Power Comparison of Dell PowerEdge 2950 using Intel X5355 and E5345 Quad Core Xeon Processors

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Section 1

Executive Summary

The datacenter of today is a much different place than it was a decade ago. In the early days of x86 datacenter build out, much of the focus was on density in terms of space. Datacenter IT Managers were concerned with the physical size of a server and how many would fit in a rack. How much power these systems would consume was an afterthought. Power was cheaper, systems didn't require as much of it, and it was easy to make additional power available to a rack.

Today, power is not cheap, systems use more of it, and it is not easy to bring additional power resources into the datacenter. Many datacenters are constrained by the amount of power that is available. IT Managers are faced with the dilemma of increasing datacenter workload without expanding or increasing the datacenter. Performance per watt is now a major focus in the datacenter.

This paper will compare the performance of the PowerEdge 2950 using two different quad-core Intel® Xeon® processors that consume different amounts of power. Results will show that the Intel Xeon E5300 family of processors can approach the performance of the X5300 series of processors while realizing a power savings of approximately 15%.

Section 2

Introduction

Not long ago it was easy to add capacity to the datacenter. If there was space in a rack, a server could be placed into it. The amount of power that was available at the rack level was enough to power anything placed in the rack. Performance of servers has increased significantly in recent years and the power requirements to run these servers has also increased. At the same time, servers are now available in form factors that make it possible to load more of them into a single rack. Capacity in the datacenter is now limited by the amount of power available.

Customers who are able to meet their IT demands without increasing power demands can forgo datacenter redesign or expansion for several more years. This helps to increase the return on capital investment for the original datacenter which may have been scheduled for an expansion. There is an ever increasing focus on maximizing datacenter resources. This includes figuring out how to get the most computational power given a fixed set of kilowatts available in the datacenter.

One way to maximize datacenter power efficiency is by using lower wattage processors. Intel offers two different processors in the Xeon® 5300 family of quad-core processors. The X5300 series runs at high frequency and draws 120 watts per socket. The E5300 series runs at a slightly lower frequency and draws 80 watts per socket. Customers focused on power issues would like to know they are maximizing their performance while choosing the Intel processor that best meets their datacenter's power capacity.

This paper will show the difference in performance and power consumption using the Intel E5345 Xeon quad-core processor compared to the Intel X5355 Xeon quad-core processor. The test in this paper is designed to compare the performance of these two processors in the Dell™ PowerEdge™ 2950 running the same workload. The performance of each will be described along with an emphasis on the performance per watt.

In the next section the server and storage hardware used in the test is described. Following that, in Section 4, the virtualization environments and applications used in the test are described in detail. In Section 5 the performance and power consumption of these applications are measured on a single PowerEdge 2950 using Intel Xeon X5355 processors followed by the same test suite run on the same PowerEdge 2950 with Intel® E5345 Xeon® Processors.

Section 3

Hardware

The PowerEdge 2950 is a dual-socket server that supports Intel® Xeon® 5000, 5100, and 5300 series processors. The Dell test team configured the PowerEdge 2950 with two quad-core Intel Xeon X5355 processors at 2.66 GHz. The quad-core Intel Xeon X5355 is basically two Xeon 5160 dual-core processors put together and so has a total of 8 MB L2 cache, with 4MB shared by two cores. The Xeon X5355 has a frontside bus speed of 1333MHz. The PowerEdge 2950 was configured with 16GB of memory using 2GB DIMMs.

The quad-core Intel Xeon E5345 processor is designed similarly to the Intel Xeon X5355, but runs at a slower frequency. It has a total of 8 MB L2 cache, with 4MB shared by two cores. The Xeon E5345 has a frontside bus speed of 1333MHz. The X5355 has a rated power consumption of 120 watts per socket. The E5345 is rated at 80 watts per socket.

Power consumption in a system consists of wattage draw from many components, processors being but one aspect. The power comparison used in this paper will measure the total power draw of the system.

	PowerEdge™ 2950 with E5300 series Processors	**PowerEdge 2950 with X5300 series Processors**
Virtualization software	VMware ESX Server 3.0.1	VMware ESX Server 3.0.1
Processor	Two quad-core Intel Xeon E5345 processors at 2.33 GHz with 8MB cache (shared)	Two quad-core Intel Xeon X5355 processors at 2.66 GHz with 8MB cache (shared)
HyperTransport / Frontside bus	1,333 MHz	1,333 MHz
Memory	16 GB (8x 667 MHz fully buffered 2GB DIMMs)	16 GB (8x 667 MHz fully buffered 2GB DIMMs)
Internal disks	Two Serial Attached SCSI (SAS) 146 GB, 15,000 rpm drives	Two Serial Attached SCSI (SAS) 146 GB, 15,000 rpm drives
Network interface card (NIC)	Two 10/100/1,000 Mbps internal NICs	Two 10/100/1,000 Mbps internal NICs
Disk controller	PERC 5/i	PERC 5/i

Table 1: Configurations for the Dell PowerEdge 2950 server used in the test.

The test with the Intel Xeon E5345 processors was run on the same PowerEdge 2950. The test team simply removed the X5355 and replaced them with the E5345 processors.

The PowerEdge 2950 was connected to a storage area network (SAN) with dual-port QLogic 2462 PCI Express host bus adapters (HBA) and utilized storage on a Dell/EMC CX3-80 array with twenty 146 GB, 15,000 rpm disks. The three types of VMs—each running a different workload, as described in the “Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench” section in this article—were spread across the 20 disks on each storage array. These disks were divided into four 5-disk (4+1) RAID-5 logical units (LUNs). The three types of VMs were evenly divided across the LUNs so that a quarter of each type was on each LUN. Table 2 summarizes the storage configuration used in the test environment.

	Dell/EMC CX3-80
Controller cache	10,384 MB (3,072 MB write, 7,312 MB read)
Fibre Channel speed	Fibre Channel 4 (FC4)
Disk enclosures	Four DAE3P disk array enclosures
Disks	Twenty 146 GB, 15,000 rpm disks
LUNs	Four 5-disk RAID-5 LUNs
Software	EMC® Navisphere® Manager and Access Logix™ software

Table 2: Configuration of the CX3-80 storage used in the test environment

Section 4

Virtualization Software Platform for Test Environment

The performance tests used VMware Infrastructure 3 as the virtualization platform; this package includes ESX Server 3 and VirtualCenter 2 as well as features such as load balancing and VMware High Availability (VMware HA). ESX Server allows multiple virtual machines (VMs) to run simultaneously on a single physical server. Each VM runs its own OS, which in turn has its own set of applications and services. Because ESX Server isolates each VM from other VMs on the same physical server just as physical systems are isolated from one another, administrators have flexibility in using ESX Server to run different types of applications and operating systems at the same time. VirtualCenter 2 enables administrators to consolidate control and configuration of ESX Server systems and VMs, which can improve management efficiency in large environments.

The Dell test team utilized the results from a previous paper, "Advantages of Dell PowerEdge 2950 Two Socket Servers Over Hewlett-Packard Proliant DL 585 G2 Four Socket Servers for Virtualization"[1] for the measurements of the PowerEdge 2950 with the Intel Xeon X5355 processors. The processors in that same system were then replaced with the Intel Xeon E5345 processors and retested.

Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench

To compare the relative performance of the PowerEdge 2950 with the different processors, the test team ran three workloads on each server: the Microsoft® SQL Server™ 2005 database platform with an online transaction processing (OLTP) workload, the Novell® SUSE® Linux® Enterprise Server OS with a LAMP (Linux, Apache, MySQL, PHP) stack, and the Microsoft Windows Server® 2003 OS with NetBench® 7.03.[2] To simulate how enterprises typically run applications on VMs using ESX Server in a production environment, the test team increased the number of VMs until processor utilization for the entire physical server was as close to 85 percent as possible, with all tests within a range of 84 to 86 percent—a reasonably high level of usage that still allows for workload spikes. The test team calculated utilization levels by averaging the values from the esxtop utility run on the ESX Server service console during each test.

Each workload ran simultaneously on multiple VMs under the same load. By keeping all settings on the VM and driver systems identical and then observing how many VMs could be run simultaneously, the test team was able to measure how many VMs each physical server could support as well as the total throughput for that workload. Table 3 shows the configuration for each type of VM in the test environment.

Workload	Memory	Disk	Number of Virtual NICs	Number of virtual processors
Microsoft SQL Server 2005	512 MB	10 GB	1	1
SUSE LAMP	1,024 MB	10 GB	1	1
NetBench	512 MB	10 GB	1	1

Table 3: Configurations for the virtual machines used in the test environment

Microsoft SQL Server 2005. On the SQL Server 2005 VMs, the test team installed 32-bit versions of Microsoft Windows Server 2003 Release 2 (R2) Enterprise Edition and SQL Server 2005 with Service Pack 1 (SP1).[2] The SQL Server version of the Dell DVD Store database was loaded into SQL Server 2005 using the scripts provided with the DVD Store download to create the medium-size database. The complete DVD Store application code, including SQL Server and LAMP versions, is freely available for public use under the GNU General Public License (GPL) at linux.dell.com/dvdstore. The DVD Store database simulates the database back end of a simple Web-based storefront. The database size is small (approximately 1 GB), and representative of a database used for development or testing.

To simulate a load on the VMs, the test team used the DVD Store driver program, which is included in the DVD Store download. Each SQL Server 2005 VM was driven by four threads of the driver application with a 20-millisecond delay.

SUSE LAMP. For the LAMP workload, the test team installed 32-bit versions of Novell SUSE Linux Enterprise Server 9, Apache 2, and MySQL 5 on a VM. The MySQL version of the DVD Store application was loaded into MySQL 5, and the PHP version of the DVD Store application was set up on Apache. In this setup, the Web tier and the database tier ran on the same VM to create a complete LAMP stack.[3]

The driver for the LAMP stack differs from the driver used in the SQL Server testing in that it sends HTTP requests and receives HTML code returned from the Apache/PHP layer, whereas the SQL Server driver communicates directly with the database. However, the LAMP workload measures the same parameters: total orders per minute (OPM) handled by the application, and average response time experienced by the simulated customers. Each SUSE LAMP VM was driven by a single thread of the driver program with a 20-millisecond delay.

NetBench. NetBench 7.03, developed by *PC Magazine,* is a benchmark tool designed to simulate a file server workload. The program creates and accesses a set of files according to predefined scripts. NetBench is typically run with an increasing number of client engines running against a single server to measure how much throughput (in megabits per second) can be achieved with a given number of connections.

The NetBench VMs were installed with the 32-bit version of Microsoft Windows Server 2003 R2 Enterprise Edition. To determine how many VMs could run on an ESX Server host, the test team increased the number of VMs and the number of client engines at the same rate until the processor utilization on the ESX Server host reached 85 percent. NetBench 7.03, with the included standard DiskMix script, was used with a 0.6-second think time to connect two client engines to each VM.[4] This simulates multiple file servers on the same ESX Server host, similar to a file server consolidation scenario. The driver systems on which the client engines ran had mapped drives to the test VMs. In NetBench the test directories path file was modified so that as successive client engines were added, they would use the next drive letter, which corresponded to the next VM.

Section 5

Test Results Measuring Performance and Power Consumption

The test team first ran the VMs on the two-socket PowerEdge 2950 server in successive tests, adding VMs in each round as described in the "Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench" section. Next, they replaced the processors in the PowerEdge 2950 with the Intel Xeon E5345 processors and repeated the tests. A power meter attached to the server measured the actual power consumption during these tests.

Performance and Power Consumption. In terms of performance with virtualization there are two components. The first is a sizing or capacity issue in terms of the number of VMs supported. This immediately leads to the second component, which is the aggregate performance that those VMs are able to achieve. The performance results from the testing that was done are presented both in number of VMs and the sum of the associated performance of those VMs.

The power consumption of systems has become a real issue for customers and needs to be considered as part of the overall server performance. To measure the power consumption of these systems a meter was placed between the power source and the server to get the actual power consumption in watts while the tests were running.

The difference in the number of VMs and the associated performance metric—orders per minute (OPM) for SQL Server 2005 and SUSE LAMP and megabits per second for NetBench—indicated the relative difference in performance. The test team calculated the performance results for the SQL Server 2005 and SUSE LAMP VMs by totaling the OPM from all the VMs running in the test environment; NetBench provides the megabits-per-second metric as part of the results displayed at the end of a test.

Table 4 summarizes the performance results including the power consumption for the three workloads on each server.

	PowerEdge™ 2950 with Intel® Xeon® E5345 processors			**PowerEdge 2950 with Intel Xeon X5355 processors**			
Workload	VMs	Performance	Power	VMs	Performance	Power	Power Difference
Microsoft SQL Server 2005	31	28,482 OPM	383	32	29,346 OPM	449	**15%**
SUSE LAMP	41	9,082 OPM	385	44	9,852 OPM	447	**14%**
NetBench	44	918 Mb/sec	382	42	1,001 Mb/sec	444	**14%**

Table 4: Workload performance results for each server in the test environment

The power consumption numbers reported for these tests were captured by logging the power readings while the test was running and then averaging them. No hardware changes were made to the configurations, except for changing the processors.

Observations

The PowerEdge 2950 with Intel Xeon E5345 quad-core processors approaches the performance of the same server with Intel Xeon X5355 quad-core processors and consumes less power.

- MS SQL Server Workload: **Within 3% of the performance of X5355 with a 15% power savings.**
- SUSE LAMP Workload: Within 8% of the performance of X5355 with a 14% power savings.
- Netbench Workload: Within 9% of the performance of X5355 with a 14% power savings.

Table 5 shows the average power consumption difference between the two servers. This result is the average of the power draw for all three workloads during the execution of the three tests.

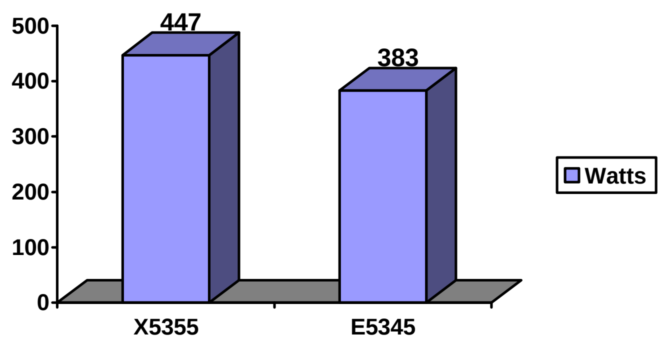

Table 5: Average wattage draw for each PowerEdge 2950

Example Power Savings in a Full Rack

We can use the average cost per Kilowatt-hour of electricity of $.0942 in the US, to determine the annual power savings.[5] Our example will assume the customer has a farm of servers in a single rack, running 24 hours a day, seven days per week for an entire year.Twenty Dell PowerEdge 2950 servers can be configured in this single rack. Taking the average power consumption of all three tests for this example, the difference in power between using Dell PowerEdge 2950s outfitted with E5345 processors versus the X5355 is 1.280 Kilowatts per rack. Assuming your servers run at an equivalent load as the benchmarks above, this equates to an annual savings of $1,056.

Performance Per Watt

In order to understand the relationship between performance and power consumption a simple calculation of the amount of performance achieved per watt of power consumed is needed. This is referred to as performance per watt and higher numbers are better as more performance per watt is good.

Table 6 shows the performance per watt calculations for all three VM workloads on both servers tested (based on the workload and average power consumption results in

Table 4).

	PowerEdge 2950 with E5345	PowerEdge 2950 with X5355	E5345 Advantage
SQL Server 2005	74.4 OPM / watt	65.4 OPM / watt	14%
SUSE LAMP	23.6 OPM / watt	22.0 OPM / watt	7%
NetBench	2.4 Mb/s / watt	2.3Mb/s / watt	4%
		Average Advantage - 8%	

Table 6: Performance per watt comparison

Section 6

Conclusions

Customers looking for pure performance should choose the Dell™ PowerEdge™ 2950 using the Intel® Xeon® X5355 quad-core processor. Those customers focused on power savings in the datacenter can approach the same level of performance as can be achieved on the PowerEdge 2950 with the X5355 processor using the Intel Xeon E5345 processor instead, while realizing a power savings of approximately 15%.

Customers choosing a more energy efficient server may be able to put off the expansion or construction of a new datacenter. This allows them to invest those savings into server resources to help the business.

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1 “Advantages of Dell PowerEdge 2950 Two Socket Servers Over Hewlett-Packard Proliant DL 585 G2 Four Socket Servers for Virtualization” by Todd Muirhead, Dave Jaffe, and Terry Schroeder, Dell Enterprise Product Group, December 2006, http://www.dell.com/downloads/global/power/dell2socket_vs_hp4socket_vmware.pdf.

2 The use of Microsoft SQL Server 2005 in these tests does not indicate that Dell or Microsoft has tested or certified SQL Server with VMware virtualization software. As described at support.microsoft.com/?kbid=897615, Microsoft typically does not support problems with Microsoft operating systems or applications that run on VMs using non-Microsoft virtualization software unless the same problem can be reproduced outside the VM environment.

3 The LAMP stack has been fully documented in “MySQL Network and the Dell PowerEdge 2800: Capacity Sizing and Performance Tuning Guide for Transactional Applications,” by Todd Muirhead, Dave Jaffe, and Nicolas Pujol, Dell Enterprise Product Group, April 2005, www.dell.com/downloads/global/solutions/mysql_network_2800.pdf.

4 The NetBench client driver systems were two Dell PowerEdge 6650 servers with four Intel Xeon processors at 2.8 GHz and nine Dell PowerEdge 1855 servers with two dual core 2.8 GHz processors. All client driver systems had 8 GB of RAM, Intel Gigabit Ethernet adapters, and Windows Server 2003. The NetBench client driver systems and ESX Server hosts were connected to a Dell PowerConnect™ 5224 Gigabit Ethernet switch. The NetBench controller ran Windows Server 2003 Enterprise Edition and used an Intel Gigabit Ethernet adapter.

5 The average price for commercial electrical power in the US is available from this website, http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_b.html.