Performance Scaling

with Dell PowerEdge 2950 Servers and VMware Virtual Infrastructure 3

To assess virtualization scalability and performance, Dell engineers tested two Dell™ PowerEdge™ 2950 servers with dual-core Intel® Xeon® 5160 and quad-core Intel Xeon X5355 processors alongside a previous-generation PowerEdge 2850 server with dual-core Intel Xeon processors in a virtualized environment based on VMware® Virtual Infrastructure 3. The results show that the PowerEdge 2950 servers can provide enhanced performance and host more virtual machines than the PowerEdge 2850.

BY TODD MUIRHEAD

When deciding how to implement a virtualized environment with industry-standard components such as Dell PowerEdge servers and VMware Virtual Infrastructure 3 software, two key factors are how many virtual machines (VMs) a single server can run and what level of performance these VMs can provide. Although the answer depends on many different factors, testing with common applications and workloads can provide a starting point for enterprises planning such an environment.

In September and October 2006, Dell engineers tested virtualized environments based on VMware Virtual Infrastructure 3 on two differently configured PowerEdge 2950 servers and one previous-generation PowerEdge 2850 server. Using three different workloads, the test team assessed the number of VMs that each server could host and the overall system performance, and found that the PowerEdge 2950 servers offered significant gains in both regards compared to the PowerEdge 2850. These tests are intended to provide an example of the scalability and performance increases possible when migrating to a new enterprise IT environment.

Hardware configuration for test environment

The PowerEdge 2950 is a dual-socket server that supports Intel Xeon 5000, 5100, and 5300 series processors. The Dell test team configured one PowerEdge 2950 with two dual-core Intel Xeon 5160 processors at 3.0 GHz, and another with two quad-core Intel Xeon X5355 processors at 2.66 GHz. The Intel Xeon 5160 has a 4 MB processor cache that is shared between the two cores and a 1,333 MHz frontside bus. The Intel Xeon X5355 is essentially two dual-core Intel Xeon 5160 processors combined, and so has an 8 MB level 2 (L2) cache (4 MB shared by each set of two cores) and a 1,333 MHz frontside bus.

An additional benefit of Intel Xeon 5160 processors is lower power consumption compared to previous-generation Intel Xeon processors. A previous study found that ninth-generation PowerEdge servers with Intel Xeon 5100 series

	PowerEdge 2850 server	PowerEdge 2950 servers	
Processors	Two dual-core Intel Xeon processors DP at 2.8 GHz with two 2 MB L2 caches (one per core)	Two dual-core Intel Xeon 5160 processors at 3.0 GHz with 4 MB cache (shared)	Two quad-core Intel Xeon X5355 processors at 2.66 GHz with 8 MB cache (shared)
Frontside bus	800 MHz	1,333 MHz	
Memory	8 GB (400 MHz DDR2 DIMMs)	16 GB (667 MHz fully buffered DIMMs)	
Internal disks	Two Ultra320 SCSI 73 GB, 10,000 rpm drives	Two Serial Attached SCSI (SAS) 146 GB, 15,000 rpm drives	
Network interface cards (NICs)	Two 10/100/1,000 Mbps internal NICs and one Intel PRO/1000 XT Gigabit* Ethernet NIC	Two 10/100/1,000 Mbps internal NICs	
Disk controller	PowerEdge Expandable RAID Controller (PERC) 4/ei	PERC 5/i	
Fibre Channel HBA	Two QLogic 2340 PCI Extended HBAs	One QLogic 2462 PCI Express HBA	
Virtualization software	VMware ESX Server 2.5.2	VMware ESX Server 3	

* This term does not connote an actual operating speed of 1 Gbps. For high-speed transmission, connection to a Gigabit Ethernet server and network infrastructure is required.

Figure 1. Configurations for the PowerEdge 2850 server and two PowerEdge 2950 servers used in the test environment

	Dell/EMC CX700	Dell/EMC CX3-80
Attached servers	One PowerEdge 2850 server	Two PowerEdge 2950 servers
Controller cache	3,614 MB (2,818 MB write, 796 MB read)	10,384 MB (3,072 MB write, 7,312 MB read)
Fibre Channel speed	Fibre Channel 2 (FC2)	Fibre Channel 4 (FC4)
Disk enclosures	Two DAE2 disk array enclosures	Four DAE3P disk array enclosures
Disks	Twenty 73 GB, 10,000 rpm disks	Twenty 146 GB, 15,000 rpm disks
LUNs	Four 5-disk RAID-5 LUNs	Four 5-disk RAID-5 LUNs
Software	EMC® Navisphere® Manager and Access Logix™ software	EMC Navisphere Manager and Access Logix software

Figure 2. Configurations for the Dell/EMC CX700 and CX3-80 storage used in the test environment

processors use up to 25 percent less power than eighth-generation PowerEdge servers with dual-core Intel Xeon processors.[1] The combination of lower power consumption and higher performance over previous-generation processors can result in increased performance per watt.

PowerEdge 2950 servers support up to 32 GB of RAM when using 4 GB dual in-line memory modules (DIMMs), but in the Dell tests both servers were configured with 16 GB of RAM using 2 GB, 667 MHz fully buffered DIMMs.

The PowerEdge 2850 server was configured with two dual-core Intel Xeon processors at 2.8 GHz—the fastest supported processors for this server—with a dedicated 2 MB cache for each core, 800 MHz frontside bus, and 8 GB of RAM using 400 MHz double data rate 2 (DDR2) DIMMs. Figure 1 summarizes the server configuration in the test environment.

The PowerEdge 2950 servers were connected to a storage area network (SAN) with a dual-port QLogic 2462 PCI Express host bus adapter (HBA) and utilized storage on a Dell/EMC CX3-80 array with twenty 146 GB, 15,000 rpm disks. The PowerEdge 2850 was connected to the SAN with two QLogic 2340 PCI Extended HBAs and utilized storage on a Dell/EMC CX700 array with twenty 73 GB, 10,000 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 were on each LUN. Figure 2 summarizes the storage configuration used in the test environment.

Virtualization platform for test environment

The Dell tests used VMware Virtual 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 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
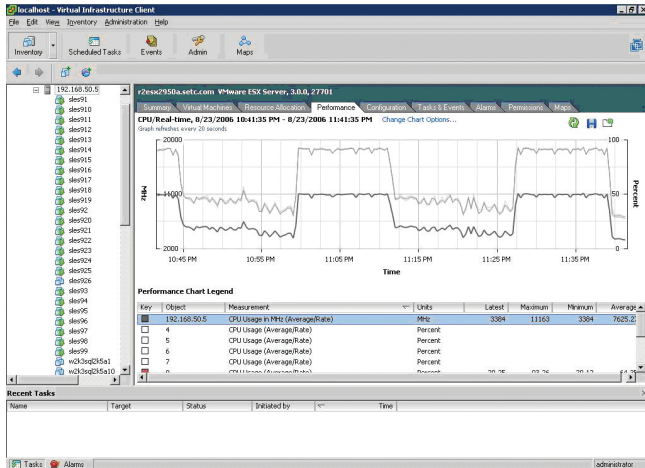
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Figure 3. Processor utilization graph in VMware VirtualCenter 2 during a SUSE LAMP test

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 PowerEdge 2950 servers used ESX Server 3, and the PowerEdge 2850 server used ESX Server 2.5.2; both were managed by an existing VirtualCenter 2 console. All VMs were first tested on the PowerEdge 2850, then migrated to each PowerEdge 2950 in turn. The test team used VirtualCenter 2 to shut down the VMs, migrate them to a PowerEdge 2950, upgrade the virtual hardware and VMtools, and then restart the VMs.

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

To compare the relative performance of the PowerEdge 2850 and PowerEdge 2950 servers, 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 exceeded 85 percent, with the highest utilization reaching 88 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, and also monitored the utilization from the VirtualCenter console, as shown in Figure 3.

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. Figure 4 shows the configuration for each type of VM 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).[3] 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

Workload	Memory	Disk	Virtual NIC type	Number of virtual processors
Microsoft SQL Server 2005	512 MB	10 GB	Vmxnet	1
SUSE LAMP	1,024 MB	10 GB	Vlance/Flexible*	1
NetBench	512 MB	10 GB	Vmxnet	1

* The SUSE LAMP VMs used a Vlance NIC under ESX Server 2.5.2, but this was upgraded to Flexible as part of the migration to ESX Server 3.

Figure 4. Configurations for the virtual machines used in the test environment

[2] The SUSE LAMP and NetBench workloads used for these tests were also used in previous studies; for more information, see "VMware ESX Server Multiple Workload Performance on Dell PowerEdge 2850 and PowerEdge 6850 Servers," by Todd Muirhead, Dave Jaffe, and Scott Stanford, Dell Enterprise Product Group, July 2005, www.dell.com/downloads/global/solutions/vmware_mixed_workload.pdf; and "VMware ESX Server Performance Gains on Dell PowerEdge 2850 Dual Core Servers," by Todd Muirhead and Dave Jaffe, Dell Enterprise Product Group, November 2005, www.dell.com/downloads/global/solutions/esx_2850_dualcore.pdf. These two studies also used a SQL Server 2000 workload that was updated to use SQL Server 2005 for the tests described in this article.

[3] 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.

Workload	PowerEdge 2850 with dual-core Intel Xeon processors		PowerEdge 2950 with dual-core Intel Xeon 5160 processors			PowerEdge 2950 with quad-core Intel Xeon X5355 processors			
	Number of VMs	Performance	Number of VMs	Performance	Performance gain compared to PowerEdge 2850	Number of VMs	Performance	Performance gain compared to PowerEdge 2850	Performance gain compared to PowerEdge 2950 with Intel Xeon 5160 processors
Microsoft SQL Server 2005	14	11,782 OPM	20	20,026 OPM	70%	32	29,346 OPM	149%	47%
SUSE LAMP	16	2,650 OPM	25	6,057 OPM	129%	44	9,852 OPM	272%	63%
NetBench	18	411 MB/sec	23	593 MB/sec	44%	42	1,001 MB/sec	144%	69%

Figure 5. Workload performance results for each server in the test environment

Web tier and the database tier ran on the same VM to create a complete LAMP stack.[4]

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 megabytes 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.[5] 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 all 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.

Test results measuring scalability and performance

The test team first ran the VMs on the PowerEdge 2850 server in successive tests, adding VMs in each round as described in the "Test workloads: Microsoft SQL Server 2005, SUSE LAMP, and NetBench" section in this article. Next, they migrated the VMs to the PowerEdge 2950 server with Intel Xeon 5160 processors and repeated the tests. Finally, they migrated the VMs to the PowerEdge 2950 server with Intel Xeon X5355 processors and repeated the tests once again.

The difference in the number of VMs and the associated performance metric—OPM for SQL Server 2005 and SUSE LAMP and megabytes 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 megabytes-per-second metric as part of the results displayed at the end of a test. Figure 5 summarizes the results for the three workloads on each server.

For all three workloads, the number of VMs that each PowerEdge 2950 server could host was consistently higher than the number the PowerEdge 2850 could host, with the largest number of VMs achieved by the PowerEdge 2950 server with quad-core Intel Xeon X5355 processors running the SUSE LAMP workload. This PowerEdge 2950 server, running with eight cores and 16 GB of RAM, was able to host more than 40 VMs for two of the three workloads.

The PowerEdge 2950 servers also showed significant gains in workload performance when compared with the PowerEdge 2850. The PowerEdge 2950 server with Intel Xeon X5355 processors showed much larger performance gains than the PowerEdge 2950 with Intel Xeon 5160 processors, with the largest gain—272 percent—generated by the SUSE LAMP workload. Figure 6 illustrates the relative

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[4] 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.

[5] The NetBench client driver systems were two Dell PowerEdge 6650 servers with four Intel Xeon processors at 2.8 GHz, 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.
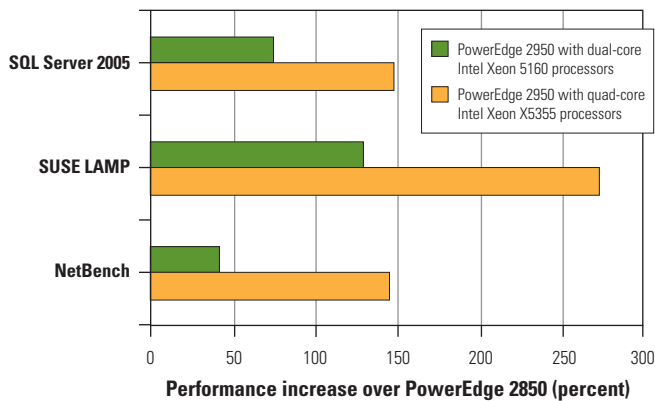
Figure 6. Relative performance increases for the PowerEdge 2950 servers over a PowerEdge 2850 server with dual-core Intel Xeon processors

performance increases for the PowerEdge 2950 servers over the PowerEdge 2850 server.

Enhanced virtualization performance

Dual-core Intel Xeon 5160 and quad-core Intel Xeon X5355 processors are designed to provide a significant boost in performance over previous-generation dual-core Intel Xeon processors. Performance increases may vary depending on the workload and other factors, but in the Dell tests described in this article, the PowerEdge 2950 performance gains were significant enough to allow more VMs to be hosted, with greater overall system throughput, than was possible on the PowerEdge 2850—including performance gains of up to 272 percent on a PowerEdge 2950 server with quad-core Intel Xeon X5355 processors.

The performance gains of the quad-core Intel Xeon X5355 over the dual-core Intel Xeon 5160 demonstrate that in virtualized environments, additional cores enable the hosting of additional VMs and help increase overall performance. These results suggest the type of enhanced scalability and performance possible with ninth-generation Dell PowerEdge servers and VMware virtualization software, which enterprises can take into account when planning to implement or upgrade a virtualized environment. ⬭

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