

Microsoft SQL Server 2005 Virtualization in the Dell Scalable Enterprise

The Dell scalable enterprise architecture uses industry-standard components to help simplify operations, improve resource utilization, and scale cost-effectively. Virtualization technology is advancing IT infrastructure standards by abstracting software from hardware, which can facilitate deployment and management of software in the scalable enterprise. To demonstrate this, the Dell Scalable Enterprise Technology Center deployed Microsoft® SQL Server™ 2005 software in a virtualized environment.

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Virtualization can enable enterprise IT organizations to easily create new virtual systems in minutes, but such systems should still be deployed in a controlled and manageable manner, similar to how physical systems are deployed. The Dell Scalable Enterprise Technology Center used a farm of servers running VMware® ESX Server™ software to manage a deployment of Microsoft SQL Server 2005 virtual machines (VMs). This article provides an introduction to current virtualization products and SQL Server 2005 in a virtualized environment. It also includes best practices for managing a virtualized server farm, example usage scenarios for virtualization and SQL Server 2005, and basic performance results from testing SQL Server 2005 in a virtualized environment.

Defining the Dell scalable enterprise

The Dell scalable enterprise strategy focuses on standardizing core elements of IT infrastructures to help simplify

operations, improve utilization, and enable cost-effective scaling. Using virtualization technology to implement Microsoft SQL Server 2005 can help deliver all three of these benefits:

- **Simplified operations:** Managing VMs can be, in some ways, much easier than managing physical systems. Adding a virtualized layer provides a key advantage—portability. A VM can be moved from one server to another without any changes in configuration because the virtualization layer remains the same. Additionally, deploying VMs is a software-only task once the physical hosts running the virtualization layer are set up. Administrators can also quickly create a clone of an existing VM to take advantage of an existing application setup without having to perform a second installation and configuration on another system.

- **Improved utilization:** One common use of virtualization is server consolidation, which is intended to improve utilization of existing server resources. The ability to run many VMs on a single physical server can help greatly reduce the number of physical servers while improving utilization.
- **Cost-effective scaling:** Virtualization can help make adding capacity easy and cost-effective. The high level of utilization of existing resources and the ease of management allow each new server added to the virtualization server farm to be fully utilized quickly—which, because of the portability advantages, enables IT functions using virtualization to grow quickly and take advantage of the latest technology.

Understanding virtualization technology

Different forms of server virtualization have been available on expensive proprietary systems for decades. In the last five years, server virtualization technology for industry-standard Intel® processor-based servers has matured and is now widely used. The availability of virtualization technology on industry-standard Intel Xeon® processor-based servers has made this cost-effective technology accessible to enterprises of all sizes.

Microsoft and VMware are leading vendors of virtualization products today. Both have products that are installed as an application on top of an existing OS that then allows the creation of VMs on top of that OS. The Microsoft product, Microsoft Virtual Server, and the comparable VMware product, VMware Server, are both available as free downloads.

VMware also has a virtualization product called ESX Server, which loads directly onto the hardware instead of being hosted on an OS. Administrators can use ESX Server to create VMs that host guest operating systems without the overhead of a host OS. ESX Server provides features such as wizard-based cloning, centralized management of VMs, and live migration of VMs from one physical server to another.

ESX Server 3 is sold as part of a bundle called Virtual Infrastructure 3 Enterprise Edition, which includes ESX Server 3, VirtualCenter 2, the VMotion™ feature, the Virtual SMP™ feature, resource load balancing, consolidated backup, and high availability. This bundle of products is designed to allow flexible use of virtualization and provides many features needed to support production-level applications.

Using Microsoft SQL Server 2005 in a virtualized environment

Microsoft SQL Server 2005 introduces many features and tools that administrators may find useful. As with any migration of critical data, however, administrators should thoroughly test these features

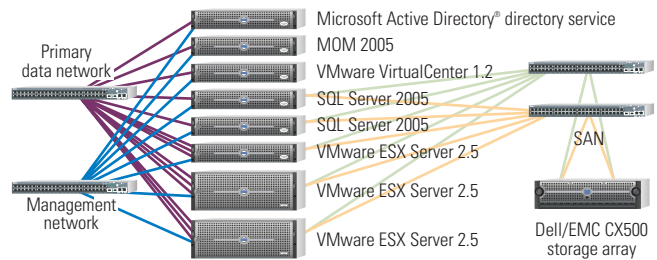


Figure 1. Dell Scalable Enterprise Technology Center virtualization architecture

before upgrading existing SQL Server 2000 databases or deploying new databases. Key features included with SQL Server 2005 are enhanced support for business intelligence, tight integration with Microsoft Visual Studio® 2005 software, and database mirroring. Virtualization can be used to create a test and development environment for SQL Server 2005 where these features can be tested.

To demonstrate the advantages of managing virtualized SQL Server 2005 on Dell™ PowerEdge™ servers, the Scalable Enterprise Technology Center set up VMs (see Figure 1) to test scenarios such as creating test and development environments, implementing disaster recovery, and consolidating servers. This section discusses how such environments can be monitored; the “Studying example virtualization usage cases” section describes each of these scenarios.

Management tools for virtual machines

Microsoft and VMware both provide tools to manage the VMs created using their respective products. The Microsoft Virtual Server administrative Web console provides tools for creating and modifying the VMs on an individual server. VMware Server comes with a similar administrative console to manage VMs on an individual server; ESX Server also has a Web interface for this purpose. Additionally, VMware offers VirtualCenter, which can be used to manage and monitor VMware-based VMs across an enterprise. VirtualCenter offers more advanced management capabilities than the previously mentioned management tools, such as the abilities to clone VMs and to move VMs from one physical server to another.

The Dell server management tool, Dell OpenManage™ Server Administrator (OMSA), can be loaded on servers using Microsoft Virtual Server, VMware Server, or VMware ESX Server. With the first two products, OMSA is installed on the host OS and interfaces with the Dell server hardware as usual. In the case of ESX Server, the Linux® OS version of OMSA is used, but a few changes have been made to account for the differences between Linux and ESX Server.¹

Microsoft Operations Manager (MOM) also plays a significant role in managing these virtual environments. One of the primary

¹ For more information, see the *VMware ESX Server 2.5.2 Software for Dell PowerEdge Servers Deployment Guide*, by Dell Inc., www.dell.com/downloads/global/solutions/vmware_252_deployment_guide.pdf.

functions of MOM is to monitor the virtualized operating systems and applications running on the VMs. It can also monitor the virtualization layer itself with the addition of Virtual Server or VMware management packs. Administrators should handle many of the detailed virtualization operations using the tools included with the individual products, but should use MOM to integrate the virtualization products into the same management process as other systems. Doing so can provide administrators with a comprehensive view of the entire IT infrastructure or data center.

Microsoft Operations Manager and associated management packs

The management tools that are included with ESX Server and Virtual Server are strictly for managing the virtual infrastructure used to run the VMs. To manage the operating systems and applications running on these VMs, administrators should apply the same methodology used in the rest of the scalable enterprise architecture: a single enterprise management console, standard deployment practices, and structured monitoring and alerting.

MOM provides a platform for administrators to manage not only the virtualization infrastructure (the hardware and software supporting virtualization), but also the applications running within the virtualized environment. The Scalable Enterprise Technology Center configured MOM with the Virtual Server management pack and the eXc Software Virtual Agent with VMware management pack to monitor its environment. The SQL Server management pack was also loaded to support monitoring of the SQL Server 2005 databases loaded onto the VMs.

In addition to these management packs, the Dell OpenManage management pack allows MOM to receive alerts based on server hardware health. This functionality enables MOM to be aware of hardware-level issues in addition to OS- and application-level information, enabling administrators to obtain a comprehensive view of their environment. Figure 2 shows the management packs used in the Scalable Enterprise Technology Center for this project.

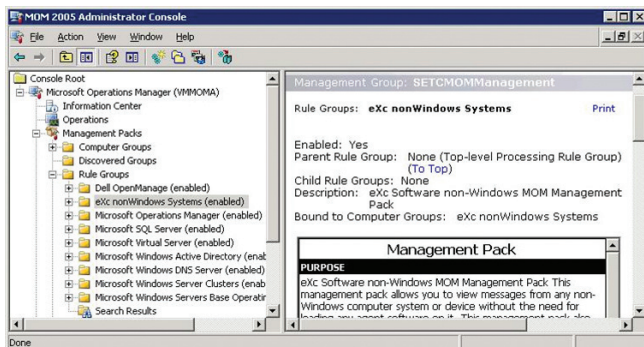


Figure 2. MOM 2005 Administrator console showing management packs for virtualization, SQL Server, and more

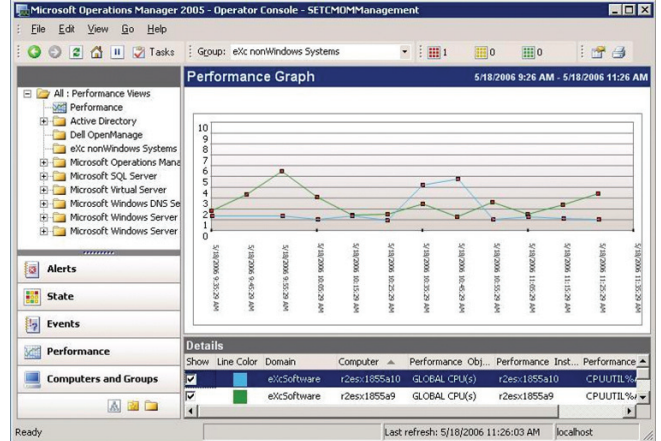


Figure 3. MOM 2005 Operator console showing CPU utilization of two servers running ESX Server

Planning and policies for virtual machines

Creating and deploying a new VM is relatively easy, and can cost much less to deploy than a physical server. These advantages do not remove the need for management, nor eliminate the cost of the physical server that is hosting the VM. IT organizations should deploy virtualization in a controlled, managed manner and treat VMs just like physical servers except when there is a significant reason to take advantage of a virtualization feature. The following policies can be established for a virtualization server farm:

- Justification for new VMs should be approved using the same process as for new physical servers.
- MOM should be used to monitor ongoing operations on every VM.
- VM cloning should be used whenever possible to help reduce the time required to configure a system.
- VMs should be the default option for a new server deployment, with exceptions made only when sufficient justification for a new physical server is provided.

Performance monitoring

Administrators can use several tools to monitor the performance of a virtualized environment. MOM provides a tool for overall performance monitoring, and can show performance for servers running ESX Server in the context of the entire environment (see Figure 3). VirtualCenter provides more detailed performance information than MOM, and should be used to obtain information about specific VMs and host servers. Additionally, administrators can use Microsoft Windows® Performance Monitor, the Linux version of the top tool, or other traditional OS-level tools within a VM to monitor application performance.

Studying example virtualization usage cases

Many usage models take advantage of the strengths of virtualization, including test and development, disaster recovery, and server consolidation. This section discusses these usage cases with SQL Server 2005 as the example application.

Test and development

SQL Server 2005 introduces several features, including integration with Visual Studio 2005 and support for the .NET common language runtime (CLR) within the database. This support allows database developers to use Transact-SQL, as with previous versions of SQL Server, as well as CLR languages such as the Microsoft Visual Basic® .NET or Visual C#® .NET languages to create their database applications.

To quickly create a large number of SQL Server 2005 test and development environments, the Scalable Enterprise Technology Center used a farm of servers running ESX Server to host a virtualized environment. A new clone was created in about 15 minutes using the existing Microsoft Windows Server® 2003 R2 OS master VM. SQL Server 2005 was then installed on the new VM, creating a SQL Server 2005 master VM to be used for creating all future SQL Server 2005 VMs. Installing SQL Server 2005 and creating the test database took approximately two hours. A script was then used to clone the SQL Server 2005 VM 16 times. Each clone creation took about 15 minutes to complete, with all 16 finishing in about four hours. To create and replicate a test and development environment for SQL Server 2005, all steps were completed in less than eight hours, with about half the time being handled by the vmclone script (available at www.dell.com/downloads/global/solutions/vmclone.zip).

A major feature introduced in SQL Server 2005, available with Service Pack 1 (SP1), is database mirroring. The Scalable Enterprise Technology Center set up and tested database mirroring with three SQL Server 2005 VMs running on the ESX Server farm. Database mirroring can be configured in several ways; in this example, a fully synchronous mirror with a witness was configured, which allows a SQL Server 2005 database to have changes written to both the primary and secondary systems at the same time and a third witness SQL Server 2005 instance to watch for failures and initiate automatic failover if necessary. If SQL Server is moved into production on a

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physical server, it may be beneficial in some environments to leave the secondary and witness databases on VMs. Doing so can help maintain high availability while using less hardware than if all three systems were moved to physical servers.

Disaster recovery

Each VM is stored on the server as a set of files: a configuration file, a disk file, and potentially a redo file. The configuration file contains information such as the amount of RAM, number of network interface cards (NICs), and disk file location. The disk file is basically the hard disk of the VM. In the case of servers running ESX Server, disk files are typically given a .vmdk or .dsk file extension. If the ESX Server incremental changes feature is used, a redo file stores all the changes made to the VM disk since the last time a snapshot was made. Because a complete VM is represented by these two or three files, it can easily be backed up.

But even more important for a disaster recovery scenario, the virtualization layer provides enhanced flexibility for the restore. Any server that runs ESX Server can be used as the server to which VMs are restored. Additionally, a server running ESX Server can be set up and waiting as a recovery server that can support systems that fail, which can help improve recovery time. Even if ESX Server must be installed first, the installation generally adds approximately 30 minutes to the recovery time.

SQL Server 2005 VMs are no different than other VMs in the case of disaster recovery. VMs can also use traditional backup agents and perform backups just like physical servers. These backups are typically performed for production databases to conform to existing policies and procedures already established in a data center for database backups. Additional LAN and storage area network (SAN) backup options are available for ESX Server, which can off-load server processing and help reduce the complexity that can be caused by backup agents installed on all VMs.²

The features and capabilities of VMware High Availability (VMware HA), part of Virtual Infrastructure 3, allows for automatic restarting of VMs that are affected by the failure of an ESX Server system. Affected VMs can be automatically restarted on a remaining ESX Server system in the server farm with spare capacity, which can help improve availability.

Server consolidation

Server consolidation is perhaps the most obvious benefit of running multiple VMs on a single physical server. Likely candidates for this type of consolidation are existing low-utilization servers and applications that have low to moderate performance requirements.

² For more information about these backup options, see "Using VMware ESX Server System and VMware Virtual Infrastructure for Backup, Restoration, and Disaster Recovery," by VMware, Inc., www.vmware.com/pdf/esx_backup_vip.pdf.

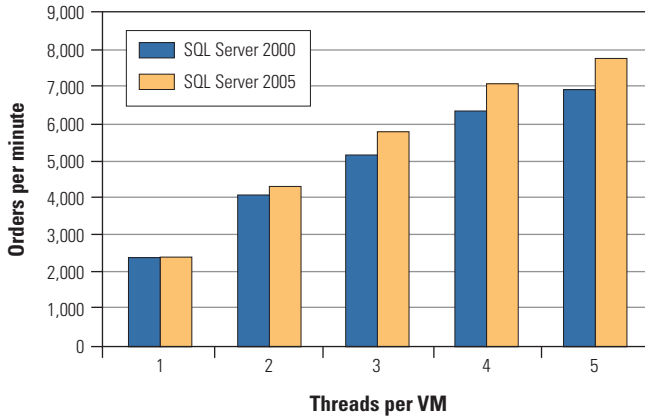


Figure 4. Orders per minute for SQL Server 2000 and SQL Server 2005

Many virtualization efforts start with these systems, and the reduction in total hardware requirements can help improve data center cost-effectiveness.

ESX Server provides a virtualized environment that can be used to run VMs at a reasonable level of performance. Dell has published several performance-based studies using ESX Server and a range of different types of VMs running a variety of applications that show high performance in a virtual environment.³

To investigate the performance of SQL Server 2005 in a server consolidation environment, in May 2006 the Scalable Enterprise Technology Center compared the performance of 15 VMs running SQL Server 2000 with 15 VMs running SQL Server 2005 on a Dell PowerEdge 2850 server with two dual-core Intel Xeon processors at 2.8 GHz and 8 GB of RAM. Each VM had the same configuration except for the version of SQL Server, with 512 MB of RAM, a 10 GB hard disk, and a vmxnet virtual Gigabit Ethernet⁴ NIC. ESX Server 2.5.2 was installed on the PowerEdge 2850 server, and Windows Server 2003 Enterprise Edition with SP1 was the guest OS on all the VMs. The number of VMs running on the server was set at 15, which was based on findings in the Dell white paper “VMware ESX Server Performance Gains on Dell PowerEdge 2850 Dual Core Servers.”⁵

The application used for testing was Dell DVD Store, which is available at linux.dell.com/dvdstore and has been released under the GNU General Public License. The DVD Store application includes build scripts and driver programs for testing on several databases, including SQL Server.

To simulate multiple small databases, the medium-size (approximately 1 GB) version of the DVD Store database was created. A separate PowerEdge 2650 server was used as the load driver system.

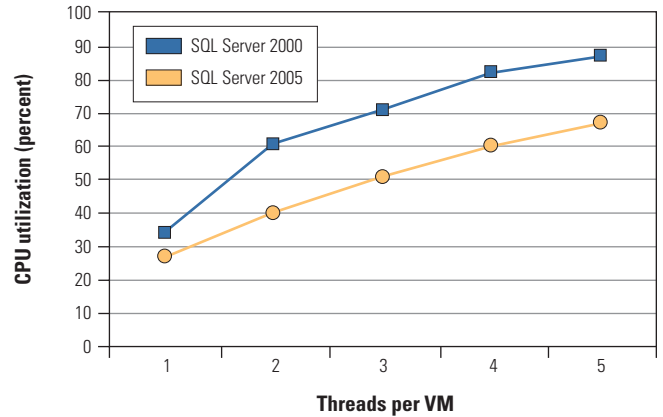



Figure 5. CPU utilization for SQL Server 2000 and SQL Server 2005

A separate driver program thread was started for each VM simultaneously, and the results from all drivers were captured and totaled to obtain the orders per minute for the server. The ESX Server CPU utilization was monitored with the `esxtop` utility.

The results of this test show that both SQL Server 2000 and SQL Server 2005 achieved a high rate of orders (or transactions) per minute, but SQL Server 2005 did so more efficiently than SQL Server 2000. Under the same load, the SQL Server 2005 VMs processed more orders per minute at a lower CPU utilization than the SQL Server 2000 VMs. Figures 4 and 5 show orders per minute and CPU utilization for the 15 VMs running simultaneously on a single PowerEdge 2850 server.

Implementing virtualization in scalable enterprise architectures

Virtualization can provide a key infrastructure layer that enables scalable enterprise architectures, and the ability to easily provision and copy environments is well suited for test and development endeavors. Running multiple VMs on the same server can help improve efficiency of resource use, which makes server consolidation a key motivation for implementing virtualization. Crucial to server virtualization is the ability to use management tools such as Microsoft Operations Manager and VMware VirtualCenter to centralize and consolidate views of the environment, which can help improve management and overall cost-effectiveness. 

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³ For more information, visit www.dell.com/vmware and select “White Papers.”

⁴ 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.

⁵ “VMware ESX Server Performance Gains on Dell PowerEdge 2850 Dual Core Servers,” by Todd Muirhead and Dave Jaffe, Ph.D., www.dell.com/downloads/global/solutions/esx_2850_dualcore.pdf.