IT@Intel Brief

Intel Information Technology

Computer Manufacturing

Server Consolidation

November 2006

Server Consolidation Using Quad-Core Processors

Profile: Server Consolidation

- 8:1 consolidation
- 66% faster when running all 8 workloads
- USD 6,024 potential annual savings per consolidation
- USD 7.5 million savings in a data center with 10,000 servers

Intel IT used the Quad-Core Intel® Xeon® processor 5300 series to consolidate test workloads from eight physical machines into virtual machines (VMs) running on a single server.

The dual-socket server completed the workloads 66 percent faster than the original eight servers based on the Intel® Pentium® III processor, using 86 percent less power per workload. The quad-core processors were also 34 percent faster than the Dual-Core Intel Xeon processor 5148 running the same consolidated workloads, with workload completion times remaining much more uniform and predictable as the number of workloads increased.

The results show the strong potential of the Quad-Core Intel Xeon processor 5300 series for high levels of consolidation and virtualization, particularly with CPU intensive applications. We anticipate that each 8:1 server consolidation could save about USD 6,024 a year in direct operating costs, based on support, network depreciation, and power and cooling.

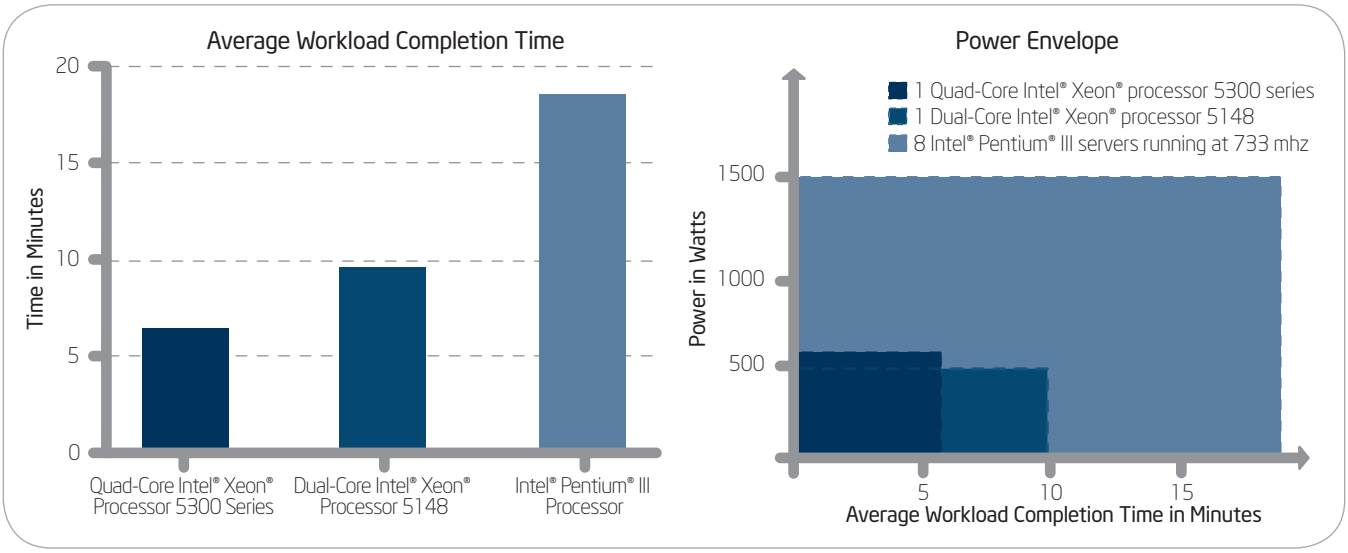

Figure 1. Workload completion time and power envelope when running eight CPU intensive workloads.

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Background

Like other large organizations, Intel faces significant challenges in managing data center cost and efficiency. Servers have proliferated but are often underutilized, leading to higher capital, support, maintenance, and power and cooling costs.

Intel IT is using server consolidation to reduce these costs. In an earlier test, we consolidated the workloads of four physical servers into four VMs on one dual-socket server equipped with the Dual-Core Intel Xeon processor 5100 series.

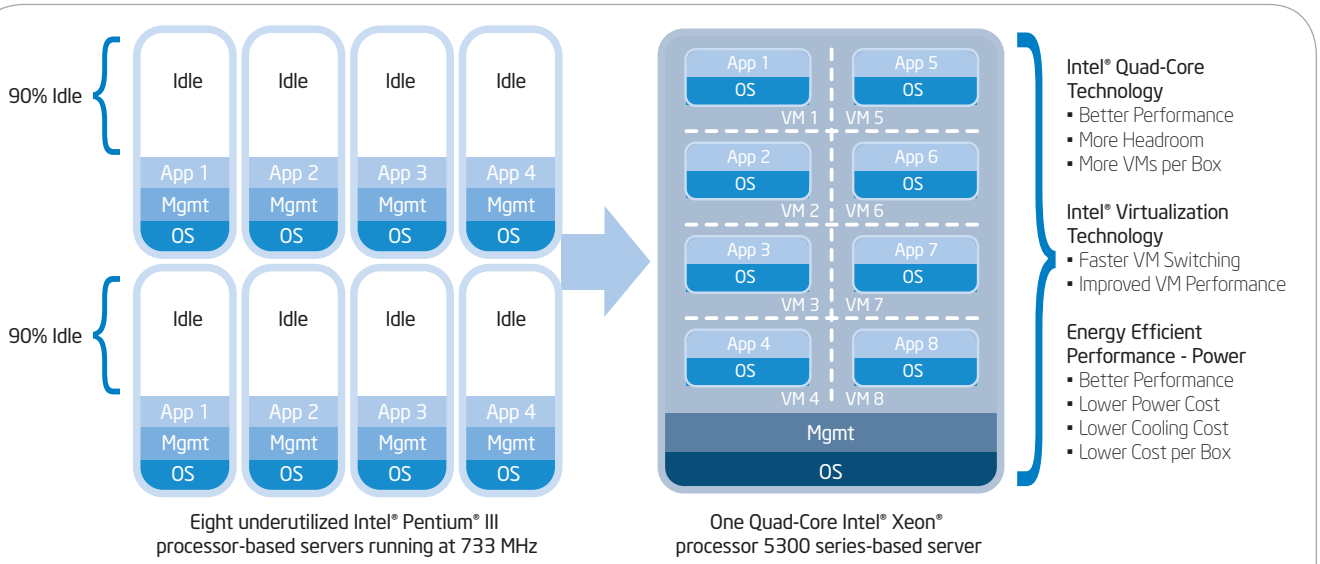
The solution effectively handled the four virtualized workloads. However, we found that with CPU intensive workloads, performance started to degrade once the number of VMs exceeded the number of cores. This made our dual-core solution less suitable for consolidating more than four workloads. We anticipated that dual-socket Quad-Core Intel Xeon processor 5300 series-based servers, with a total of eight cores, might enable us to achieve 8:1 consolidations.

Method

We built a CPU intensive database application representative of many data analysis applications. This was similar to the workload we used for our earlier dual-core consolidation test, but designed to increase CPU utilization to about 65 percent. We ran eight copies of this workload in three test environments:

- A dual-socket Quad-Core Intel Xeon processor 5300 series-based server
- The same dual-socket server model running the Dual-Core Intel Xeon processor 5148
- Our traditional solution, eight servers based on the Intel Pentium III processor

The configurations and virtualized environment are shown in Figure 2.



Key

App	application	OS	operating system
FBD	fully buffered DIMM	SDRAM	synchronous dynamic random access memory
FSB	front side bus		
Mgmt	management	VM	virtual machine

Processor	Frequency	L2 Cache	FSB	RAM	Memory Type	Number of Servers
Quad-Core Intel® Xeon® Processor 5300 Series	2.4 GHz	4 MB	1,066 MHz	20 GB 2 GB per VM	FBD	1
Dual-Core Intel® Xeon® Processor 5148	2.33 GHz	4 MB	1,066 MHz	20 GB 2 GB per VM	FBD	1
Intel® Pentium® III Processor	733 MHz	256 K	133 MHz	2.5 GB per machine	SDRAM	8

Figure 2. Consolidating servers 8:1.

Results

When running all eight consolidated workloads, the Quad-Core Intel Xeon processor 5300 series completed each workload 34 percent faster, on average, than the Dual-Core Intel Xeon processor 5148, and up to 66 percent faster than our traditional solution of eight individual servers running one workload each, as shown in Table 1. The server with quad-core processors consumed about 29 percent less power per job than the server with dual-core processors and about 86 percent less power than the eight Intel Pentium III processor-based servers, as shown in Figure 1.

The server with quad-core processors was clearly faster and more power-efficient, at all workload levels, than the traditional eight servers. The comparison with dual-core processors is more complex, as shown in Figure 3.

When running fewer than four workloads, the low-voltage Dual-Core Intel Xeon processor 5148-based server completed each workload slightly faster than the server with quad-core processors and consumed less power per job.

Table 1. Summary of Test Results

	Quad-Core Intel® Xeon® Processor 5300 Series-based Server	Dual-Core Intel® Xeon® Processor 5148-based Server	Intel® Pentium® III Processor-based Servers Running at 733 MHz
Job Performance			
Average Workload Completion Time in Minutes	6.34	9.6	18.5
Average Power in Watts	535	497	1,344
Power Envelope in Watt-Minutes	3,392	4,771	24,864
Power Envelope per Job in Watt-Minutes per Job	424	596	3,108
Quad-Core Benefits			
Savings in Workload Completion Time		34%	66%
Power Envelope Savings		29%	86%

Comparison of Quad-Core and Dual-Core Results

Quad-Core Intel® Xeon® Processor 5300 Series

	Completion times for each VM in minutes											
Job	VM 1	VM 2	VM 3	VM 4	VM 5	VM 6	VM 7	VM 8	Average Power	Watt Minutes	Watt-Minutes/Job	Average VM Execution Time
1	5.35								466	2,493	2,493	5.35
2	5.33	5.32							478	2,548	1,274	5.33
3	5.32	5.28	5.32						489	2,598	866	5.31
4	5.32	5.28	5.32	6.07					500	3,034	759	5.50
5	5.32	5.28	5.32	6.17	5.28				508	3,133	627	5.47
6	5.32	5.28	5.32	6.27	7.15	7.18			513	3,682	614	6.09
7	5.33	5.32	5.33	6.53	7.17	7.20	5.27		523	3,769	538	6.02
8	5.38	5.30	5.32	6.48	7.17	7.20	6.95	6.92	535	3,853	482	6.34

Dual-Core Intel® Xeon® Processor 5148

	Completion times for each VM in minutes											
Job	VM 1	VM 2	VM 3	VM 4	VM 5	VM 6	VM 7	VM 8	Average Power	Watt Minutes	Watt-Minutes/Job	Average VM Execution Time
1	5.2								438	2,261	2,261	5.2
2	5.2	5.2							454	2,347	1,174	5.2
3	5.2	5.2	5.2						471	2,441	814	5.2
4	5.2	5.2	5.2	7.6					471	3,577	894	5.8
5	6.1	6.2	6.0	7.8	6.1				478	3,722	744	6.4
6	6.5	6.5	6.5	7.9	9.4	9.5			484	4,582	764	7.7
7	7.7	7.7	7.7	8.8	10.1	10.1	7.6		491	4,947	707	8.5
8	8.6	8.6	8.9	9.7	10.6	10.6	9.9	9.9	497	5,267	658	9.6

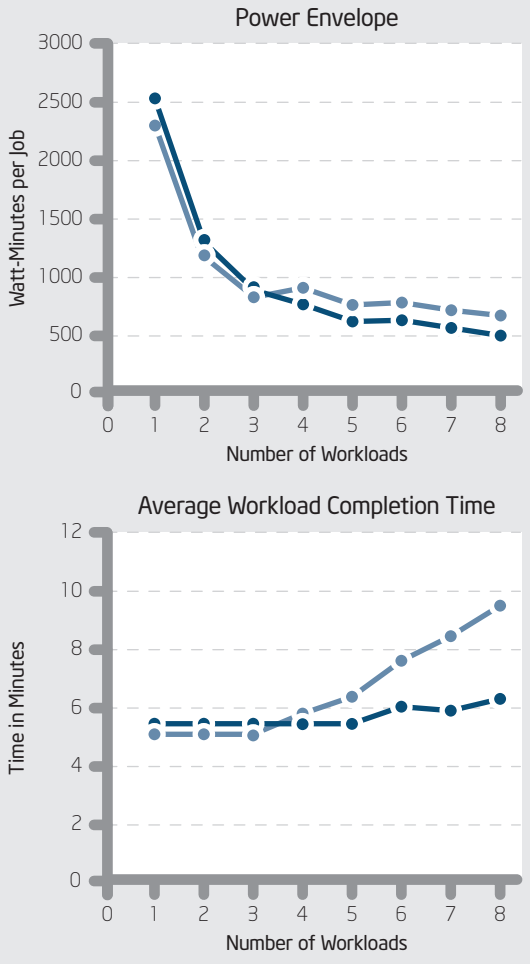


Figure 3. Results demonstrate performance and power savings.

However, the picture changed as we progressively added more workloads. With the Quad-Core Intel Xeon processor 5300 series, job completion times remained relatively uniform. With eight workloads, the server took only 18 percent longer, on average, to complete each one than when it was running a single workload. With the Dual-Core Intel Xeon processor 5148, completion times increased sharply, reaching an average 85 percent longer with eight workloads, as shown in Figure 3.

As the number of VMs started to exceed the number of cores, performance degraded as the virtualization software incurred more overhead managing workloads among the available cores. In our test, this shift began to occur when we added a fourth workload to the Intel Xeon processor 5148-based server.

More predictable, uniform runtimes support Quality of Service. In a virtualized environment, jobs may be allocated to any available server. Servers based on the Quad-Core Intel Xeon processor 5300 series could complete tasks quickly even when heavily loaded, potentially allowing IT organizations to meet service levels without investing in more capacity.

This consistent performance also improved the power envelope. As the number of workloads increased, the quad-core processors consumed progressively less power per workload than the dual-core processors, because they completed the workloads faster.

We expect that that the Quad-Core Intel Xeon processor 5300 series will enable aggressive consolidation of physical machines to VMs, generating considerable financial benefits. We project savings based on reduced support, depreciation, and power and cooling costs, as shown in Figure 4.

Our assumptions yield a USD 6,024 per year reduction in direct operational costs per consolidation. This calculation is conservative and does not include savings from reduced server room square footage, racks, network switches and routers, backup power supplies, and universal power supplies (UPSs). This translates to USD 7.5 million for a 10,000-server data center.

Our results confirm that the Quad-Core Intel Xeon processor 5300 series is capable of extending a 4:1 server consolidation strategy to an 8:1 strategy when managing CPU intensive workloads and that this strategy could deliver substantial benefits to Intel.

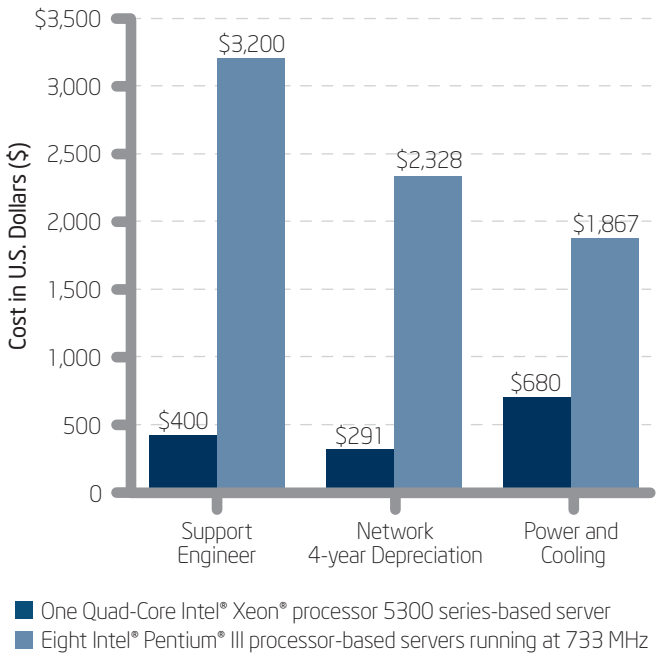


Figure 4. Cost comparison of 8:1 server consolidation.

Acronyms

VM	virtual machine
UPS	universal power supply

All tests are Intel Internal Measurements, October 2006.

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