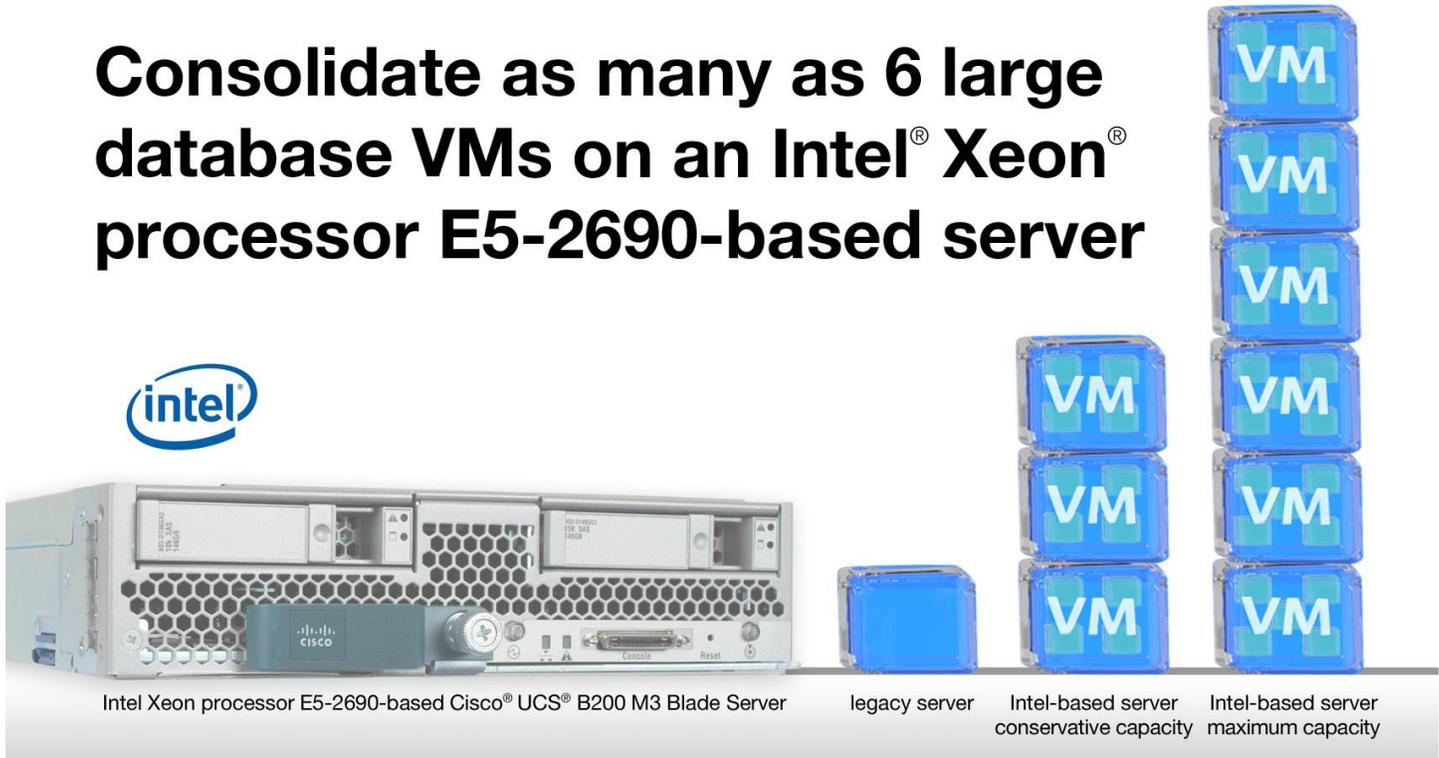


DATABASE SERVER CONSOLIDATION WITH AN INTEL® XEON® PROCESSOR E5-2690-BASED SERVER

Consolidate as many as 6 large database VMs on an Intel® Xeon® processor E5-2690-based server



If your organization runs database applications on multiple legacy servers, you are probably considering consolidating them through virtualization. Replacing your older servers with a single powerful new server running your applications in virtual machines (VMs) will bring savings in a variety of areas—space, power and cooling, licensing, maintenance time, and more. Because servers vary considerably in terms of how many legacy servers they can consolidate, it is essential you select the right one.

In tests in our labs, we consolidated multiple legacy servers onto an Intel Xeon processor E5-2690-based server. Under typical conditions at roughly 60 percent CPU utilization, the server comfortably supported the workload of three quad-core legacy servers in three VMs, all delivering strong and consistent database performance. Thanks to the improved I/O architecture of the Intel Xeon processor E5-2690, the server could consolidate as many as six legacy servers in VMs at 100 percent CPU utilization.



IMPROVED I/O ARCHITECTURE BOOSTS VIRTUALIZATION CAPACITY

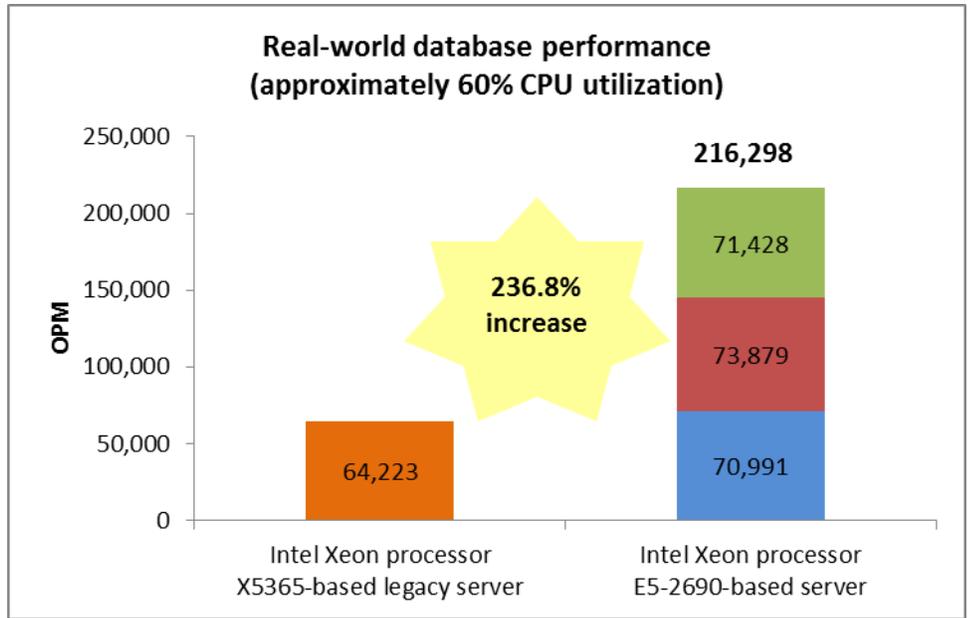
Migrating your older servers, each running a single application, to a single powerful server running virtual machines brings many advantages: you can save money on hardware, power consumption, and maintenance while improving reliability. To maximize these advantages, you need to select the best server for the job.

We migrated database applications running on multiple legacy servers to an Intel Xeon processor E5-2690-based Cisco® UCS® B200 M3 Blade Server. To determine how many quad-core Intel Xeon processor X5365-based legacy servers the new Intel Xeon processor E5-2690-based server could consolidate, we used the DVD Store Version 2.1 (DS2) benchmark with 10GB databases against our legacy server and then against increasing numbers of virtual machines on the Intel Xeon processor E5-2690-based Cisco UCS B200 M3 Blade Server.

We increased the number of virtual CPUs (vCPUs) until we reached approximately 60 percent CPU utilization, which reflects typical data center usage. With four vCPUs and 8 GB of vRAM per VM, the server comfortably supported three 10GB database servers. It did so without overcommitting resources, allowing all VMs to run in parallel.

As Figure 1 shows, the Intel Xeon processor E5-2690-based server running a typical workload at roughly 60 percent CPU utilization could handle 216,298 orders per minute (OPM), 236.8 percent more than the legacy server's 64,223 OPM. This performance win shows that the Intel Xeon processor E5-2690-based server could easily consolidate three legacy servers running at typical processor utilization, while delivering greater total performance.

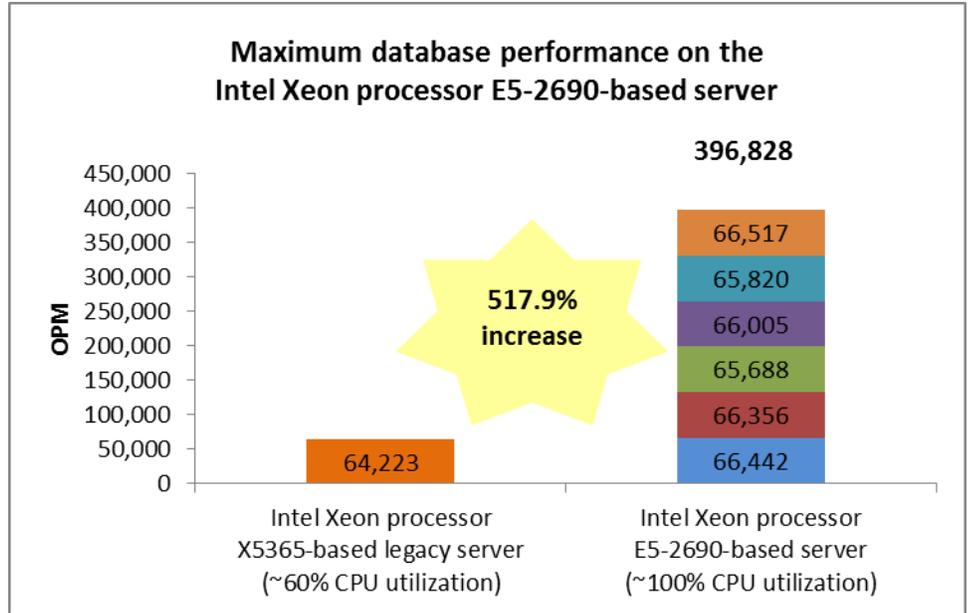
Figure 1. The Intel Xeon processor E5-2690-based server running at 60 percent CPU utilization could consolidate three legacy servers in three VMs, each of which delivered greater performance than the legacy server. The legacy server is also running at 60 percent CPU utilization.



Once we determined the typical consolidation ratio of the Intel Xeon processor E5-2690-based server, we worked to raise the CPU utilization from 60 percent to 100 percent to determine maximum consolidation potential, while still maintaining the threshold OPM in each VM set by our Intel Xeon processor X5365-based legacy server. To do so, we added one more vCPU, for a total of five, and increased the vRAM to 16 GB per VM. By fully utilizing the Intel Xeon processor E5-2690's performance headroom, the server was able to support the workload of six legacy servers in six VMs.

As Figure 2 shows, the Intel Xeon processor E5-2690-based server running at 100 percent CPU utilization could handle 396,828 OPM, 517.9 percent more than the legacy server's 64,223 OPM. This performance win shows that the Intel Xeon processor E5-2690-based server could easily consolidate six legacy servers running at 100 percent CPU utilization, while delivering greater total performance.

Figure 2. The Intel Xeon processor E5-2690-based server was able to consolidate six legacy servers (running at 60%) when the Intel Xeon processor E5-2690 is running at 100 percent CPU utilization.



WHAT WE TESTED

We used an Intel Xeon processor X5365-based legacy server (quad-core processor circa 2007) as our baseline system to determine the specifications for the virtual machines we ran on the Intel Xeon processor E5-2690-based server in our tests. Our test results show how many legacy servers we were able to consolidate on the newer server. For detailed configuration information about our legacy baseline system and our consolidation server, see [Appendix A](#).

We used VMware® vSphere® 5 to create the VMs on the servers, each of which ran a Microsoft SQL Server® 2008 R2 database in a Microsoft Windows Server® 2008 R2 guest operating system. To create the workload and test performance, we used the DVD Store Version 2.1 benchmark. We ran these tests three times and report the median run results. For step-by-step instructions on how we tested, see [Appendix B](#).

While we were running our performance tests, we recorded processor utilization on our legacy server using Windows Performance Monitor. On the Intel Xeon processor E5-2690-based server we used esxtop to track the system processor utilization for the ESX host based on the % Processor Time counter.

About DVD Store Version 2.1

To create our ecommerce workload, we used the DVD Store Version 2.1 (DS2) benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute (OPM) that the system could handle, to show what kind of

performance you could expect for your customers. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment. For more information about the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

WHAT WE FOUND

Figure 3 shows the OPM each VM on the Intel Xeon processor E5-2690-based server (three at roughly 60 percent CPU utilization and six at 100 percent CPU utilization) achieved. The OPM scores of all of the VMs are higher than the OPM score of the single SQL Server instance on the legacy server.

	Intel Xeon processor X5365-based legacy server (~60% CPU utilization)	Intel Xeon processor E5-2690-based server (~60% CPU utilization)	Intel Xeon processor E5-2690-based server (100% CPU utilization)
Non-virtualized SQL Server instance	64,223		
VM 1		70,991	66,442
VM 2		73,879	66,356
VM 3		71,428	65,688
VM 4			66,005
VM 5			65,820
VM 6			66,517
Total	64,223	216,298	396,828

Figure 3. The processing power and other capabilities of the Intel Xeon processor E5-2690-based server allowed all VMs to run with consistent performance greater than that of the single SQL Server instance on the legacy server.

SUMMARY

These results show an Intel Xeon processor E5-2690-based server's capacity for running virtual machines. This processor lets your enterprise easily handle three large database applications, effectively consolidating three older servers each running a single database application into one server running multiple instances. In addition, the Intel Xeon processor E5-2690-based server has headroom to handle three additional large database application virtual machines. The potential savings you can gain by consolidating legacy servers onto a new Intel Xeon processor E5-2690-based server are great: virtualizing with the new platform can reduce the cost of hardware, data center costs, power costs, and more.

APPENDIX A – SERVER AND STORAGE CONFIGURATION INFORMATION

Figure 4 provides detailed configuration information about the test servers.

System	Intel Xeon processor E5-2690-based server	Intel Xeon processor X5365-based legacy server
General		
Number of processor packages	2	2
Number of cores per processor	8	4
Number of hardware threads per core	2	1
System power management policy	OS Control	OS Control
CPUs		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2690	X5365
Stepping	6	B3
Socket type	LGA2011	LGA771
Core frequency (GHz)	2.90	3.00
Bus frequency	8.0 GT/s	1,333 MHz
L1 cache	32 KB + 32 KB	32 KB + 32 KB
L2 cache	256 KB (per core)	8 MB
L3 cache	20 MB	N/A
Platform		
Vendor and model number	Cisco UCSB-B200-M3	Intel custom system
Motherboard model number	Cisco FCH153271DA	Intel S5000PSL
BIOS name and version	Cisco B200M3.1.0.2.29c.121220110014 ver. 2.0 (1.104d)B	S5000.86B.15.00.0101.110920101604
BIOS settings	OS Power Control	OS Power Control
Memory module(s)		
Total RAM in system (GB)	256	8
Vendor and model number	Samsung M393B2G70BH0-YK0	Samsung M395T5750EZ4-CE66
Type	PC3L-12800R	PC2-5300
Speed (MHz)	1,600	666
Speed running in the system (MHz)	1,333	666
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-27	5-5-5-15
Size (GB)	16	2
Number of RAM module(s)	16	4
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual
Hard disk		
Vendor and model number	Seagate ST9146803SS	Western Digital WD2500JD-00GBB0
Number of disks in system	1	1
Size (GB)	146	232
Buffer size (MB)	16	8

System	Intel Xeon processor E5-2690-based server	Intel Xeon processor X5365-based legacy server
RPM	15,000	7,200
Type	SAS	SATA
RAID controller		
Vendor and model	Cisco UCS-VIC-M82-4P	QLogic™ QLE2462
Controller firmware	2.0(1.104d)	4.00.90
Operating system		
Name	VMware ESXi 5.0.0	Windows Server 2008 R2 Enterprise SP1
Build number	515841	7601
Language	English	English
Operating system power profile	Maximum Performance	Maximum Performance
Guest operating system		
Name	Windows Server 2008 R2 Enterprise SP1	N/A
Build number	7601	N/A
Language	English	N/A
Ethernet		
Vendor and model number	Cisco UCS-VIC-M82-4P	Intel PRO/1000 EB
Type	Mezzanine	Integrated

Figure 4. Server configuration information.

Figure 5 provides detailed configuration information about the blade enclosure.

Cisco UCS 5108 Blade Enclosure	
Power supplies	
Total number	4
Wattage of each (W)	2,500
Cooling fans	
Total number	8
Dimensions (h x w) of each	3-5/8" x 5-1/2"

Figure 5. Blade enclosure configuration information.

Figure 6 provides detailed configuration information about the storage we used for testing.

Storage system	
Total number of disks tested in solution	103
Storage connectivity (Fibre Channel, SAS, SATA, iSCSI)	Fibre Channel
Storage model and OS/firmware revision	EMC CX3-40
Storage memory	8 GB
Number of storage controllers	2
Number of storage ports	4

Figure 6. Storage configuration information.

APPENDIX B – DETAILED TEST METHODOLOGY

In this appendix, we present the steps we followed as we conducted our testing. To measure database performance, we used DVD Store 2.1.

Figures 7 and 8 present an overview of our test beds.

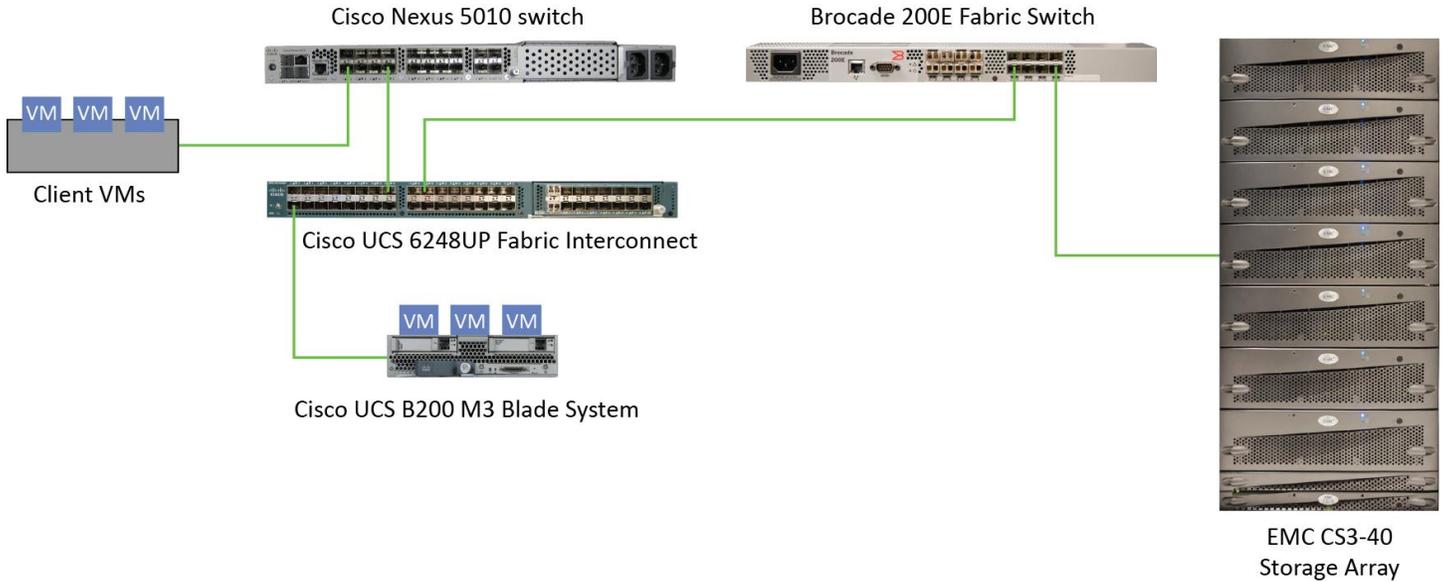


Figure 7. Our test bed setup for the Intel Xeon processor E5-2690-based server.

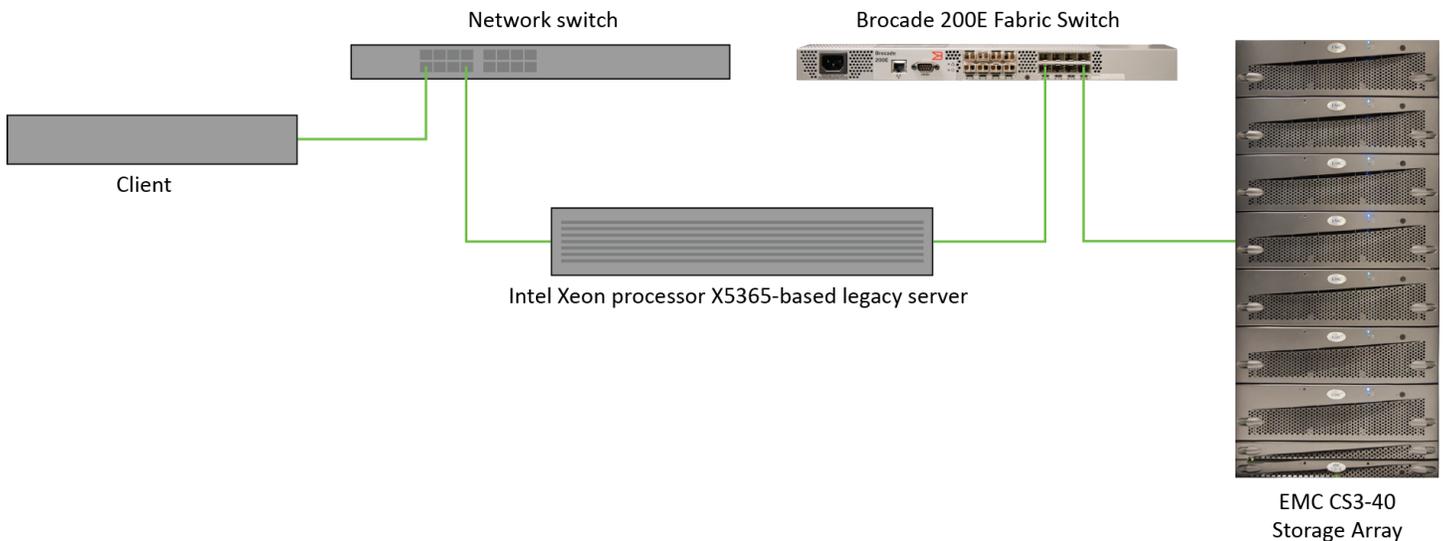


Figure 8. Our test bed setup for the Intel Xeon processor X5365-based legacy server.

Setting up and configuring the EMC storage

We used an EMC® CLARiiON® Fibre Channel-connected SAN for this testing. The CX3-40 has two storage processors, SP-A and SP-B. We cabled an HBA port to each SP (A and B) on the SAN to balance the load between SPs. We used seven enclosures of disks on the SAN; with one exception, each enclosure had 15 disks. One of the trays only had 13 disks.

We ran one SQL Server 2008 R2 instance per VM. We created eight RAID groups for our test server, one for VM operating systems and seven for VM databases/logs. Each of the six RAID groups was composed of 14 disks, and set up as a RAID 10. We then created eight 400GB LUNs, one on each RAID group.

Setting up and configuring the Intel Xeon processor E5-2690-based server

Installing VMware vSphere 5.0 (ESXi)

1. Insert the disk (or attach the ISO), and select Boot from disk.
2. On the Welcome screen, press Enter.
3. On the End User License Agreement (EULA) screen, press F11.
4. On the Select a Disk to Install or Upgrade Screen, select the relevant volume to install ESXi on, and press Enter.
5. On the Please Select a Keyboard Layout screen, press Enter.
6. On the Enter a Root Password Screen, assign a root password and confirm it by entering it again. Press Enter to continue.
7. On the Confirm Install Screen, press F11 to install.
8. On the Installation complete screen, press Enter to reboot.

Configuring ESXi

1. On the 5.0.0 ESXi screen, press F2, enter the root password, and press Enter.
2. On the System Customization screen, select troubleshooting options, and press Enter.
3. On the Troubleshooting Mode Options screen, select enable ESXi Shell, and press Enter.
4. Select Enable SSH, press Enter, and press Esc.
5. On the System Customization screen, select Configure Management Network.
6. On the Configure Management Network screen, select IP Configuration.
7. On the IP Configuration screen, select set static IP; enter an IP address, subnet mask, and default gateway; and press Enter.
8. On the Configure Management Network screen, press Esc. When asked if you want to apply the changes, type Y.

Installing vSphere client on a management workstation

1. Configure your management workstation to be on the same subnet as your vSphere server. In Internet Explorer, navigate to the IP address of your vSphere server.
2. Accept certificate warnings by clicking Continue to this website (not recommended), and continue.
3. Click Download vSphere Client to download the vSphere client.
4. Choose Run to Install.
5. Choose your language, and click OK.
6. At the Welcome screen, click Next.
7. Read the End-User Patent Agreement, and click Next.
8. Accept the license terms, and click Next.
9. Enter user and organization details, and click Next.
10. At the Destination folder screen, click Change if you wish to change your install destination; otherwise click Next.
11. Click Install.
12. To complete the installation, click Finish.

Configuring VM networking on ESXi

1. Using the vSphere client from your management workstation, connect to the ESXi server.
2. Add the necessary vSwitch for the network that DVD Store traffic will use:
 - a. Click the host, click the Configuration tab, and click Networking.
 - b. Click Add Networking.
 - c. Choose Virtual Machine, and click Next.
 - d. Choose create a vSphere standard switch.

- e. Choose the NIC associated with VM traffic.
- f. Assign the network label, and assign IP settings.
- g. Click Finish.

Configuring the external volumes in VMware vSphere 5.0

1. In the vSphere client, select the host.
2. Click the Configuration tab.
3. Click Storage, and click Add Storage...
4. Choose Disk/LUN.
5. Select the disk, and click Next.
6. Accept the default of VMFS-5 for the file system.
7. Review the disk layout, and click Next.
8. Enter the datastore name, and click Next.
9. Accept the default of using maximum capacity, and click Next.
10. Click Finish.
11. Repeat steps 3 through 10 for the remaining LUNs.

Creating a virtual machine with vSphere

1. In the vSphere client, connect to the vCenter Server and browse to the ESXi host.
2. Click the Virtual Machines tab.
3. Right-click, and choose New Virtual Machine.
4. Choose Custom, and click Next.
5. Assign a name to the virtual machine, and click Next.
6. Select the OS datastore on the external storage, and click Next.
7. Choose Virtual Machine Version 8, and click Next.
8. Choose Windows, and choose Microsoft Windows Server 2008 R2 (64-bit), and click Next.
9. Choose 6 virtual processors (1 virtual socket with 6 virtual cores per socket), and click Next.
10. Choose 16GB RAM, and click Next.
11. Click 1 for the number of NICs, select vmxnet3, and click Next.
12. Leave the default virtual storage controller, and click Next.
13. Choose to create a new virtual disk, and click Next.
14. Make the OS virtual disk size 30 GB, choose thick-provisioned lazy zeroed, specify the OS datastore on the external storage, and click Next.
15. Keep the default virtual device node (0:0), and click Next.
16. Click Finish.
17. Right-click the VM, and choose Edit Settings.
18. On the Hardware tab, click Add...
19. Click Hard Disk, and click Next.
20. Click Create a new virtual disk, and click Next.
21. Specify 40GB for the virtual disk size, choose thick-provisioned lazy zeroed, and specify the datastore for that VM's SQL Server data usage (storage pool 2).
22. Choose SCSI(0:1) for the device node, and click Next.
23. On the Hardware tab, click Add...
24. Click Hard Disk, and click Next.
25. Click Create a new virtual disk, and click Next.
26. Specify 20GB for the virtual disk size, choose thick-provisioned lazy zeroed, and specify the datastore for SQL Server log usage (storage pool 3).
27. Choose SCSI (1:0) for the device node, and click Next.
28. Click Finish, and click OK.

Installing Windows Server 2008 R2 SP1 Enterprise Edition on the VMs

1. Insert the installation DVD for Windows Server 2008 R2 x64 into the ESXi host's DVD drive.
2. In vSphere, right-click the virtual machine, and choose Edit Settings.
3. Click CD/DVD drive 1, click the Host Device radio button, and choose the appropriate drive.
4. Click OK.
5. Right-click the machine, and choose Power→Power On.
6. Right-click the machine, and choose Open console.
7. At the Language Selection Screen, click Next.
8. Click Install Now.
9. Select Windows Server 2008 R2 SP1 Enterprise (Full Installation), and click Next.
10. Click the I accept the license terms check box, and click Next.
11. Click Custom.
12. Click Drive options (advanced).
13. Ensure you select the proper drive, and click New.
14. Click Apply.
15. Click Next.
16. At the User's password must be changed before logging on warning screen, click OK.
17. Set the Administrator password, and click the arrow to continue.
18. At the Your password has been changed screen, click OK.

Installing VMware Tools on the VM

1. Right-click the virtual machine, select Guest→Install/Upgrade VMware Tools.
2. Click OK to close the VMware Tools warning.
3. Right-click the VM, and choose Open Console.
4. Double-click Run setup.exe
5. At the Welcome screen, click Next.
6. Select Typical Installation, and click Next.
7. Click Install.
8. After installation is complete, click Finish, and restart the virtual machine.

Installing system updates in Windows Server 2008 R2 SP1

We installed all updates available on December 14, 2011 on each virtual machine.

Setting up network configuration on the VM

1. Click Start→Control Panel.
2. Click Network and Internet.
3. Click View network status and tasks.
4. Click the Local Area Connection assigned to client/server network traffic.
5. Click Properties.
6. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
7. In the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
8. Enter a valid static IP address, subnet mask, and default gateway.
9. Click OK, and click Close to exit.

Installing SQL Server 2008 R2 SP1 on the VM

1. Load the SQL Server 2008 R2 iso on your computer or insert the DVD into the ESXi host's DVD drive.
2. Click the connect CD/DVD button. Choose CD\DVD Drive 1, Connect to host device.
3. On the Autoplay menu, click Run SETUP.EXE.
4. If the application prompts you to install the .NET Framework, click OK to install.

5. At the SQL Server Installation Center screen, select Installation.
6. Click New Installation or add features to existing installation.
7. At the Setup Support Rules page, click OK.
8. Enter the product key, and click Next.
9. At the License Terms screen, accept the license terms, and click Next.
10. At the Support Files screen, select Install.
11. At the Setup Support Rules screen, click Next.
12. At the Setup Role screen, select SQL Server Feature Installation, and click Next.
13. At the Feature Selection screen, choose Database Engine Services, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete, and click Next.
14. At the Installation Rules screen, click Next.
15. At the Instance Configuration screen click Next.
16. At the Disk Space Requirements screen, click Next.
17. At the Server Configuration screen, type Administrator as the account name and Password1 as the password for the SQL Server Agent and the SQL Server Database Engine services, and click Next.
18. At the Database Engine Configuration screen, select Mixed Mode as the authentication mode, enter your password for the (sa) account, and click Add Current User to add the Administrator to the SQL server administrator's account. Click Next.
19. At the Error Reporting screen, click Next.
20. At the Installation Configuration Rules screen, click Next.
21. At the Ready to Install screen, click Install.
22. At the Complete screen, click Close.
23. Create a SQL Server login for the ds2user (see the [Configuring the database server \(DVD Store\) section](#) for the specific script to use).
24. Copy the pre-created DVD Store backup to the specified backup VHD volume.
25. Click Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools, and click SQL Server Configuration Manager.
26. Expand SQL Server Network Configuration, and click Protocols for MSSQLSERVER.
27. Right-click TCP/IP, and select Enable.
28. Download and install Microsoft SQL Server 2008 R2 SP1.

Setting up vCenter Server

We used vCenter Server solely to clone our VMs. If you want to clone your VMs using a different utility, skip this section.

1. Install ESXi on a utility server using the instructions above.
2. Import the OVF containing the vCenter Server appliance from VMware.
3. Start the vCenter Server and perform basic installation steps, such as setting the name, IP, credentials, etc.
4. Connect to the vCenter Server VM via the vSphere client, create a cluster, and add the Cisco B200 M3 to the cluster.

Configuring additional VMs on VMware vSphere 5.0

1. Log into the vCenter Server, which manages the host.
2. Right-click the first VM, and choose Clone.
3. Name the new VM.
4. Choose the cluster, and select the host.
5. For the storage screen, choose advanced and direct the new virtual disks to the applicable datastores. Again, we used a round-robin approach to spread our VM database files to the first 6 of the 8 LUNs. For example, the database for VM 1 was placed on LUN 1, the database for VM2 was placed on LUN 2, and so on.

6. Choose to customize using the customization wizard. Save the clone details as a new customization specification.
7. Continue cloning each VM, modifying the customization specification as necessary for IP addressing and other settings.
8. Ensure in each VM that the necessary virtual disks are all online and the IP addressing was properly assigned by the customization wizard.
9. To configure automatic start for your specified number of VMs, click the Host configuration tab in the vSphere client, and click Virtual Machine Startup/Shutdown.

Setting up and configuring the legacy system

Installing Windows Server 2008 R2 SP1 Enterprise Edition

1. Insert the installation DVD for Windows Server 2008 R2 x64 into the DVD drive.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 SP1 Enterprise (Full Installation), and click Next.
5. Click the I accept the license terms check box, and click Next.
6. Click Custom.
7. Click Drive options (advanced).
8. Ensure you select the proper drive, and click New.
9. Click Apply.
10. Click Next.
11. At the User's password must be changed before logging on warning screen, click OK.
12. Set the Administrator password, and click the arrow to continue.
13. At the Your password has been changed screen, click OK.

Installing system updates in Windows Server 2008 R2 SP1

We installed all updates available on December 14, 2011 on each virtual machine.

Setting up network configuration

1. Click Start→Control Panel.
2. Click Network and Internet.
3. Click View network status and tasks.
4. Click the Local Area Connection assigned to client/server network traffic.
5. Click Properties.
6. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
7. In the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
8. Enter a valid static IP address, subnet mask, and default gateway.
9. Click OK, and click Close to exit.

Installing SQL Server 2008 R2 SP1 on the server

1. Insert the DVD into the DVD drive.
2. On the Autoplay menu, click Run SETUP.EXE.
3. If the application prompts you to install the .NET Framework, click OK to install.
4. At the SQL Server Installation Center screen, select Installation.
5. Click New Installation or add features to existing installation.
6. At the Setup Support Rules page, click OK.
7. Enter the product key, and click Next.
8. At the License Terms screen, accept the license terms, and click Next.
9. At the Support Files screen, select Install.

10. At the Setup Support Rules screen, click Next.
11. At the Setup Role screen, select SQL Server Feature Installation, and click Next.
12. At the Feature Selection screen, choose Database Engine Services, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete, and click Next.
13. At the Installation Rules screen, click Next.
14. At the Instance Configuration screen click Next.
15. At the Disk Space Requirements screen, click Next.
16. At the Server Configuration screen, type `Administrator` as the account name and `Password1` as the password for the SQL Server Agent and the SQL Server Database Engine services, and click Next.
17. At the Database Engine Configuration screen, select Mixed Mode as the authentication mode, enter your password for the (sa) account, and click Add Current User to add the Administrator to the SQL server administrator's account. Click Next.
18. At the Error Reporting screen, click Next.
19. At the Installation Configuration Rules screen, click Next.
20. At the Ready to Install screen, click Install.
21. At the Complete screen, click Close.
22. Create a SQL Server login for the `ds2user` (see the [Configuring the database server \(DVD Store\) section](#) for the specific script to use).
23. Copy the pre-created DVD Store backup to the specified backup VHD volume.
24. Click Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools, and click SQL Server Configuration Manager.
25. Expand SQL Server Network Configuration, and click Protocols for MSSQLSERVER.
26. Right-click TCP/IP, and select Enable.
27. Download and install Microsoft SQL Server 2008 R2 SP1.

Running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. We tracked the DVD Store orders-per-minute metric with Windows Performance Monitor, which is a running average calculated through the test. In this report, we report the last OPM reported by each client/target pair.

Each complete test cycle consisted of the general steps listed below. For each scenario, we ran three test cycles, and chose the median outcome.

1. Clean up prior outputs from the host system and all client driver systems.
2. Drop all databases from all target VMs.
3. Restore all databases on all target VMs.
4. Shut down all VMs.
5. Reboot the host system and all client systems.
6. Wait for a ping response from the server under test (the hypervisor system), all client systems, and all VMs.
7. Let the test server idle for ten minutes.
8. Start Performance Monitor on all clients.
9. Start the DVD Store driver on all respective clients.

We used the following DVD Store parameters for testing the virtual machines in this study:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=15 --  
n_threads=16 --db_size=10GB --detailed_view=Y --warmup_time=5 --  
pct_newcustomers=20
```

Configuring the database (DVD Store)

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 10GB database size and the database platform on which we ran: Microsoft SQL Server. We ran the Install.pl script on a utility system running Linux. The Install.pl script also generated the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2008 R2 SP1. We built the 10GB database in SQL Server 2008 R2 SP1, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore on both servers between test runs. We performed this procedure once, and used the same backup file for both VMware vSphere 5.0 VMs and the legacy server.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Besides this file size modification, the database schema was created and loaded according to the DVD Store documentation. Specifically, we followed the steps below:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 10GB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
    DEFAULT_DATABASE=[master],
    DEFAULT_LANGUAGE=[us_english],
    CHECK_EXPIRATION=OFF,
    CHECK_POLICY=OFF
GO
```

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.

12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Figure 9 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
Database files		
Primary	PRIMARY	3
cust1	DS_CUST_FG	5,632
cust2	DS_CUST_FG	5,632
ind1	DS_IND_FG	2,560
ind2	DS_IND_FG	2,560
ds_misc	DS_MISC_FG	2,560
orders1	DS_ORDERS	2,560
orders2	DS_ORDERS	2,560
Log files		
ds_log	Not Applicable	13,312

Figure 9. Our initial file size modifications.

ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.
1007 Slater Road, Suite 300
Durham, NC, 27703
www.principledtechnologies.com

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