



SQL Server consolidation: Replacing eight legacy servers with one Cisco UCS B200 M1 Blade Server

Executive summary

Cisco Systems®, Inc. (Cisco) commissioned Principled Technologies (PT) to see how many legacy servers we could replace with one Cisco UCS B200 M1 Blade Server using VMware vSphere™ 4 (vSphere).

We tested the following two servers:

- Cisco UCS B200 M1 Blade Server with Intel® Xeon® Processor X5570 (Cisco UCS B200 M1 Blade Server)
- HP ProLiant DL380 G4 server with Intel Xeon processor 3.6 GHz (legacy server)

As Figure 1 shows, the Cisco UCS B200 M1 Blade Server provides a performance consolidation factor of eight. One Cisco UCS B200 M1 Blade Server with VMware vSphere can replace eight legacy servers. We define the number of legacy servers the Cisco UCS B200 M1 Blade Server replaced based on the Microsoft® SQL Server® performance running DVD Store Version 2. We explain the scores in more detail in the Test results section below.

For testing, the Cisco UCS B200 M1 Blade Server ran Microsoft Windows Server® 2008 x64 with Microsoft SQL Server 2008, while the legacy server ran Microsoft Windows Server 2003 with Microsoft SQL Server 2005. We used an older version of Microsoft Windows Server and SQL Server on the legacy server because we assume a 3- to 5-year old server would run an older version of the operating systems and SQL Server. The goal of this report is to show that one Cisco UCS B200 M1 Blade Server can replace eight legacy systems and achieve greater performance.

Workload

To build the workload, we used DVD Store Version 2 (DS2). DS2 is an open-source simulation of an online e-commerce DVD store, where customers log in, browse, and order products. DS2 has database components and Web server components, and includes driver programs that put heavy loads on these components. We used the included driver program to stress the database component. Each blade server under test ran multiple Microsoft SQL Server 2008 workloads, one per VM. One copy of the DS2 database was on each VM, with a 10GB database per VM. By combining multiple virtual machines, all running a CPU, memory, and disk-intensive

workload, the test placed a heavy load on both the server and the storage. Thus, it measured the performance of the blade server, especially as it relates to an active online transaction processing (OLTP) environment. The main DS2 metric is orders per minute (OPM), which the driver program calculates and reports via the Windows Performance Monitor utility on the client machines. We used the output from the driver program to record OPM, and we report the last OPM score the benchmark reported.

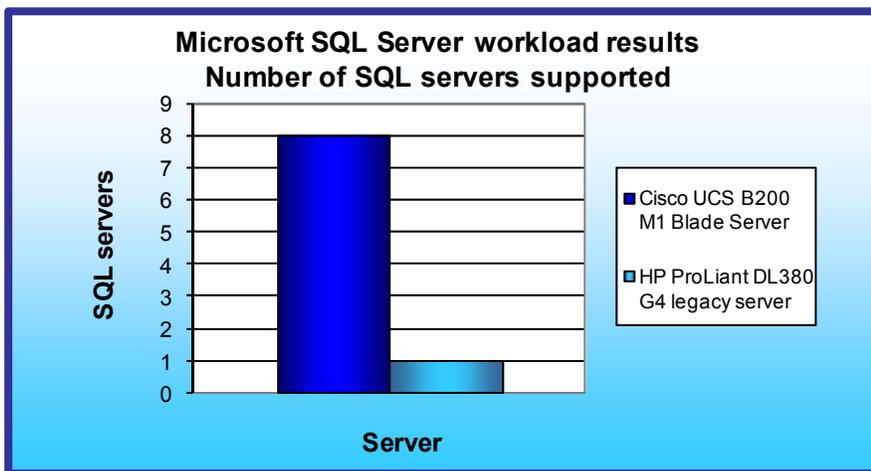


Figure 1: SQL Server performance consolidation results for the servers. Higher numbers are better. (The legacy server ran a single, non-virtual version of the SQL Server test.)

When DS2 is executing, simulated customers log in;

KEY FINDING

One Cisco UCS B200 M1 Blade Server with VMware vSphere can replace eight legacy servers running SQL Server. (See Figure 1.)

browse movies by actor, title, or category; and purchase movies. Each DS2 order consists of a customer login, a number of searches for movies, and a purchase. Each search is by either title, actor, or category. The title and actor searches use full-text search. The other customer actions, including adding new customers, exercise a wide range of database functions.

As we note above, because our goal was to isolate and test database server performance, we did not use the front-end Web client component of DS2. Instead, we ran the included driver application on client machines directly via its command-line interface. We used the default DS2 parameters and setup configuration, with the exceptions we note in the DVD Store setup section in the Test methodology section of this report.

Each client machine ran a single instance of DS2, with 32 threads, and the legacy server ran a single instance of DS2, with 10 threads. This simulated a heavily loaded environment; the load-generating client machines ran with no think time, blasting requests as quickly as the servers could handle them.

The DS2 driver application creates an orders-per-minute performance counter on the client VM. While the DVD Store client application outputs OPM at 10-second intervals visually, we chose to collect this OPM metric via a performance monitor counter on each client VM at 1-second intervals.

We ran this workload on the Cisco UCS B200 M1 Blade Server's virtual machines simultaneously for 30 minutes. We considered a server to have delivered acceptable performance if the minimum OPM result on every VM at the end of the test was above the legacy server OPM.

For more details about the DS2 tool, see <http://www.delltechcenter.com/page/DVD+Store>.

System comparison

Figure 2 shows a side-by-side comparison of the key hardware differences between the Cisco UCS B200 M1 Blade Server and the HP ProLiant DL380 G4 legacy server.

Hardware specifications	Cisco UCS B200 M1 Blade Server	HP ProLiant DL380 G4 legacy server
CPU	Intel Xeon X5570	Intel Xeon 3.6 GHz
CPU speed (GHz)	2.93	3.60
Number of processor packages	2	2
Number of cores per processor package	4	1
Number of hardware threads per core	2	2
Memory type	DDR3 PC3-10600R	DDR2 PC2-3200
Total memory (GB)	96	4
Maximum supported memory (GB)	96	12

Figure 2: System configuration information for the Cisco UCS B200 M1 Blade Server and the HP ProLiant DL380 G4 legacy server.

Figure 3 shows the settings we used on the Cisco UCS B200 M1 Blade Server VMs for testing. Refer to the Test methodology section below for detailed steps of how we set up the VMs. The HP ProLiant DL380 G4 legacy server ran as a standalone server with no VMs.

VM specifications	VM settings
vCPU	2
Memory (GB)	8
Virtual NIC type	VMXNET 3
Number of virtual disks	3 (OS, SQL Logs, SQL database)

Figure 3: VM configuration information we used for testing.

Test results

Figure 4 shows the OPM results for the Cisco UCS B200 M1 Blade Server, by VM, and the legacy server, running as a standalone. The Cisco UCS B200 M1 Blade Server results show that all eight VMs achieved a higher OPM than the legacy server. Thus, the Cisco UCS B200 M1 Blade Server can replace eight legacy servers by providing equal or greater performance.

To determine the maximum number of simultaneous virtual machines the Cisco UCS B200 M1 Blade Server could handle, we added virtual machines until one or more had OPMs drop below the 16,135 threshold. We then subtracted one VM to identify the total number of VMs the server could handle. We performed three runs at the total number to verify the scores met these standards.

OPM	Cisco UCS B200 M1 Blade Server	HP ProLiant DL380 G4 legacy server
Virtual machine 1	16,587	16,135
Virtual machine 2	16,798	
Virtual machine 3	16,710	
Virtual machine 4	16,702	
Virtual machine 5	16,730	
Virtual machine 6	16,721	
Virtual machine 7	16,726	
Virtual machine 8	16,434	

Figure 4: OPMs from the median run for each virtual machine for the two servers. Higher numbers are better. (The legacy server ran a single, non-virtualized version of the DS2 test.)

Figure 5 shows the read, write, and total input/output operations per second (IOPS) for the median run of the two servers. Higher numbers are better, as they show that the system is handling more requests.

IOPS	Cisco UCS B200 M1 Blade Server	HP ProLiant DL380 G4 legacy server
Read	2,909.7	965.8
Write	5,825.8	549.2
Total	8,735.5	1,515.0

Figure 5: IOPS from the median run of the two servers. Higher numbers are better.

Test methodology

Setting up and configuring the EMC storage

We used an EMC® CLARiiON® Fibre Channel connected SAN for this testing. The CX4-240 has two Storage Processors, SP-A and SP-B. We used the integrated dual port host bus adapter (HBA) in the Cisco UCS B200 M1 Blade Server. We cabled one HBA port to each SP (A and B) on the SAN to balance the load between SPs. We used five enclosures of disks on the SAN; with one exception, each enclosure had 15 disks. We designated RAID 5 for the virtual machine OS LUN and RAID 10 for all other RAID group configurations.

We created one RAID group on the enclosure that had only five disks. We then created one logical unit number (LUN) on this RAID group for the virtual hard drives (VHDs) that would hold the operating systems for the virtual machines.

We created eight RAID groups for SQL Server database data. Each of these eight RAID groups was composed of six disks. We then created one 256GB LUN in each RAID group, for a total of eight LUNs dedicated to virtual machines to hold SQL Server database data. We used the EMC MetaLUN feature and assigned four LUNs to MetaLUN-1 and four LUNs to MetaLUN-2. To balance processing load and disk transfers, we assigned MetaLUN-1 to SP-A and MetaLUN-2 to SP-B.

We also created two more RAID groups for SQL Server Log data. Each of these RAID groups was composed of four disks. We then created one 536GB LUN in each RAID group, for a total of two LUNs dedicated to virtual machines to hold SQL Server log data. We assigned one log LUN to each SP. To balance processing load and disk transfers, we assigned Log-LUN-1 to SP-B and Log-LUN-2 to SP-A.

Figure 6 shows the configuration that we used to connect the EMC CLARiiON CX4-240 to the Cisco UCS B200 M1 for testing. For the legacy server, we installed a dual port QLogic QLA2462 in the server and connected it to the EMC CLARiiON CX4-240. We used one shelf of storage with 15 drives for the legacy server configuration. We configured the 14 of the 15 drives in two partitions. We configured one 4-disk RAID 10 volume for logs and one 10-disk RAID 10 volume for the database.

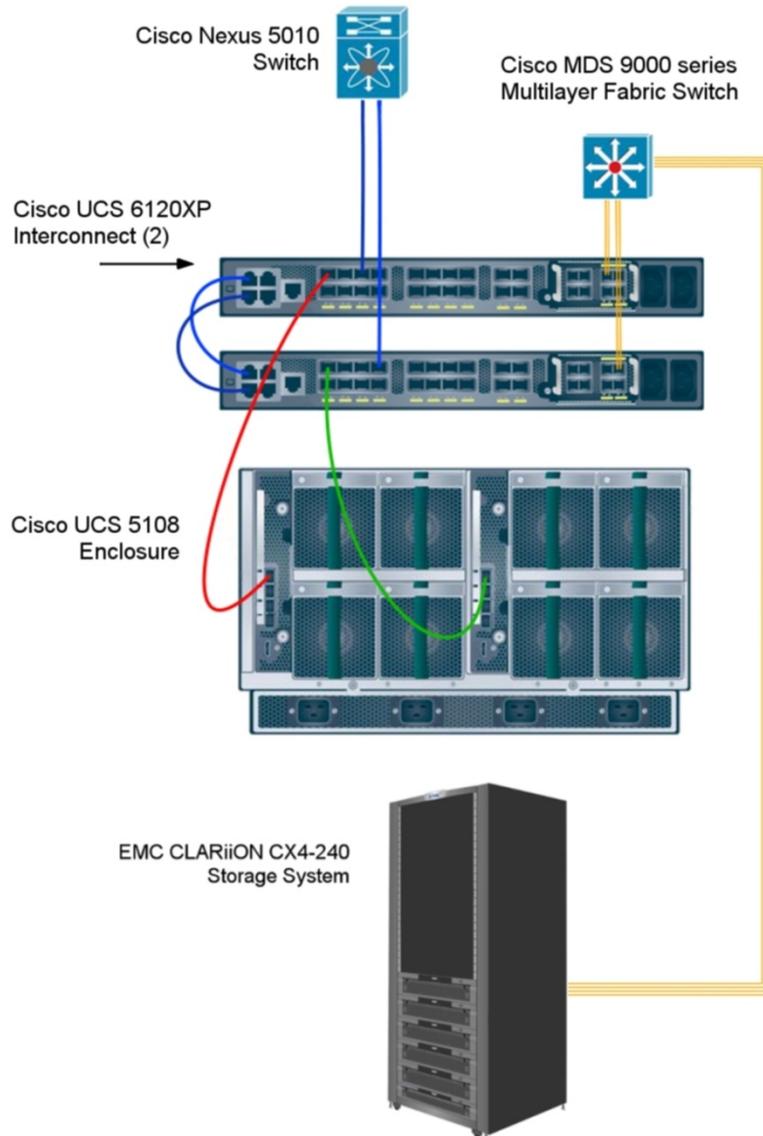


Figure 6: Our test bed configuration for the Cisco Blade Server.

Setting up the Cisco UCS B200 M1 Blade Server

We installed a fresh copy of VMware vSphere 4 on the Cisco UCS B200 M1 Blade Server.

Installing VMware vSphere 4 on the host

1. Insert the vSphere DVD, and restart the computer.
2. To start vSphere in graphical mode, press Enter.
3. On the Welcome screen, click Next.
4. Click the checkbox to accept the terms of the license agreement, and click Next.
5. Accept the default keyboard layout, and click Next.
6. On the Custom Drivers screen, choose No to install custom drivers, and click Next.
7. You will receive a warning if you chose No. Click Yes to proceed. Drivers will load at this point.
8. Click Next.
9. Enter your serial number now, or choose to enter one later. Click Next.
10. On the Network Configuration screen, choose the NIC that you will use for system tasks and for the client/server test traffic. Click Next.
11. On the next Network Configuration screen, set your IP addressing information, subnet mask, DNS, and hostname. Click Next.
12. On the Setup Type screen, choose standard setup.
13. Select the virtual disk you wish to install vSphere on, and click Next.
14. On the Data Loss warning screen, click OK.
15. On the Time Zone Settings screen, choose your appropriate time zone, and click Next.
16. On the Date and Time screen, modify the date and time as you wish, and click Next.
17. Assign a root password for vSphere. Optionally, add additional users if you wish, and click Next.
18. On the Summary screen, click Next to install.
19. When the installation is complete, click Next.
20. Click Finish to reboot the system.

Enabling secure shell (ssh) access for the root user

1. Log in as root to the vSphere console.
2. Type the following command to change to the appropriate directory:

```
# cd /etc/ssh
```
3. Edit the sshd_config file using vi. Use the following command:

```
# vi sshd_config
```
4. Press the down arrow key to move the cursor to the PermitRootLogin line, and move the cursor to the word no. Press the i key to insert text.
5. Type the word `yes` and delete the word `no`.
6. Press the Escape key to return to command mode.
7. Type the following command to save and exit the file:

```
:wq
```
8. Type the following command to restart the ssh service:

```
# service sshd restart
```

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, and continue.
3. Click vSphere to download the vSphere client.
4. Choose Run to install.
5. Choose your language, and click OK.
6. On the Welcome screen, click Next.
7. Accept the license terms, and click Next.
8. Enter user and organization details, and click Next.
9. Optionally, click the checkbox to install the update utility. Click Next.
10. On the Destination Folder screen, click Next.
11. Click Install.

12. Click OK.

Adding the external LUNs as datastores to vSphere storage

1. In vSphere, click the Configuration tab.
2. In the Hardware pane, click Storage.
3. Click Add Storage...
4. Choose Disk/LUN. Click Next.
5. Select the appropriate LUN. Click Next.
6. Click Next.
7. Enter a name for the datastore. Click Next.
8. Click Next to accept the defaults for block size.
9. Click Finish to complete the addition of the LUN.
10. Repeat steps 3 through 9 on the remaining two LUNs that you will use for SQL Server data virtual disks and SQL Server log virtual disks.

Creating the virtual machine with vSphere

1. On the vSphere workstation, click Start, All Programs, VMware, VMware vSphere client.
2. Enter the IP address or hostname, user name, and password. Click Login.
3. Click the Virtual Machines tab.
4. Right-click, and choose New Virtual Machine.
5. Choose Custom, and click Next.
6. Assign a name to the virtual machine. Click Next.
7. Select a datastore for the virtual machine files. We chose the OS Datastore. Click Next.
8. Choose Virtual Machine Version 7. Click Next.
9. Choose Microsoft Windows, then Microsoft Windows Server 2008 (64-bit). Click Next.
10. Choose two virtual processors. Click Next.
11. Choose 8192MB RAM. Click Next.
12. Click 1 for the number of NICs, and select vmxnet3. Click Next.
13. Leave the default virtual storage controller. Click Next.
14. Choose to create a new virtual disk. Click Next.
15. Make the OS virtual disk size 30 GB, specify the OS datastore on the external storage, and click Next.
16. Keep the default virtual device node, and click Next.
17. Click Finish.
18. Right-click the VM, and choose Edit Settings.
19. On the Hardware tab, click Add...
20. Click Hard Disk, and click Next.
21. Click Create a new virtual disk for SQL Server data, and click Next.
22. Specify 25GB for the virtual disk size, and specify the datastore for SQL Server data. Note that we alternated even numbered VMs on one set of LUNs and odd numbered VMs on another. See the storage section for more details.
23. Choose SCSI(1:0) for the device node, and click Next.
24. On the Hardware tab, click Add...
25. Click Hard Disk, and click Next.
26. Click Create a new virtual disk for the SQL Server log, and click Next.
27. Specify 22GB for the virtual disk size, and specify the datastore for SQL Server log virtual disks. Note that we alternated even numbered VMs on one set of luns and odd numbered VMs on another. See the storage section for more details.
28. Choose SCSI(2:0) for the device node, and click Next.
29. Click SCSI Controller 1, and choose Change Type.
30. Choose Paravirtual, and click OK.
31. Click SCSI Controller 2, and choose Change Type.
32. Choose Paravirtual, and click OK.
33. Click Finish, and click OK.

Installing the guest operating system

1. Insert the installation DVD for Windows Server 2008 x64 into the DVD drive.
2. In vSphere, right-click the virtual machine, and choose CD/DVD drive.
3. 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. Choose the language, time and currency, and keyboard input. Click Next.
8. Click Install Now.
9. Choose Windows Server Enterprise (Full Installation). Click Next.
10. Accept the license terms, and click Next.
11. Click Custom.
12. Click the Disk, and click Drive options (advanced).
13. Click New, Apply, Format, and click Next.
14. Let the installation process continue. The VM will reboot several times.
15. After the installation completes, click OK to set the Administrator password.
16. Enter the administrator password twice, and click OK.
17. When the operating systems finishes booting, choose VM, Guest, Install/Upgrade VMware Tools.
18. On the Install VMware Tools screen, click OK.
19. On the AutoPlay menu, click Run setup.exe.
20. On the Welcome screen, click Next.
21. On the Setup Type screen, choose Typical, and click Next.
22. Click Install.
23. On the various Windows Security screens, click Install each time.
24. Click Finish to complete the installation.
25. Click Yes to reboot the VM.
26. Log into the VM after reboot.
27. Click Start, Control Panel, and double-click System.
28. Click Change Settings.
29. Click Change.
30. Enter the new computer name, and click OK.
31. Click OK to restart, click Close, and click Restart Now.

Installing Windows updates

1. Click Start, Windows Update.
2. Click View Advanced Options.
3. Click Never Check for Updates.
4. Click OK.
5. Click Check for Updates.
6. Click Install Now when the application prompts you to install an update for Windows Update.
7. Click View available updates to ensure you install the necessary updates.
8. Click Install.
9. Agree to the license terms, and click Finish.
10. Reboot the VM when the application requests you do so.
11. After reboot, check Windows Update again for further updates. Click Start, Windows Update.
12. Click Check for updates.
13. If Windows lists no important updates, close the updates window.
14. Power off the VM.

Installing SQL Server 2008 on the VM

1. Insert the DVD into the physical DVD drive.
2. Right-click the VM, and choose Power, Power On.
3. Right-click the VM, and choose Open Console.
4. Click the Connect CD/DVD button. Choose CD/DVD Drive 1, Connect to host device...
5. Click Run SETUP.EXE on the AutoPlay menu.

6. If the application prompts you to install the .NET Framework, click OK.
7. Select the Accept radio button, and click Install.
8. When the installation finishes, click Exit.
9. If any warnings appear about compatibility, accept them because installing SP1 in the next section should solve them.
10. If the application prompts you, click OK to install a hotfix for Windows (KB942288).
11. Click Restart now to restart the server upon completion.
12. After rebooting, log into the server.
13. Click Start, and click Computer.
14. Double-click the CD/DVD drive.
15. Click Installation.
16. Click New SQL Server stand-alone installation.
17. On the Setup support rules screen, click OK.
18. Specify the Enterprise Evaluation free edition. Click Next.
19. Click the checkbox to accept the license terms. Click Next.
20. Click Install to install the setup support files.
21. You may see a Windows Firewall warning. For now, ignore this, and click Next.
22. On the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backward Compatibility, Management Tools –Basic, and Management Tools – Complete. Click Next.
23. On the Instance configuration screen, leave the default selection of default instance, and click Next.
24. On the Disk space requirements screen, click Next.
25. On the Server configuration screen, choose NT AUTHORITY\SYSTEM for SQL Server Agent, and choose NT AUTHORITY\SYSTEM for SQL Server Database Engine. Click Next.
26. On the Database Engine Configuration screen, select Mixed Mode.
27. Enter a password for the system administrator account (sa).
28. Click Add Current user. This may take several seconds.
29. Click Next.
30. On the Error and usage-reporting screen, click Next.
31. On the Installation rules screen, click Next.
32. On the Ready to Install screen, click Next.
33. After installation completes, click Start, All Programs, Microsoft SQL Server 2008, Configuration Tools, SQL Server Configuration Manager.
34. Expand the Network Configuration node, and select the relevant instance.
35. In the right pane, right-click TCP/IP, and choose Enable.
36. In the left pane, click SQL Server Services.
37. In the right pane, right-click the SQL Server service, and select Restart.
38. Create a SQL Server login for the ds2user (see the DVD Store setup section below for the specific script to use).
39. Place the DVD Store backup file you prepared in the default location for SQL Server: C:\Program Files\Microsoft SQL Server\MSSQL10.MSSQLSERVER\MSSQL\Backup.

Installing SQL Server 2008 SP1

Service Pack 1 is available for download from

<http://www.microsoft.com/downloads/details.aspx?FamilyID=66ab3dbb-bf3e-4f46-9559-ccc6a4f9dc19&displaylang=en>.

1. Run SQLServer2008SP1-KB968369-x64-ENU.exe.
2. On the Welcome screen, click Next
3. On the License terms screen, accept the license terms, and click Next.
4. On the Features screen, select available features, and click Next.
5. On the Check files in use screen, click Next.
6. On the Update screen, click Next.
7. When the update completes, click Next, and click Close.

Configuring additional drives in the VM in Disk Management

1. Power on the VM, and open the console.
2. Click Start, Administrative Tools, Computer Management.
3. Click Disk Management.
4. Right-click the uninitialized disks (if any), and choose Initialize Disk.
5. Choose MBR.
6. Right-click the volume meant for SQL Server data, and choose New Simple Volume. Click Next.
7. Accept the default volume size. Click Next.
8. Choose E: from the drop-down menu for the drive letter. Click Next.
9. Type `sqldata` for the volume name. Click Next.
10. Choose NTFS, 64K allocation unit size, and check the Perform a quick format checkbox. Click Next.
11. Right-click the volume meant for SQL Server logs, and choose New Simple Volume. Click Next.
12. Accept the default volume size. Click Next.
13. Choose F: from the drop-down menu for the drive letter. Click Next.
14. Type `sqllog` for the volume name. Click Next.
15. Choose NTFS, 64K allocation unit size, and check the Perform a quick format checkbox. Click Next.
16. Click Finish.

Creating the additional VMs on the host blade

After installing and configuring the initial VM, we cloned that VM using a combination of the `vmkfstools` and `vmware-cmd` utilities on the VMware vSphere Server platform. vSphere does offer a GUI wizard to clone out VMs. Because we were cloning out a lot of the same VMs, we used scripts instead of their GUI. Below is a sample shell script to clone VMs containing three virtual disks, such as in our configuration.

```
# cp -reply=yes /sourcepath/VM1.vmx /destpath/VM2.vmx
# sed -i "s/VM1/VM2/g" /destpath/VM2.vmx
# sed -i '/sched.swap.derivedName/d' /destpath/VM2.vmx
# sed -i '/checkpoint.vmState/d' /destpath/VM2.vmx
# vmkfstools -i /sourcepath/VM1.vmdk /destpath/VM2.vmdk
# vmkfstools -i /sourcepath/VM1_1.vmdk /destpath/VM2_1.vmdk
# vmkfstools -i /sourcepath/VM1_2.vmdk /destpath/VM2_2.vmdk
# vmware-cmd -s register /destpath/VM2.vmx
```

Configuring the additional VMs after cloning

1. Power on the VM, and open the console.
2. In the task bar, right-click the network icon, and choose Open Network and Sharing Center.
3. Click Change Adapter Settings.
4. Right-click the NIC, and choose properties.
5. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
6. In the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
7. Enter a valid static IP address for this new VM, subnet mask, and default gateway.
8. Click OK, and click Close to exit.
9. Click Start, and type `computer name` in the search box.
10. Choose Rename this computer.
11. Click the Change button
12. Type the new computer name
13. Click OK, and click OK again.
14. When the application prompts you to do so, reboot the VM.
15. Repeat steps 1 through 14 for each VM.

Installing and configuring the database clients

For the DVD Store scripts, we used a number of clients to simulate a number of users putting a load on the server. For our clients, we created a folder we called `C:\ClientShare` to store workload scripts, and shared this folder for access from our controller machine. We installed the .NET 3.5 framework on each client VM, as the

DVD Store test executable requires at least .NET2.0. We created a performance counter log on each client machine to track the number of orders per minute (OPM) each virtual database server returns. We followed this process for each installation:

1. Install Microsoft Windows Server 2003 R2 Enterprise x86 Edition Service Pack 2 on the client.
2. Assign a computer name of `Clientx` for the database client, where `x` is the client number.
3. For the licensing mode, use the default setting of five concurrent connections.
4. Enter a password for the administrator log on.
5. Select Eastern Time Zone.
6. Use typical settings for the Network installation.
7. Type `Workgroup` for the workgroup.
8. Install Windows Updates, .NET 3.5 framework, and copy the DVD Store client executable into the `c:\clientshare` folder.

DVD Store setup

Data generation overview

We built the database schema using the scripts in the DS2 distribution package, though we made a few minor modifications. The DS2 stress tool provides options to generate 10MB, 1GB, or 100GB datasets. To get the tool to generate the 10 GB of user data we used in this test, we had to make a few straightforward changes to the source code and to the DVD Store application's scripts. Note: We created our test data on a Linux system to take advantage of the larger RAND MAX.

Editing the `ds2_create_orders.c` module

The module `ds2_create_orders.c` defines constants that define the maximum values for the customer ID and the product ID. The constants for the 10GB database size did not exist. We added the constants for this size.

On the command line for the `ds2_create_orders.c` module, we specified the size. The available options were S (small), M (medium), and L (large). We added the case T for the 10GB database. In the switch statement that sets the values for the variables `max_cust_id` and `max_prod_id`, we added cases that assigned them the proper values for the 10GB database size.

We recompiled the `ds2_create_orders.c` module on Linux, following the instructions in the header comments. We used the following command line:

```
gcc -o ds2_create_orders ds2_create_orders.c -lm
```

Editing the `ds2_create_cust.c` module

We had to make the same changes to the `ds2_create_cust.c` module that we made to the `ds2_create_orders.c` module. On the command line for the `ds2_create_cust.c` module, we specified the size. The available options were S (small), M (medium), and L (large). We added the case T for the 10GB database. In the switch statement that sets the values for the variables `max_cust_id` and `max_prod_id`, we added cases that assigned them the proper values for the 10GB database size.

We recompiled the `ds2_create_cust.c` module on Linux, following the instructions in the header comments. We used the following command line:

```
gcc -o ds2_create_cust ds2_create_cust.c -lm
```

Generating the data for the 10GB database

We used shell scripts to run all four of the executables that generate the data. The distribution did not include shell scripts for the 10GB size. We wrote shell scripts based on the `ds2_create_cust_large.sh` and `ds2_create_orders_large.sh` scripts. The `ds2_create_prod` and `ds2_create_inv` executables did not ship with associated shell scripts, so we created shell scripts using the instructions in the readme files. We ran the shell scripts in the following order to generate the data for the 10GB database:

1. `ds2_create_orders_10gb.sh`
2. `ds2_create_inv_10gb.sh`

3. ds2_create_prod_10gb.sh
4. ds2_create_cust_10gb.sh

We waited until the processes finished before we moved onto the next step.

Creating the database

We modified the database creation SQL Server scripts in the DVD Store distribution package to build the database schema, which includes the file structure, tables, indices, stored procedures, triggers, and so on. We built a master copy of the 10GB database version for SQL Server 2005 and for SQL Server 2008, and then used those master copies to restore our test database to the HP ProLiant DL380 G4 legacy server and Cisco UCS B200 M1 Blade Server between each test run. We stored the backup file on the C: drive of each server for quick access.

We followed these steps to create the database:

1. We 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 created database tables, stored procedures, and objects.
3. We set the database recovery model to bulk-logged to prevent excess logging.
4. 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.
5. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
6. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
7. On each 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
```

8. We set the database recovery model back to full.

We made the following changes in the build scripts:

- Because we varied the size of the datasets, we sized the files in our scripts to reflect the database size and the number of files per filegroup. We allowed for approximately 40 percent free space in our database files to ensure that filegrowth activity did not occur during the testing.
- We followed Microsoft's recommendation of having 0.25 to 1 file per filegroup per logical processor. We used two files per filegroup on the HP ProLiant DL380 G4 legacy server and on each VM in the Cisco UCS B200 M1 Blade Server.
- We did not use the DBCC PINTABLE command for the CATEGORIES and PRODUCTS tables, both because Microsoft recommends against this practice and because the commands do nothing in SQL Server 2005 and SQL Server 2008.
- In the case of SQL Server 2008, we added the FORCESEEK hint in the BROWSE_BY_ACTOR stored procedure because in initial testing we found that SQL Server 2008 was choosing an index scan instead of the preferred index seek, adding unnecessary overhead. This problem was not evident in SQL Server 2005.

- We created a SQL Server login we called `ds2user` and mapped a database user to this login. We made each such user a member of the `db_owner` fixed database role.
- Using the DVD Store scripts as a reference, we created the full-text catalog and index on the `PRODUCTS` table manually in SQL Server Management Studio.

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.

Editing the workload script - `ds2xdriver.cs` module

To use the 10GB database we created earlier, we had to change the following constants:

- In the routine `Controller()`, we changed the string sizes. We added the `T` option for the 10GB database size. `DS2` uses the sizes string to interpret the `db_size_str` option.
- In the class `Controller`, we changed the arrays `MAX_CUSTOMER` and `MAX_PRODUCT`. To each, we added values specifying the bounds for the customer and product IDs. The `Controller()` routine uses these arrays.
- We added a command line parameter for the database name:

```
-database_name
```

Editing the workload script - `ds2sqlserverfns.cs` module

We changed the connection string to increase the number of available connections, to not use the default administrator ("`sa`") account, and to include a parameter for the database name. We raised the available connections limit from the default of 100 to 200 to allow room for experimentation. We created a user account we called `ds2User` and used that account.

The `ds2connect` routine in the `ds2sqlserverfns.cs` module defines `sConnectionString`. We used the following string; the changes we made appear in bold:

```
string sConnectionString = "User ID=ds2User;Initial Catalog=+dbname+";Max  
Pool Size=200;Connection Timeout=120;Data Source=" + Controller.target;
```

Recompiling the `ds2sqlserverdriver.exe` executable

We recompiled the `ds2xdriver.cs` and `ds2sqlserverfns.cs` module in Windows by following the instructions in the header comments. Because the `DS2` instructions were for compiling from the command line, we used the following steps:

1. Open a command prompt.
2. Use the `cd` command to change to the directory containing our sources.
3. Run the batch file `C:\Program Files\Microsoft Visual Studio 9.0\Common7\Tools\vsvars32.bat`. This sets up the environment variables for us.
4. Execute the following command:

```
csc /out:ds2sqlserverdriver.exe ds2xdriver.cs ds2sqlserverfns.cs  
/d:USE_WIN32_TIMER /d:GEN_PERF_CTRS
```

Setting up and configuring the HP DL380 G4 legacy server

Setting up the EMC storage

On the baseline HP ProLiant DL380 G4 legacy server, we configured two of the internal disks in a RAID 1 configuration to hold the operating system. We installed Windows Server 2003 R2 with SP2 and enabled the `/3GB` switch in the `boot.ini` file. We cabled one of our two fibre channel ports directly to one port on an EMC CX3 storage area network (SAN). We used only one storage processor for the HP ProLiant DL380 G4 legacy server baseline test. On the external storage, we created two RAID groups. The first was a 10-disk RAID 10 configuration, and the second was a 4-disk RAID 10 configuration. We used only one tray of storage, 14 disks, on

the EMC CX3. We created one LUN per raid group and presented each of those LUNs to the host operating system. We used diskpart as recommended by EMC and Microsoft to properly align the partitions.

Installing the guest operating system

1. Insert the Microsoft Windows Server 2003 R2 Enterprise Edition CD into the CD-ROM drive.
2. Reboot the system.
3. When a screen appears prompting you to press any key to boot from the CD, press any key.
4. Press Enter at the Welcome to Setup screen to setup Windows Server 2003.
5. Press F8 at the Windows Licensing Agreement screen.
6. If a previous version of Windows Server is already present, you will get a prompt asking if you would like to repair the damaged installation. Press Esc to continue installing a fresh copy of Windows without repairing.
7. At the Windows Server 2003 Setup screen, delete any existing C: partitions by selecting the partition to delete and pressing the D key.
8. Press Enter to confirm the deletion.
9. Press L to reconfirm the deletion.
10. At the Windows Server 2003 Setup screen, select the Unpartitioned Space, and press Enter.
11. Using the arrow keys, select Format the partition using the NTFS file system (Quick), and press Enter.
12. Once Windows Server finishes the formatting and the file copy, it prompts you to restart your computer. Press Enter to restart.
13. A Windows Server 2003 loading screen and then a Windows installation screen will appear. Wait for both of those windows to close.
14. Click Next at the Regional and Language Options screen.
15. When the installation software prompts you to Personalize Your Software, type `user` as the name, leave the organization field blank, and click Next.
16. At the Your Product Key screen, enter the product key, and click Next.
17. Leave the default settings at the Licensing Modes screen, and click Next.
18. For computer name, type `mailserver` and for administrator's password, type `Password1` Type `Password1` again to confirm the password. Click Next.
19. A Windows Setup Alert window will warn that the password you selected is not strong. Select Yes to continue.
20. At the Date and Time Settings screen, select the current date and time and the appropriate time zone. Leave the Automatically adjust clock for daylight savings changes checked, and click Next.
21. Windows will automatically complete the installation process and restart the server.
22. Press Ctrl+Alt+Delete when the system prompts you to begin running Windows Server.
23. Log onto Windows Server using the password you selected earlier.
24. At the Windows Setup Screen, the system will prompt you to insert Windows Server CD 2. Insert the CD, and click OK.
25. At the Windows Server 2003 R2 Setup Wizard Welcome Screen, click Next.
26. At the Windows Server 2003 R2 Setup Wizard Setup Summary, click Next.
27. The Installer will copy more files to the server. When the Windows Server 2003 R2 Setup Wizard Completing Windows Server Setup screen appears, click Finish.
28. At the Windows Server Post-Setup Security Updates screen, click Finish.
29. At the Windows Server Post-Setup Security Updates WARNING pop-up, click Yes to close the page.
30. At the Manage Your Server screen, check the box next to Don't display this page at logon, and click the X in the top right corner to close the screen.

Installing Windows updates

1. Click Start, Windows Update.
2. Click Check for Updates.
3. Click View available updates to ensure you install the necessary updates.
Note: We installed all critical updates up to the date of 9/1/2009.
4. Click Install.
5. Agree to the license terms, and click Finish.
6. Reboot the server when the application requests you do so.

7. After reboot, check Windows Update again for further updates. Click Start, Windows Update.
8. Click Check for updates.
9. If Windows lists no important updates, close the updates window.

Installing SQL Server 2005

1. Insert the SQL server 2005 DVD into the DVD drive.
2. Click the Server components link under the Install section to begin the installation.
3. At the End User License Agreement, accept the licensing terms, and click Next.
4. After installing the prerequisites, click Next.
5. At the Welcome screen, click Next.
6. At the System Configuration Check, click Next. Note: This assumes that each component successfully passes the system configuration check.
7. At the Registration Screen, enter the appropriate name and company.
8. At the Components to Install screen, select SQL Server Database Services and Workstation components.
9. Click Advanced.
10. Uncheck Business Intelligent Development Studio, and uncheck Books Online & Sample Databases.
11. Click Next to start the installation.
12. At the Instance Name screen, click the Default instance radio button, and click Next.
13. At the Service Account screen, select the Use the built-in System account radio button.
14. Select Local system, and click Next.
15. At the Authentication Mode screen, select Mixed Mode.
16. Specify the sa logon password by entering a password in both fields, and click Next.
17. At the Collation Settings screen, click Next.
18. Accept the default Error and Usage Report Settings, and click Next.
19. At the Ready to Install screen, click Install to begin the installation.
20. At the end of the installation in the Setup Progress screen, click Next.
21. Click Finish to complete the installation.

Installing Service Pack 3 for Microsoft SQL Server 2005

Service Pack 3 is available for download from

<http://www.microsoft.com/downloads/details.aspx?FamilyID=ae7387c3-348c-4faa-8ae5-949dfbe59c4&displaylang=en>.

1. Run SQLServer2005SP3-KB955706-x86-ENU.exe.
2. At the Welcome screen, click Next.
3. At Accept the License Agreement, click Next.
4. At the Feature Selection screen, keep the defaults, and click Next.
5. At the Authentication screen, click Next.
6. At the Error and Usage Reporting Settings screen, click Next.
7. At the Running Processes screen, click Next.
8. Click Install.
9. If a compatibility error occurs during the installation, click Run program.
10. Click Next.
11. At the Installation Complete screen, click Next.
12. Click Finish.
13. Reboot the server.

Testing procedure

To perform the test, we used a series of batch files. We stored batch files respective to each system on that system, either under the C:\ServerShare folder or the C:\ClientShare folder, and we used the psexec, plink, and winscp utilities to coordinate the test procedures amongst the client machine, server machine, and controller. We use simple file sharing, or secure ftp to copy files from machine to machine as we needed.

The testing procedure consisted of the following steps:

1. Execute batch files and shell scripts to clean up prior outputs on client virtual machines, the server physical machine, and the controller.
2. Drop the database on each server VM.
3. Restore the database on each server VM.
4. Pause for 5 minutes to wait for background tasks to complete before server reboot.
5. Reboot the physical machines, and wait for a ping response from the physical machine, as well as from all VMs involved in testing.
6. Wait 10 additional minutes for any background tasks to complete.
7. Start esxtop on the server under test.
8. Start the workload connections.
9. Start the workload ramp up period. Run the DBCC FREEPROCACHE command if necessary (see the Creating the database section).
10. Start the workload.
11. Stop the workload.
12. Copy all output files to the controller.

Appendix A – Server configuration information

Figure 4 provides detailed configuration information about the servers.

Servers	Cisco UCS B200 M1 Blade Server	HP ProLiant DL380 G4 legacy server
Enclosure		
Blade enclosure	Cisco UCS 5108	N/A
Power supplies		
Total number	4	2
Wattage of each (W)	2,500	575
Cooling fans		
Total number	8	8
Dimensions (h x w) of each	3-5/8" x 5-1/2"	2-3/4" x 2"
General processor setup		
Number of processor packages	2	2
Number of cores per processor package	4	1
Number of hardware threads per core	2	2
CPU		
Vendor	Intel	Intel
Name	Xeon X5570	Xeon 3.6
Stepping	5	3
Socket type	LGA 1366	604 mPGA
Core frequency (GHz)	2.93	3.60
Bus frequency	6.4 GT/s (QPI)	800 MHz
L1 cache (KB)	128	16
L2 cache (KB)	4 x 256	2,048
L3 cache	8 MB	N/A
Thermal design power (TDP, in watts)	95	100
Platform		
Vendor and model number	Cisco B-200 M1 Blade	HP DL380 G4
Motherboard model number	QC11327030G	P7B840KMQQPIVP
Motherboard chipset	Intel 5500	Intel E7520
BIOS name and version	Intel S5500.86B.01.00.0036-191	HP P51
BIOS settings	Default	Default
Memory modules		
Total RAM in system (GB)	96	4
Number of types of memory modules	1	2
Speed in the system currently running @ (MHz)	1,333	400
Timing/Latency (tCL-tRCD-iRP-tRASmin)	9-9-9-27	3-3-3-11
First memory type		
Vendor and model number	Samsung M393B1K70BH1	Infineon 72T128000HR5A
Type	DDR3 PC3-10600R	DDR2 PC2-3200
Speed (MHz)	1,333	400
Size (GB)	8	1

Servers	Cisco UCS B200 M1 Blade Server	HP ProLiant DL380 G4 legacy server
Number of RAM modules	12	2
Chip organization	Double-sided	Double-sided
Second memory type		
Vendor and model number	N/A	Micron Technology 18HTF12872Y-40EB3
Type	N/A	DDR2 PC2-3200
Speed (MHz)	N/A	400
Size (GB)	N/A	1
Number of RAM modules	N/A	2
Chip organization	N/A	Double-sided
Hard disk		
Vendor and model number	Seagate ST9146802SS	HP MAS3735NC
Number of disks in system	2	6
Size (GB)	146	73
Buffer size (MB)	16	8
RPM	10,000	15,000
Type	SAS	SATA
Controller	LSI Logic SAS1064E	Intel 82801EB (ICH5)
Operating system		
Name	vSphere 4.0	Windows Server 2003 Enterprise Edition R2
Build number	171294	3790
File system	VMFS	NTFS
Kernel	2.6.18-128.ESX	ACPI Multiprocessor x64-based PC
Language	English	English
Network card/subsystem		
Vendor and model number	Intel 82958BE 10 Gigabit AF Dual Port	HP NC7782 Gigabit Server Adapter
Type	Integrated	Integrated
Fibre adapter		
Vendor and Model number	QLogic QLA2432	QLogic QLA2462
Type	PCI-Express	PCI-X
USB ports		
Number	0	3
Type	N/A	2.0

Figure 4: Detailed configuration information for the server systems.

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