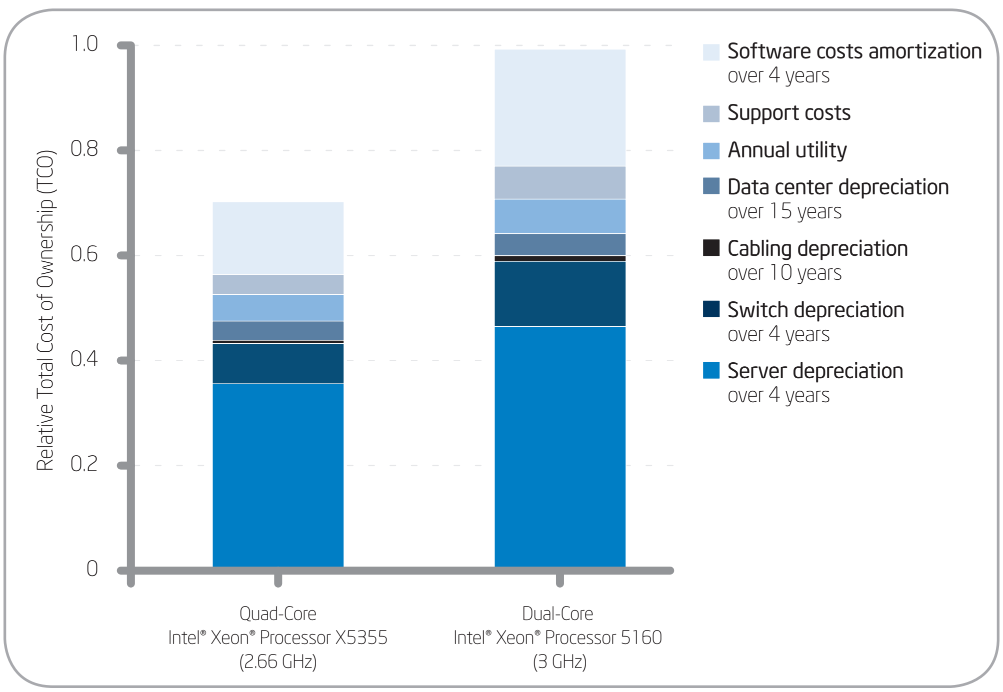

Figure 1. Annual cost savings and avoidance from server virtualization comparing Dual-Core and Quad-Core Intel® Xeon® processor-based servers. Intel internal measurements, November 12, 2006.

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Using a Real-World Model

With each new generation of Intel® multi-core technology, we anticipate dramatic power and performance improvements; these improvements directly contribute to lower TCO. Better performance per acquisition cost and performance per watt, for example, result in lower capital expenditures, smaller utility bills for power and cooling, and cost avoidance or savings for data center construction.

To quantify the actual financial benefits of server virtualization solutions, we developed a performance-driven methodology with easily obtainable objective measures and a real-world model that simulates a production data center environment. We correlated workload performance, platform performance, and power consumed with financial data to determine TCO. With this methodology, we demonstrated as much as a 2x performance improvement and up to 53 percent reduction in TCO for the Dual-Core Intel Xeon processor 5150 as compared to its predecessor.[1]

[1] "Building a Real-World Model to Assess Virtualization Platforms," Intel Corporation. November 2006.

When we introduced the Quad-Core processor, we again expected significant improvements in power and performance and a lower TCO. We compared the Quad-Core Intel Xeon processor X5355 running at 2.66 GHz to the Dual-Core Intel Xeon processor 5160 running at 3.0 GHz using our real-world model to verify and quantify the improvement.

Testing the Technology

Figure 2 shows the logical configuration of the test bed, comprised of 32-bit virtual machines (VMs) running on a robust enterprise virtualization environment. We used the same procedure and workloads as in our previous Dual-Core processor performance assessment, running each workload individually to simplify the testing process.

Our workloads represent real-world applications and include stress tests for online transaction processing (OLTP), decision support systems (DSS), business intelligence (BI), enterprise reporting services, and Lightweight Directory Access Protocol (LDAP). We ran two OLTP stress tests: one mid-range test involving four VMs configured to run with two virtual processing units and a larger test involving two VMs configured to run four virtual processing units.

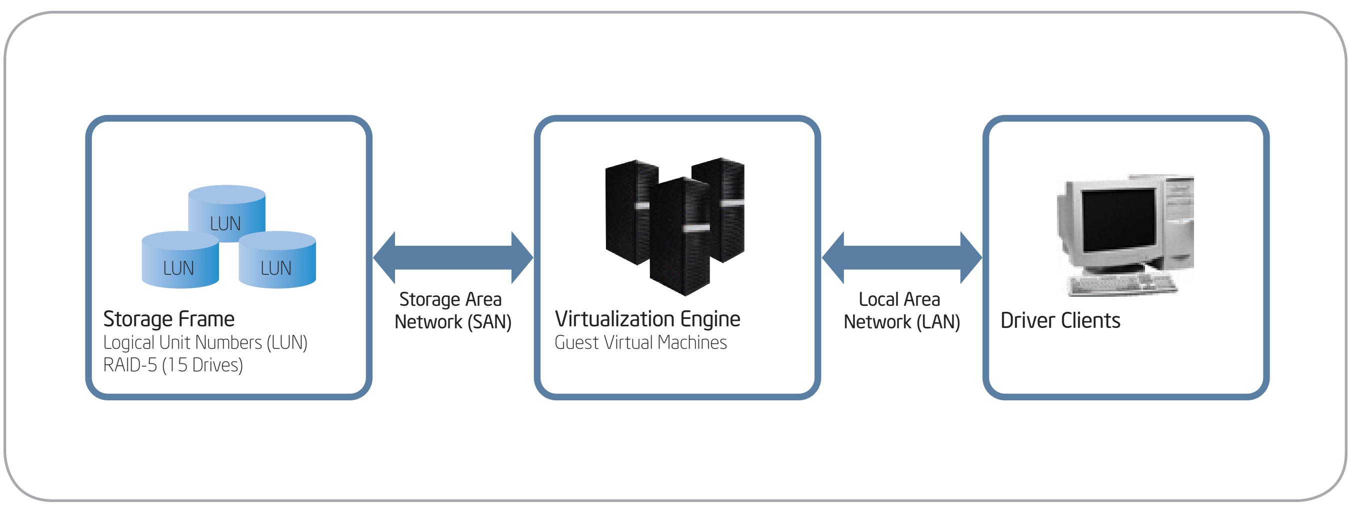

Figure 2. Test configuration topology.

Measuring Performance

Table 1 summarizes the key measurements we made to determine workload performance, platform performance, and power consumption.

We ran a commercial performance monitoring tool that was provided with the virtualization software on each physical machine with a sampling rate of 20 seconds to gather platform performance metrics. We analyzed the output, which was in CSV format, and exported the data to a spreadsheet file to generate outcome graphs.

For power consumption metrics, we connected power monitors directly inline with the AC power cords attached to the servers. The monitors ran continuously with a one-second sampling interval. We collected the data from the monitoring equipment on a dedicated PC in CSV format and transferred the values for each 30-second interval to a spreadsheet file.

Validating and Normalizing the Data

We performed multiple test passes for each workload and averaged the results to reduce the impact of any incidental effects and validate the data. We normalized application performance metrics to a fixed average CPU utilization, typically 65 percent, which eliminated measurement artifacts associated with:

- Slight application loading differences and corresponding differences in processor utilization
- Some VMs completing workloads earlier than others
- Impacts of external I/O bottlenecks
- Incidental, subtle variations in the configuration of the I/O subsystem

Determining TCO and IT Impact

After gathering sufficient data for analysis, we correlated the performance results with cost factors to determine the TCO implications for each platform under test. Our model quantifies TCO for an implementation with 4,000 virtual servers—a reasonable representation of a large enterprise's requirements.

Table 2 lists our assumptions for the costs associated with establishing and running a data center. Based on these assumptions, we calculated the hypothetical cost requirements associated with various platforms, encompassing the following factors:

- Hardware and software acquisition costs
- Depreciation and amortization costs
- Data center annual costs (depreciation and operating)
- Server support personnel costs
- LAN, SAN, and cabling costs

Table 3 summarizes our TCO test results.

Table 1. Workload performance metrics

Workload	Key Metrics
Online Transaction Processing (OLTP)	▪ Transactions per second ▪ Number of users ▪ Average response time
Decision Support Systems (DSS) and Business Intelligence (BI)	▪ Execution time ▪ Reports per hour
Enterprise Reporting Services	▪ Requests per second ▪ Time to first byte ▪ Time to last byte ▪ Number of users
IT Infrastructure Lightweight Directory Access Protocol (LDAP)	▪ User queries per second ▪ Total execution time

Table 2. Data center cost assumptions

Category	Assumption
Virtualization Software Cost	▪ USD 2,875 (approximately) for 4 years
Data Center Physical Plant Costs	▪ Space per rack: 25 square feet ▪ Depreciation cycle: 15 years ▪ Power use: 80 watts per square foot at USD 0.08 per kilowatt-hour ▪ Busy time: 12 hours per day ▪ Cooling power multiplier: 2.0
Personnel Costs	▪ USD 100,000 per support employee per year ▪ One support employee per 250 servers (physical server support only, including installation, break fix, and de-installation). Virtual machine, operating system, and application support is not included, as it is the same for all alternatives.

Table 3. Total cost of ownership test results[1]

Statistical Findings	Quad-Core Intel® Xeon® processor X5355 (2.66 GHz)	Dual-Core Intel Xeon processor 5160 (3.0 GHz)
Servers Required	242	391
Annual Costs (TCO)	USD 1.7 million	USD 2.5 million
Relative Performance	Average of 1.63x	
Relative Price/Performance	Average of 1.33x	
Relative Power Efficiency	Average of 1.24x	

[1] Intel internal measurements, November 12, 2006.

Results

As shown in Figure 3, the Quad-Core Intel Xeon processor X5355 running at 2.66 GHz significantly outperforms the Dual-Core Intel Xeon processor 5160 running at 3.0 GHz for all workloads we tested.

The Quad-Core Intel Xeon processor has up to 1.6x the overall compute capacity and as much as 1.2x the power efficiency of the Dual-Core Intel Xeon processor. This improved performance results in a dramatic reduction in TCO. Based on our calculations using the real-world model, the Quad-Core Intel Xeon processor X5355 requires approximately 38 percent fewer servers to support the same level of processing, contributing significantly to as much as an overall 30 percent reduction in TCO as compared to its predecessor, making it a better value and platform choice for a data center production environment.

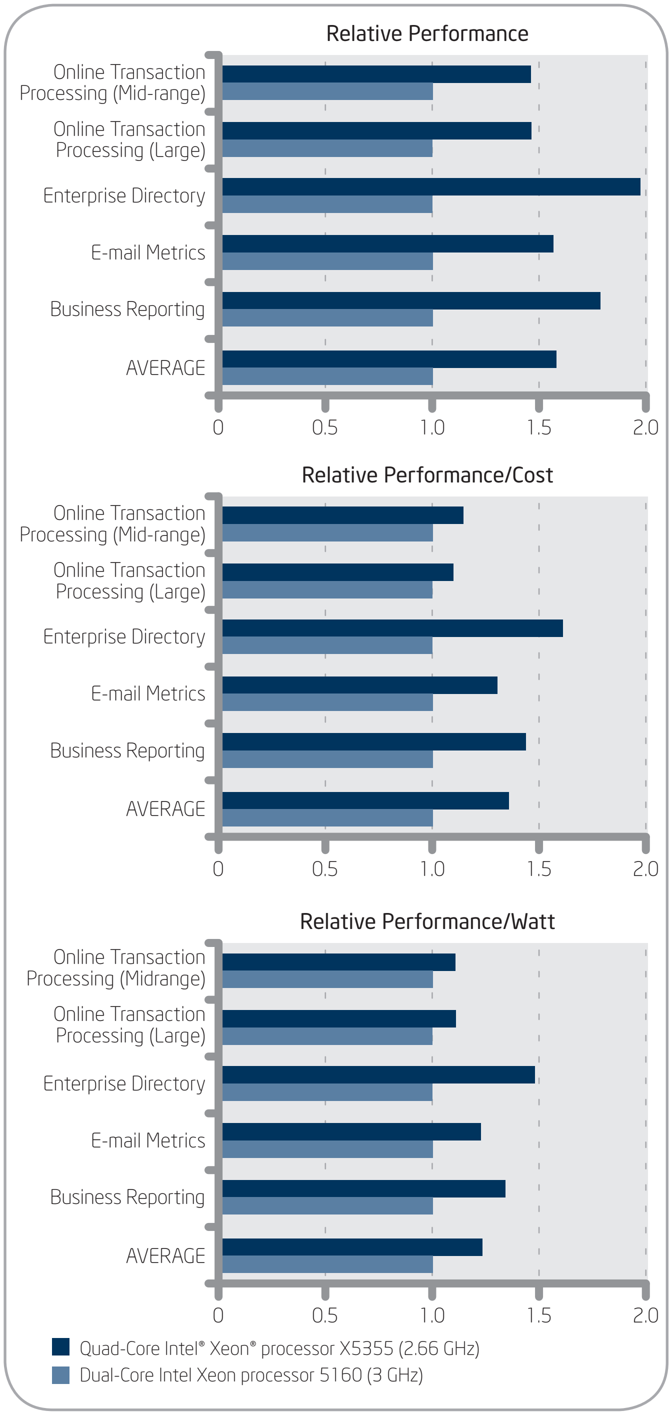

Figure 3. Platform value under various workloads. Intel internal measurements, November 12, 2006.

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