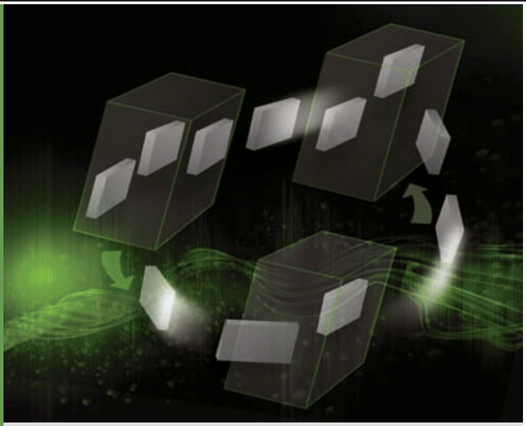

VIRTUALIZING MICROSOFT SQL SERVER 2005 ON DELL POWEREDGE SERVERS

By Todd Muirhead

Understanding performance can be critical when virtualizing key enterprise applications. To demonstrate how the Microsoft® SQL Server® 2005 database platform can perform in a VMware® virtualized environment, Dell engineers tested its performance when scaling virtual resources on a Dell™ PowerEdge™ server and when migrating virtual machines between physical hosts.

As IT organizations have become increasingly familiar with virtualization technology and begun using it for more than simple server consolidation, they may also be considering virtualizing additional applications in their environment. Microsoft SQL Server, for example, is a widely used database platform that can support other Microsoft applications such as Microsoft Office SharePoint® Server and Microsoft System Center, as well as enterprise resource planning (ERP) software such as the SAP® ERP and Oracle® PeopleSoft® applications and custom-developed applications. SQL Server 2005 utilizes a 64-bit architecture that can provide enhanced performance and capacity compared with previous versions as well as enhanced memory utilization by allowing the system to directly address more memory than previous 32-bit versions of SQL Server. Administrators looking to expand their use of virtualization may consider running SQL Server 2005 inside one or more virtual machines (VMs) to enhance the benefits that virtualized environments can provide, including increased management flexibility and cost savings through server consolidation.

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To help these organizations understand how SQL Server 2005 might perform in a virtualized environment, in February 2008 Dell Enterprise Technology Center engineers ran a series of tests to characterize its performance on a Dell PowerEdge server running VMware virtualization software. The testing was designed to evaluate performance and scalability in three different scenarios: when increasing the number of virtual processors (vCPUs) in a single VM, when increasing the number of VMs on a host server, and when migrating a VM between servers using VMware VMotion™ technology. As the results demonstrate, appropriately sized VMs with sufficient disk resources can provide good performance until the VMs begin maximizing use of the server's resources, and can continue to perform well even when used during VMotion migration events.

TEST ENVIRONMENT

The test environment was based on Dell PowerEdge servers and a Dell/EMC storage array supporting the VMware Infrastructure 3 virtualization suite, with the primary host server supporting the SQL Server 2005 VMs that were the focus of the tests.

Hardware configuration

The test team used a Dell PowerEdge 2950 III rack server with two quad-core Intel® Xeon® processors and 32 GB of RAM as the primary host server (see Figure 1). Dell PowerEdge servers are well suited for running SQL Server 2005, providing 64-bit-capable processors, external high-speed storage options, and enterprise-class support features. Dell engineers have performed tests and created online tools to help guide organizations deploying SQL Server 2005 or VMware ESX on Dell PowerEdge servers in their own environment; these tools, as well as related white papers, are available at DELL.COM/SQL and DELL.COM/VMware.

The test team first installed VMware ESX 3.5 and all available patches on the PowerEdge 2950 III server. Next, they installed the Microsoft Windows Server® 2003 OS on a PowerEdge 1950 server that would stress the VMs. Finally, they configured a PowerEdge 1855 blade server as a VMware VirtualCenter management server and console.

A storage area network (SAN)–attached Dell/EMC CX3-80 Fibre Channel storage array provided the storage. The test team attached the PowerEdge 2950 III server to the SAN through a dual-port QLogic QLE2462 host bus adapter (HBA). Figure 2 outlines the storage components used in the test environment.

Virtualization platform	VMware ESX 3.5
Processors	Two quad-core Intel Xeon X5460 processors at 3.16 GHz with two 6 MB caches
Memory	Eight 4 GB fully buffered dual in-line memory modules (DIMMs)
Internal disks	Two 146 GB, 10,000 rpm Serial Attached SCSI (SAS) drives
NICs	Two 10/100/1,000 Mbps internal NICs
Disk controller	Dell PowerEdge Expandable RAID Controller (PERC) 6/i
Fibre Channel HBA	Dual-port QLogic QLE2462 4 Gbps PCI Express (PCIe) HBA
Remote management	Dell Remote Access Controller 5 (DRAC 5)

Figure 1. *Dell PowerEdge 2950 III server configuration in the test environment*

Controller	Dell/EMC CX3-80 storage array
Disk enclosures	Six Dell/EMC DAE3P enclosures
Disks	Ninety-nine 146 GB, 15,000 rpm drives
Logical units (LUNs)	■ Eight 10-disk RAID-10 LUNs for the database ■ Four 2-disk RAID-1 LUNs for logs ■ Two 5-disk RAID-5 LUNs for VM boot disks ■ One hot spare disk

Figure 2. *Storage configuration used in the test environment*

Software configuration

The VMware Infrastructure 3 suite, which includes VMware ESX and VirtualCenter software, provided the virtualization platform for the tests. This suite also provides features such as 64-bit VM support, VMotion technology for live migration, VMware High Availability (VMware HA), and other management tools.

The PowerEdge 2950 III server used in the test environment supported four SQL Server 2005 VMs. The test team first created one VM, which they installed with Microsoft Windows Server 2003 Enterprise x64 Edition with Service Pack 1 (SP1) and the 64-bit version of SQL Server 2005 with SP2.

After attaching the storage, the team then loaded the open source Dell DVD Store test application, which simulates an online e-commerce application as users log in to a store; search for DVDs by actor, title, or category; and purchase DVDs. The software includes database creation and indexing scripts, stored procedures, data loading scripts, and client simulation driver programs. For these tests, the team loaded the large version of the DVD Store database—over 100 GB of data—onto the initial VM. During the tests, they used the client driver program included with the DVD Store kit to simulate the database load, with the driver program running on a separate system and connecting to the VMs through the network. This driver program allows testers to vary the workload by increasing the number of active threads, with each thread able to perform a complete cycle of logging in, browsing, and purchasing from the simulated store. The amount of delay or think time between steps is the primary difference between real users and simulated users: while a real user may take several seconds between each step, the driver program has a zero think time by default. This allows a small number of threads to simulate the workload that a large number of real users would generate.[1]

After installing the DVD Store software, the test team used the VirtualCenter Guest Customization wizard to clone the initial VM three times, creating a total of four SQL Server VMs. During the tests, each VM was configured with 8 GB of RAM, one virtual network interface card (vNIC), its

[1] For more information, visit www.delltechcenter.com/page/DVD+Store.

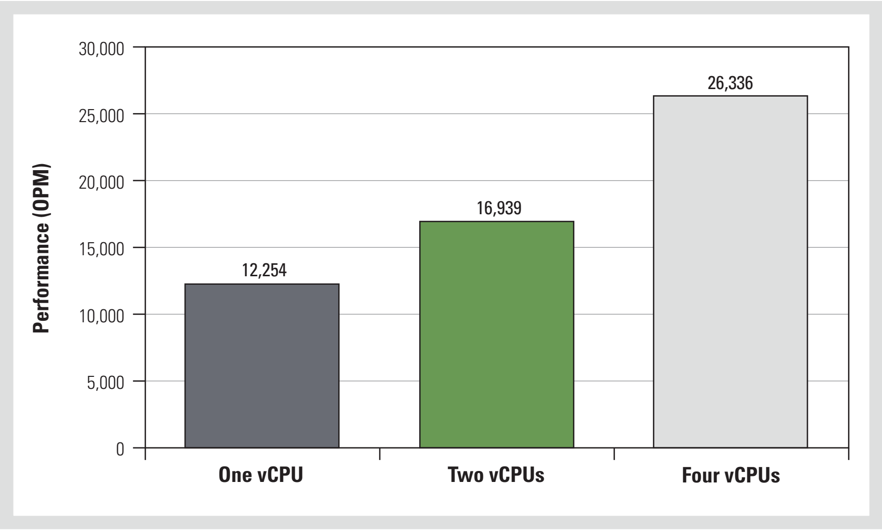

Figure 3. *Performance when scaling the number of vCPUs in a single VM*

own dedicated set of 20 data disks and 2 log disks, and one, two, or four vCPUs. Before starting the tests, the team tested the four-vCPU VM to ensure that the 20 data disks and 2 log disks provided sufficient disk I/O capacity for this configuration.

TEST RESULTS: PERFORMANCE SCALING AND VM MIGRATION

The initial set of performance tests was carried out in two phases. The first phase measured the performance of a single VM with one, two, or four vCPUs to indicate how well SQL Server 2005 performance could scale as vCPUs were added. The second phase measured the performance of one, two, and four VMs to indicate how well the VMs could perform under heavy workloads. The test team next placed a VM under stress and migrated it between two identically configured PowerEdge 2950 III servers to evaluate performance during VMotion migration.

Scaling with a single VM

To help provide an accurate measure of relative performance, the test team evaluated the performance of each VM configuration at 80 percent total processor utilization. During the tests, the team increased the number of threads specified in the DVD Store driver program, leaving the other parameters unchanged, until the processor reached that level of utilization.

Figure 3 shows the results, with performance measured in orders per minute (OPM). The VM scaled well, with performance increasing by 38 percent when moving from one vCPU to two vCPUs and by 55 percent when moving from two vCPUs to four vCPUs. As these results indicate, simply adding vCPUs can help significantly increase performance.

Scaling with multiple VMs

The single-VM test results provided a starting point for testing multiple VMs. The single-VM tests never fully utilized the resources of the PowerEdge 2950 III server: individual VMs were only assigned up to four vCPUs and 8 GB of RAM, while the server had a total of eight cores and 32 GB of RAM. Because testing multiple VMs could commit or overcommit all of the server's resources, multiple-VM tests help indicate the ability of ESX to manage resources between VMs.

During tests using four VMs, the team reduced the amount of RAM per VM from 8 GB to 7.5 GB; otherwise, performance would have degraded because of a lack of memory resources for ESX. This reduction in RAM for the VMs actually helped increase performance, providing the necessary headroom for ESX to have its own dedicated resources and avoiding the need for it to compete with the VMs.

Figure 4 shows the results of increasing the number of VMs with one vCPU each, with performance again measured in OPM. These VMs scaled well. In the four-VM test, only half of the server's total processing power was assigned to VMs, while almost all of the RAM was. Linear scalability would have resulted in each of the four VMs individually providing the same performance as a single VM running on its own. In these tests, four VMs handled an average of 10,766 OPM each, 12 percent lower than the 12,254 OPM handled by a single VM.

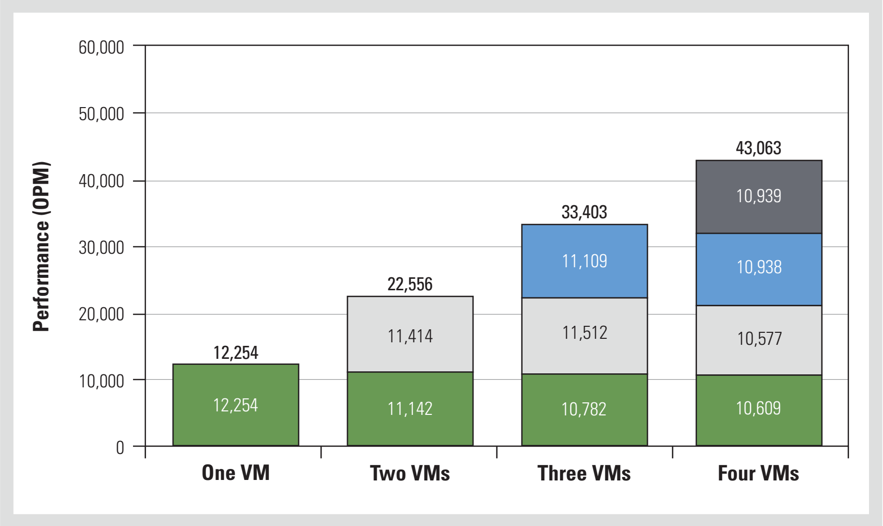

Figure 4. *Performance when increasing the number of VMs with one vCPU each*

Figure 5 shows the results of increasing the number of VMs with two vCPUs each, which also demonstrated good scalability. In the four-VM test, all of the server's processing power and almost all of its RAM were assigned to VMs. In these tests, four VMs handled an average of 13,740 OPM, 19 percent lower than the 16,939 OPM handled by a single VM.

Figure 6 shows the results of increasing the number of VMs with four vCPUs each. In these tests, running three or four VMs required sharing physical processor cores between VMs, and the results clearly show that the processor became a bottleneck at this point: total OPM did not increase even though each VM had its own memory and disk resources. Each VM did achieve approximately the same performance in all tests, however, which suggests that ESX effectively managed server resources across the VMs.

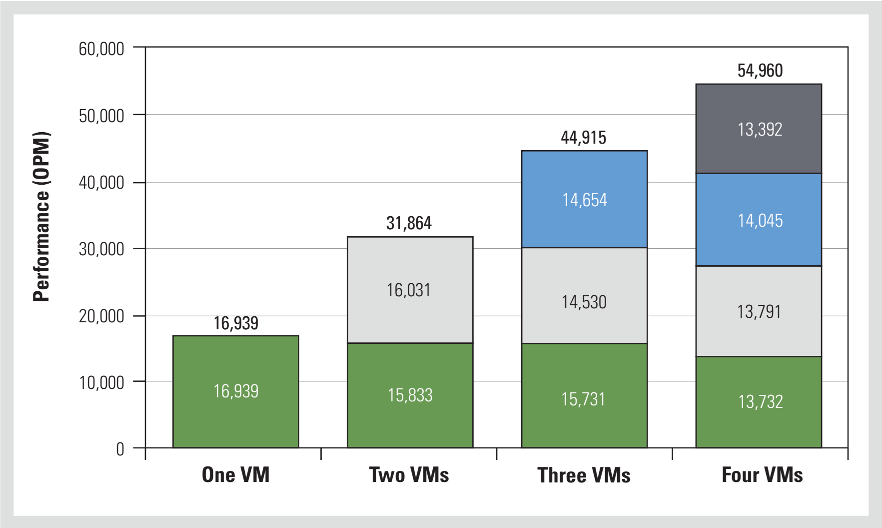

Figure 5. Performance when increasing the number of VMs with two vCPUs each

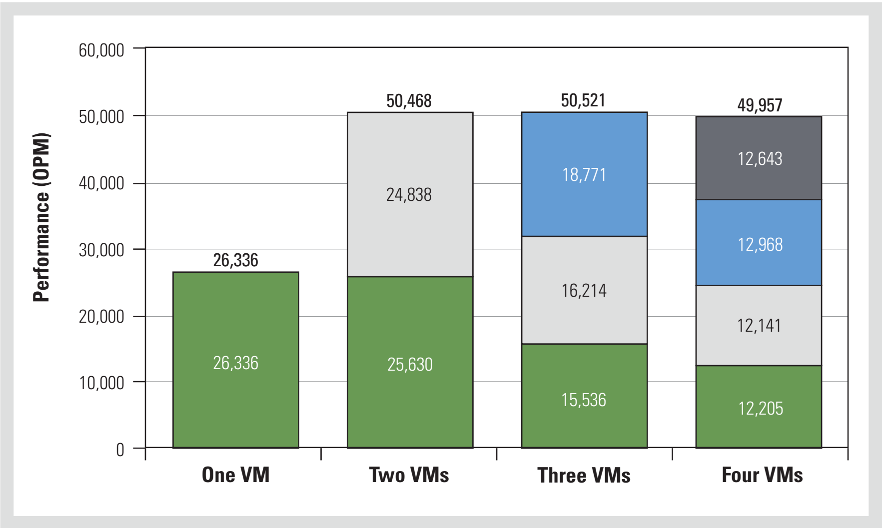

Figure 6. Performance when increasing the number of VMs with four vCPUs each

VM migration

To create a strenuous VMotion test, the test team put a VM with one, two, or four vCPUs under moderate stress of approximately 40 percent processor utilization, intended to model an average load rather than the high end of an acceptable utilization range. They achieved this level of utilization by increasing the number of DVD Store driver threads for each VM until they reached the target range, using four threads for the VM with one vCPU, five threads for the VM with two vCPUs, and eight threads for the VM with four vCPUs. They then migrated each VM every 12 minutes during a 90-minute period, using a Java program written using the Virtual Infrastructure Software Development Kit (SDK) to automate the VMotion events and help ensure that the events occurred at the same interval for all tests. The test team recorded VM performance during the VMotion events using Microsoft Windows® Performance Monitor (perfmon) in combination with VMware VirtualCenter performance monitoring and the output from the DVD Store driver program.

After a command to migrate a VM using VMotion is issued, the ESX servers prepare for the move, and the VM typically remains fully available. Only at the very end of the VMotion operation, when the VM actually moves, does the VM become inaccessible. This time should be very brief—typically less than one second—and undetectable to both users and applications.

For the VMotion tests, the team measured the time to complete a VMotion migration from the time the command was issued until the VM was on the new server. All VMotion migrations completed successfully without errors or warnings; the Windows Event Log and SQL Server error logs were clear of errors as well. Figure 7 shows the average time for each VM configuration: 1:49 for a VM with one vCPU, 2:04 for a VM with two vCPUs, and 3:06 for a VM with four vCPUs. The amount of time for a VMotion event to complete did increase as the number of vCPUs increased, in part because the increased workload kept each VM at approximately 40 percent processor utilization.

To measure the impact of these migrations on performance, the test team ran each VM with the same number of threads as the previous tests both with and

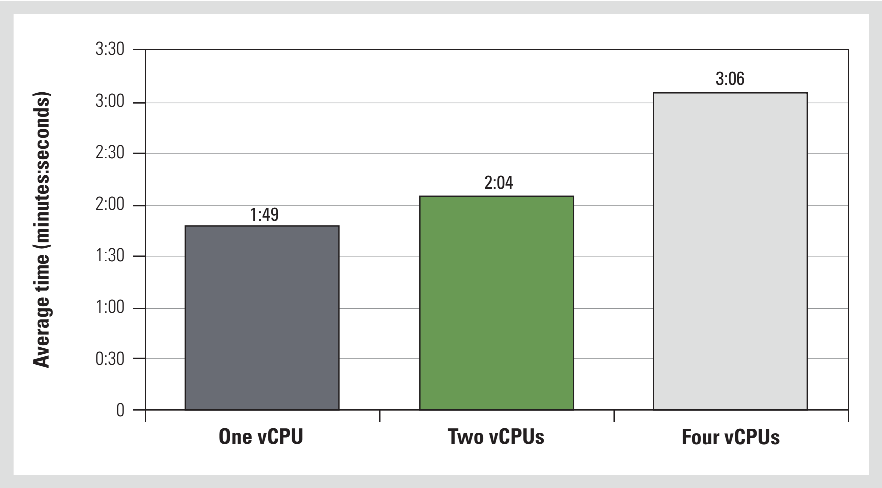

Figure 7. *Average time when migrating VMs between two identically configured servers*

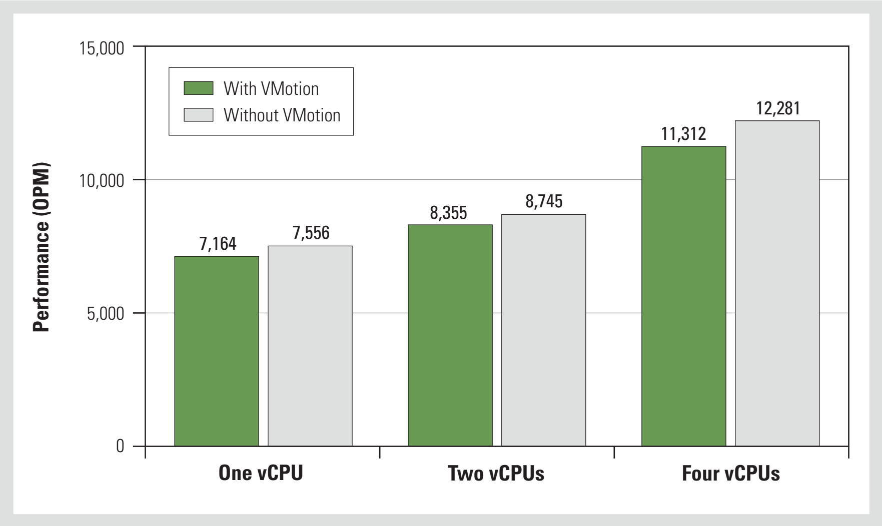

Figure 8. *Performance for individual VMs both with and without VMotion migration*

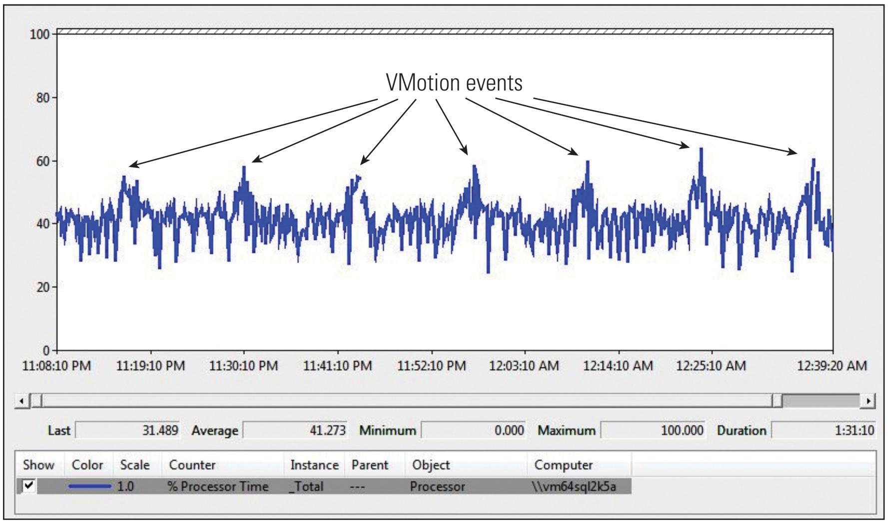

Figure 9. *Microsoft Windows perfmon graph of processor utilization for a VM with two vCPUs during a VMotion test*

without a VMotion migration. Figure 8 shows the results, which demonstrate that the VMotion migrations had only a minimal impact on performance. Figure 9 provides another way to see the impact of VMotion events, showing the visible increase in processor utilization with each VMotion event.

MICROSOFT SQL SERVER IN A VIRTUALIZED ENVIRONMENT

As the Dell tests indicate, Microsoft SQL Server 2005 can perform well when running on a virtualized Dell PowerEdge server: doubling the number of vCPUs from two to four increased performance by over 50 percent, while performance increases were near linear when increasing the number of VMs until the server processor became a bottleneck. VMotion migrations on VMs under load had only minimal impact on performance. These results can help organizations understand the type of performance and configuration considerations that they should take into account when planning a virtualized SQL Server 2005 deployment in their own environments.

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