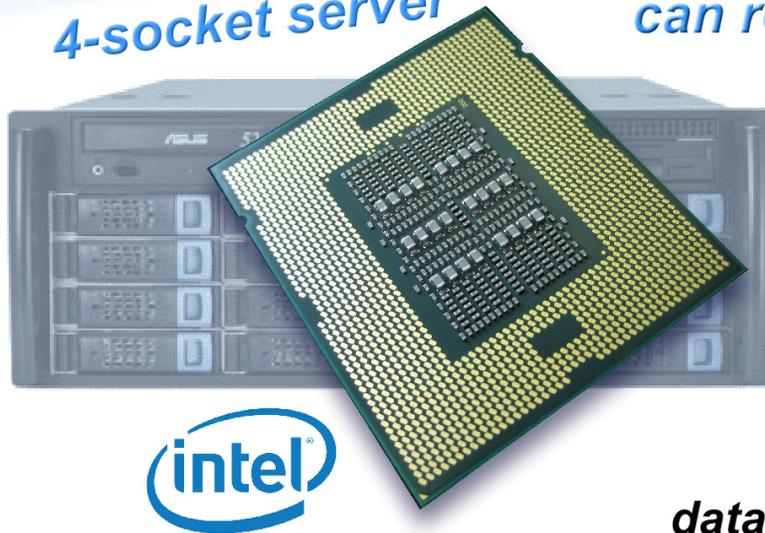


ONE Intel® Xeon® Processor X7560

4-socket server



can replace

16

AMD Opteron™
8222 SE Processor
4-socket server

or

12

Intel Xeon
Processor 7140M
4-socket server

database servers

OUR FINDINGS

Consolidating database servers via virtualization lets you reduce energy usage, save precious data center space, and lower management costs. In Principled Technologies' tests in our labs, as the above graphic illustrates, a four-socket server with the new Intel Xeon Processor X7560 would let you consolidate more than a rack full of four-socket database servers with previous-generation processors. Such consolidation would deliver significant savings in all three of these cost areas.

OUR PROCESS

We used the open-source DVD Store benchmark to provide a workload representative of many real-world database applications. With it, we measured the performance of three servers, each of which was running Microsoft® Windows Server® 2008 R2 Enterprise Edition with Microsoft SQL Server® 2008 R2 November CTP, either natively or in virtual machines (VMs) running Hyper-V™. We then created a VM on the new Intel Xeon Processor X7560-based four-socket server with the same performance level. Finally, we measured how many of those VMs the new server could host.

PROJECT OVERVIEW

We tested four-socket servers with the following processors:

- Intel Xeon Processor X7560
- AMD Opteron 8222 SE Processor
- Intel Xeon Processor 7140M

For testing, all servers ran Microsoft Windows Server 2008 R2 Enterprise Edition with Microsoft SQL Server 2008 R2 November CTP build number 10.50.1352.12 (X64). The goal of this report is to show that a single Intel Xeon Processor X7560-based server can replace 16 AMD Opteron 8222 SE Processor-based servers and 12 Intel Xeon Processor 7140M-based servers, while delivering equal or greater performance.

WORKLOAD

To build the workload, we used DVD Store Version 2 (DS2), an open-source simulation of an online e-commerce DVD store. 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. The Intel Xeon Processor X7560-based server ran one Microsoft SQL Server 2008 R2 November CTP instance 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 server, especially as it relates to an active online transaction processing (OLTP) environment. The AMD Opteron 8222 SE processor-based server and Intel Xeon Processor X7140M-based server ran a single Microsoft SQL Server 2008 R2 November CTP instance. Each instance contained a 20GB DS2 database.

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.

When DS2 is executing, simulated customers log in; 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 How We Tested section of this report.

Each client machine ran a single instance of DS2, with 32 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 new Intel Xeon Processor X7560-based 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 OPM result on the older server.

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

SYSTEM COMPARISON

Figure 1 shows a side-by-side comparison of the key hardware differences among the three servers.

Hardware specifications	Intel Xeon Processor X7560-based server	AMD Opteron 8222 SE Processor-based server	Intel Xeon Processor 7140M-based server
CPU	Intel Xeon Processor X7560	AMD Opteron 8222 SE	Intel Xeon Processor 7140M
CPU speed (GHz)	2.27	3.00	3.40
Number of processor packages	4	4	4
Number of cores per processor package	8	2	2
Number of hardware threads per core	2	1	2
Memory type	PC3-10600R	PC2-5300P DDR2	PC2-3200 DDR2
Total memory (GB)	512	32	32

Figure 1: System configuration information for the three servers.

Figure 2 shows the settings we used on the Intel Xeon Processor X7560-based server VMs for testing. Refer to the How We Tested section below for detailed steps of how we set up the VMs. The older AMD and Intel processor-based servers each ran as a standalone server with no VMs.

VM specifications	AMD Opteron 8222 SE Processor consolidation	Intel Xeon Processor 7140M consolidation
vCPU	2	2
Memory (GB)	30	32
Virtual NIC type	vmxnet3	vmxnet3
Number of virtual disks	3	3

Figure 2: VM configuration information for the AMD Opteron 8222 SE Processor-based server and Intel Xeon Processor 7140M-based server consolidation onto Intel Xeon Processor X7560-based server.

WHAT WE FOUND

As Figure 3 shows, the Intel Xeon Processor X7560-based server provides a performance consolidation factor of 16 over the AMD Opteron 8222 SE Processor-based server. As Figure 4 on the following page shows, the Intel Xeon Processor X7560-based server provides a performance consolidation factor of 12 over the Intel Xeon Processor 7140M-based server. We define the number of older servers the Intel Xeon Processor X7560-based server replaced based on the Microsoft SQL Server 2008 R2 November CTP performance running DVD Store Version 2. We explain the scores in more detail in the What We Found section below.

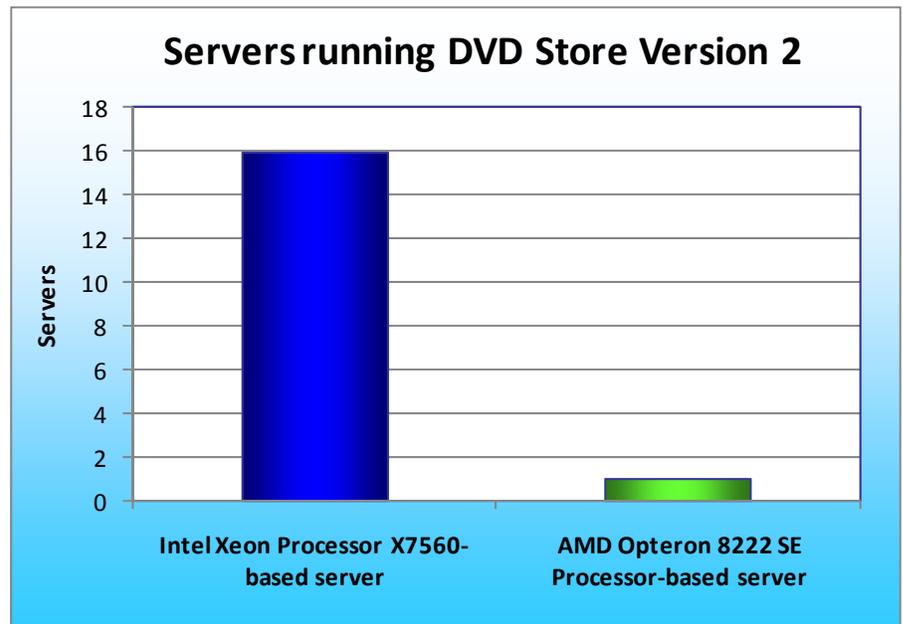


Figure 3: SQL Server performance consolidation results for the Intel Xeon Processor X7560-based server and the older AMD Opteron 8222 SE Processor-based server. Higher numbers are better. (The older AMD Opteron 8222 SE Processor-based server ran a single, non-virtual version of the SQL Server test.)

To determine the maximum number of simultaneous virtual machines the Intel Xeon Processor X7560-based server could handle, we added virtual machines until one or more had OPM drop below the older server median OPM results. 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.

Figure 5 shows the OPM results for the Intel Xeon Processor X7560-based server, by VM, and for the AMD Opteron 8222 SE Processor-based server, running as a standalone. The Intel Xeon Processor X7560-based server results show that all 16 VMs achieved a higher OPM than the older AMD Opteron 8222 SE Processor-based server. Thus, the Intel Xeon Processor X7560-based server can replace 16 AMD Opteron 8222 SE Processor-based servers while providing equal or greater performance.

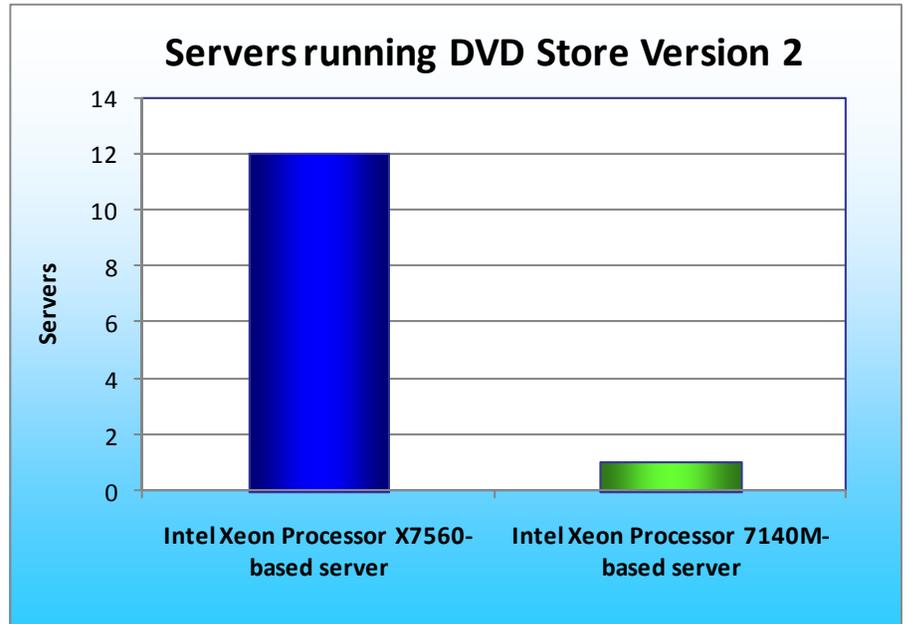


Figure 4: SQL Server performance consolidation results for the Intel Xeon Processor X7560-based server and the older Intel Xeon Processor 7140M-based server. Higher numbers are better. (The older Intel Xeon Processor X7560-based server ran a single, non-virtual version of the SQL Server test.)

OPM	Intel Xeon Processor X7560-based server	AMD Opteron 8222 SE Processor-based server
Virtual machine 1	19,391	16,548
Virtual machine 2	19,916	
Virtual machine 3	19,787	
Virtual machine 4	18,754	
Virtual machine 5	19,645	
Virtual machine 6	17,242	
Virtual machine 7	19,797	
Virtual machine 8	19,395	
Virtual machine 9	19,532	
Virtual machine 10	20,361	
Virtual machine 11	17,359	
Virtual machine 12	17,454	
Virtual machine 13	19,568	
Virtual machine 14	20,413	
Virtual machine 15	18,876	
Virtual machine 16	20,087	

Figure 5: OPM from the median run for each virtual machine for the Intel Xeon Processor X7560-based server and for the older AMD Opteron 8222 SE Processor-based server. Higher numbers are better. (The AMD Opteron 8222 SE Processor-based server ran a single, non-virtualized version of the DS2 test.)

Figure 6 shows the OPM results for the Intel Xeon Processor X7560-based server, by VM, and for the Intel Xeon Processor 7140M-based server, running as a standalone. The Intel Xeon Processor X7560-based server results show that all 12 VMs achieved a higher OPM than the older Intel Xeon Processor 7140M-based server. Thus, the Intel Xeon Processor X7560-based server can replace 12 Intel Xeon Processor 7140M-based servers while providing equal or greater performance.

OPM	Intel Xeon Processor X7560-based server	Intel Xeon Processor 7140M-based server
Virtual machine 1	25,712	23,651
Virtual machine 2	26,054	
Virtual machine 3	25,092	
Virtual machine 4	24,689	
Virtual machine 5	25,616	
Virtual machine 6	26,149	
Virtual machine 7	24,952	
Virtual machine 8	24,689	
Virtual machine 9	25,227	
Virtual machine 10	25,920	
Virtual machine 11	25,862	
Virtual machine 12	24,549	

Figure 6: OPM from the median run for each virtual machine for the Intel Xeon Processor X7560-based server and for the older Intel Xeon Processor 7140M-based server. Higher numbers are better. (The Intel Xeon Processor 7140M-based server ran a single, non-virtualized version of the DS2 test.)

HOW WE TESTED

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), SP-A and SP-B. We used a QLogic QLE2462 dual-port host bus adapter (HBA) in the Intel Xeon Processor X7560-based server. We cabled one 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 tray only had 13 disks.

We created two RAID groups of seven drives each in a RAID 0 for OS and logs. We then created two 460GB logical unit number (LUN) on each RAID group for the virtual hard drives (VHDs) that would hold the operating systems and database logs for the virtual machines.

We created two 2,772GB MetaLUNs for SQL Server database data, which we striped across six 14 disk RAID groups. We configured the six RAID groups into six 924GB LUNs. We used the EMC MetaLUN feature and

assigned three LUNs to MetaLUN-1 and three LUNs to MetaLUN-2. To balance processing load and disk transfers, we assigned MetaLUN-1 to SP-A and MetaLUN-2 to SP-B.

Setting up the Intel Xeon Processor X7560-based server

We installed a fresh copy of Windows Server 2008 R2 Enterprise Edition.

Installing Windows Server 2008 R2 Enterprise Edition on the hosts

1. Boot the server, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 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. Type Password1 as the new password in both fields, and click the arrow to continue.
13. At the Your password has been changed screen, click OK.

Setting up network configuration on the server

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

Installing system updates in Windows Server 2008 R2

We installed the following updates on each server using the Windows Update feature:

- Security Update for Windows Server 2008 x64 R2 Edition (KB972270)
- Security Update for Windows Server 2008 x64 R2 Edition (KB974571)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 x64 R2 Edition (KB978207)
- Windows Malicious Software Removal Tool x64 - January 2010 (KB890830)
- Update for Windows Server 2008 x64 R2 Edition (KB974431)
- Update for Windows Server 2008 x64 R2 Edition (KB976098)
- Security Update for ActiveX Killbits for Windows Server 2008 x64 R2 Edition (KB973525)
- Security Update for Windows Server 2008 R2 Edition (KB975467)

Connecting the storage to the host

We attached the volumes that we used for VHD storage on the EMC CX3-40 storage with a QLogic QLE2462 dual-port HBA.

Configuring the large external LUN in Disk Management and additional SQL Server data and log LUNs

1. On the host server, click Start, Administrative Tools, Computer Management.
2. Click Disk Management.
3. Right-click the uninitialized external volume, and choose Initialize Disk.
4. Choose MBR.
5. Right-click the volume, and choose New Simple Volume. Click Next.
6. Keep the default drive space, and click Next.
7. Keep the default drive letter assignment, and click Next.
8. Choose NTFS, and check the Perform a quick format checkbox. Click Next.
9. Click Finish.
10. Create folders necessary for the VM VHD storage.
11. Right-click the uninitialized smaller LUNs assigned for SQL Server data and log use, and choose Initialize Disk.
12. Choose MBR.
13. Right-click the volume, choose New Simple Volume, and click Next.
14. Keep the default drive space, assign a drive letter, and click Next.
15. Choose NTFS, assign a 64KB allocation unit size, and check the Perform a quick format checkbox. Click Next.
16. Click Finish.
17. Right-click the drive, and choose Offline to make it available to VMs for pass-through usage.
18. Repeat steps 11 through 17 for the remaining SQL Server data and log LUNs.

Creating the Hyper-V virtual machine

1. Click Start.
2. Expand Administrative Tools, and click Hyper-V Manager.
3. From the Action menu, select New→Virtual Hard Disk.
4. Choose Fixed Size, assign 30GB for size, and place the VHD in the appropriate VM folder on the external volume.
5. From the Action menu, select New→Virtual Machine.
6. On the Before You Begin page, click Next.
7. On the Specify Name and Location page, enter the name for your new virtual machine. Place the virtual machine configuration in the relevant folder on the external volume, and click Next.
8. On the Assign Memory page, enter 30GB (AMD Opteron 8222 SE Processor consolidation) or 32GB (Intel Xeon Processor 7140M Processor consolidation) of RAM.
9. On the Configure Networking, choose the network assigned to client/server traffic, and click Next.
10. Choose to add a virtual hard disk later.
11. On the installation Options page, accept the default of Install an operating system later, and click Next.
12. On the Completing the New Virtual Machine Wizard page, click Finish.
13. Right-click the virtual machine, and choose Settings.
14. Click Processors, and choose 2 virtual processors.

15. Click the virtual IDE controller 0.
16. Click Add, and click Hard Drive.
17. Browse to the VHD you created in Step 4, and choose that VHD for the guest OS VHD.
18. Click Apply.
19. Click the SCSI Controller, and click the Physical hard disk radio button to configure your SQL Server data and SQL Server log pass-through disks. You may wish to do this step after cloning VMs.
20. Choose the appropriate LUN.
21. Repeat steps 19 and 20 for the remaining SQL Server data and SQL Server log LUNs assigned to this VM.
22. Repeat steps 5 through 21 for your remaining VMs.

Installing the guest operating system

1. Insert the installation DVD for Windows Server 2008 R2 into the DVD drive.
2. In Hyper-V Manager, right-click the virtual machine, and choose Connect.
3. On the media menu, choose DVD Drive → Capture D:
4. On the Action menu, choose Start.
5. At the Language Selection Screen, click Next.
6. Click Install Now.
7. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
8. Click the I accept the license terms check box, and click Next.
9. Click Custom.
10. Click Drive options (advanced).
11. Ensure you select the proper drive, and click New.
12. Click Apply.
13. Click Next.
14. At the User's password must be changed before logging on warning screen, click OK.
15. Type Password1 as the new password in both fields, and click the arrow to continue.
16. At the Your password has been changed screen, click OK.

Configuring networking in the VM

1. Power on the VM, and open the console.
2. Click Start, Control Panel, right-click Network Connections, and choose Open.
3. Right-click the NIC, and choose Properties.
4. Select TCP/IP (v4), and choose Properties.
5. Set the IP address, subnet, gateway, and DNS server for this NIC, which will handle outgoing server traffic (e.g., the public IP). Click OK, and click Close.
6. Note that you must reconfigure all IP addresses after cloning VMs.

Installing system updates in Windows Server 2008 R2 in the VM

We installed the following updates on the VM using the Microsoft Windows Update feature:

- Security Update for Windows Server 2008 x64 R2 Edition (KB972270)
- Security Update for Windows Server 2008 x64 R2 Edition (KB974571)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 x64 R2 Edition (KB978207)
- Windows Malicious Software Removal Tool x64 - January 2010 (KB890830)

- Update for Windows Server 2008 x64 R2 Edition (KB974431)
- Update for Windows Server 2008 x64 R2 Edition (KB976098)
- Security Update for ActiveX Killbits for Windows Server 2008 x64 R2 Edition (KB973525)
- Security Update for Windows Server 2008 x64 R2 Edition (KB975467)

Installing SQL Server 2008 R2 November CTP on the VM

1. Insert the installation DVD for SQL Server 2008 R2 November CTP build number 10.50.1352.12 (X64) into the physical DVD drive.
2. In Hyper-V Manager, right-click the virtual machine, and choose Connect.
3. On the media menu, choose DVD Drive → Capture D:
4. On the Action menu, choose Start.
5. Log into the VM.
6. If autoplay does not begin the installation, navigate to the SQL Server 2008 R2 DVD, and double-click.
7. If prompted with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
8. At the SQL Server Installation Center screen, click Installation.
9. Click New installation or Add features to an existing installation.
10. At the Setup Support Rules screen, click OK.
11. At the Product Key screen, specify the free Enterprise edition evaluation, and click Next.
12. At the License Terms screen, accept the license terms, and click Next.
13. At the Setup Support Files screen, click Install.
14. At the Setup Support Rules screen, click Next.
15. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
16. At the SQL Server 2008 R2 Feature Selection screen select the following features: Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, Management Tools – Complete, and click Next.
17. At the Installation Rules screen, click Next.
18. At the Instance Configuration screen, leave the defaults, and click Next.
19. At the Disk Space Requirements screen, click Next.
20. At the Server Configuration screen, choose the service account, fill in a password if necessary, and click Next.
21. At the Database Engine Configuration screen, select Mixed Mode, fill in a password for the system administrator (sa) account, click Add Current User, and click Next.
22. At the Error Reporting screen, click Next.
23. At the Installation Configuration Rules screen, click Next.
24. At the Installation screen, click Install.
25. At the Complete screen, click Close.
26. After installation completes, click Start, All Programs, Microsoft SQL Server 2008 R2 November CTP, Configuration Tools, SQL Server Configuration Manager.
27. Expand the Network Configuration node, and select the relevant instance.
28. In the right pane, right-click TCP/IP, and choose Enable.
29. In the left pane, click SQL Server Services.
30. In the right pane, right-click the SQL Server service, and select Restart.
31. Create a SQL Server login for the ds2user (see the Setting up DVD Store section below for the specific script to use).

32. Place the DVD Store backup file you prepared in a folder on the VM C: drive.

Configuring additional VM drives in Disk Management

1. In Hyper-V Manager, right-click the virtual machine, and choose Connect.
2. On the Action menu, choose Start.
3. Log into the VM.
4. Click the Server Manager icon on the taskbar.
5. Click Disk Management.
6. Right-click the disks assigned for SQL Server data and log use, and choose Online.
7. Create the folders necessary for the database. We used <driveletter>:\SQLData for the SQL Server database volume and <driveletter>:\SQLLog for the SQL Server transaction log volume.
8. Repeat steps 6 and 7 for each volume on the VM.
9. Repeat steps 1 through 8 for each VM.

Creating the additional VMs on each host server

After installing and configuring the initial VM, we disconnected the primary VHD file, and then copied that VHD to all other VMs to use for their operating system VHD. We reconfigured all IP addresses and hostnames on new VMs. Using Hyper-V Manager, we also connected each VM's associated SQL Server data LUNs and SQL Server log LUNs. We repeated this process on each host server.

Configuring the additional VMs after cloning

1. In Hyper-V Manager, right-click the virtual machine, and choose Connect.
2. On the Action menu, choose Start.
3. Click Start→Control Panel→right-click Network Connections, and double-click the Local Area Connection.
4. Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
5. In the Internet Protocol Version 4 (TCP/IPv4) Properties screen, select the Use the following IP address radio button.
6. Enter a valid static IP address for this new VM, subnet mask, and default gateway.
7. Click OK, and click Close to exit.
8. Click Start→Control Panel→System.
9. Click Change Settings to change the computer name.
10. Click the Change button.
11. Enter the new computer name.
12. Click OK, and click OK again.
13. Restart the VM.
14. Repeat steps 2 through 13 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, as the

DVD Store test executable requires at least the .NET 2.0 Framework. We created a performance counter log on each client machine to track the number of orders per minute (OPM) each 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 20 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 20GB 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 W for the 20GB 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 20GB 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 W for the 20GB 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 20GB 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 20GB 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 20GB 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 20GB database:

1. ds2_create_orders_20gb.sh
2. ds2_create_inv_20gb.sh
3. ds2_create_prod_20gb.sh
4. ds2_create_cust_20gb.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 20GB database version for SQL Server 2008 R2 November CTP, and then used those master copies to restore our test database to each VM between each test run. We stored the backup file on the C: drive of each VM 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 20GB 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 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 2008 R2 November CTP.
- We added the FORCESEEK hint in the BROWSE_BY_ACTOR stored procedure because in initial testing we found that SQL Server 2008 R2 November CTP was choosing an index scan instead of the preferred index seek, adding unnecessary overhead.
- 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 20GB database we created earlier, we had to change the following constants:

- In the routine Controller(), we changed the string sizes. We added the W option for the 20GB 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 older Intel and AMD processor-based servers

Setting up the EMC storage

On the baseline older server, we used four internal disks and four external JBOD disks. We configured the four of the internal disks into two RAID 1 volumes. We configuration one of the RAID 1 volumes to hold the operating system and the other one to hold the database logs. We configured the external four disks into a RAID 10 to hold the database. We installed Windows Server 2008 R2 and SQL Server 2008 R2 November CTP.

Installing Windows Server 2008 R2 Enterprise Edition on the hosts

1. Boot the server, and insert the Windows Server 2008 R2 installation DVD in the DVD-ROM drive.
2. At the Language Selection Screen, click Next.

3. Click Install Now.
4. Select Windows Server 2008 R2 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. Type Password1 as the new password in both fields, and click the arrow to continue.
13. At the Your password has been changed screen, click OK.

Setting up network configuration on the server

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

Installing system updates in Windows Server 2008 R2

We installed the following updates on each server using the Windows Update feature:

- Security Update for Windows Server 2008 R2 x64 Edition (KB972270)
- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB978207)
- Windows Malicious Software Removal Tool x64 - January 2010 (KB890830)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Update for Windows Server 2008 R2 x64 Edition (KB976098)
- Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB973525)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)

Installing SQL Server 2008 R2 November CTP on the server

1. Insert the installation DVD for SQL Server 2008 R2 November CTP build number 10.50.1352.12 (X64) into the DVD drive.
2. If autoplay does not begin the installation, navigate to the SQL Server 2008 DVD, and double-click.
3. If prompted with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
4. At the SQL Server Installation Center screen, click Installation.
5. Click New installation or add features to an existing installation.
6. At the Setup Support Rules screen, click OK.
7. At the Product Key screen, specify the free Enterprise edition evaluation, and click Next.
8. At the License Terms screen, accept the license terms, and click Next.
9. At the Setup Support Files screen, click Install.
10. At the Setup Support Rules screen, click Next.

11. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
12. At the SQL Server 2008 R2 Feature Selection screen select the following features: Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, Management Tools – Complete, and click Next.
13. At the Installation Rules screen, click Next.
14. At the Instance Configuration screen, leave the defaults, and click Next.
15. At the Disk Space Requirements screen, click Next.
16. At the Server Configuration screen, choose the service account, fill in a password if necessary, and click Next.
17. At the Database Engine Configuration screen, select Mixed Mode, fill in a password for the system administrator (sa) account, click Add Current User, and click Next.
18. At the Error Reporting screen, click Next.
19. At the Installation Configuration Rules screen, click Next.
20. At the Installation screen, click Install.
21. At the Complete screen, click Close.

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 utility to coordinate the test procedures amongst the client machine, server machine, and controller. We use simple file sharing 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 performance counters 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 7 provides detailed configuration information about the test servers.

Servers	Intel Xeon Processor X7560-based server	AMD Opteron 8222 SE Processor-based server	Intel Xeon Processor 7140M-based server
General processor setup			
Number of processor packages	4	4	4
Number of cores per processor package	8	2	2
Number of hardware threads per core	2	1	2
CPU			
Vendor	Intel	AMD	Intel
Name	Xeon X7560	Opteron 8222 SE	Xeon 7140M
Stepping	D0	3	B0
Socket type	LGA1567	Socket F (1207)	Socket 604 mPGA
Core frequency (GHz)	2.27	3.00	3.40
Bus frequency	6.4 GT/s	2,000 MHz Hyper Transport	800
L1 cache (KB)	32 KB + 32 KB (per core)	64 KB + 64 KB (per core)	12 KB + 16 KB
L2 cache (KB)	256 KB (per core)	2 MB (2 x 1 MB)	2 MB (2 x 1 MB)
L3 cache	24	N/A	16
Thermal design power (TDP, in watts)	130	120	150
Platform			
Vendor and model number	Intel	HP ProLiant DL585 G2	Intel
Motherboard model number	QSSC-S4R	PB729AE9QUDO49	SR4850HW4
Motherboard chipset	Intel 7500	NVIDIA nForce Pro 2050	Intel E8500
BIOS name and version	Intel QSSC-S4R.QCI.01.00.0023.02092 0102021 (02/09/2010)	HP BIOS A07 (12/14/2009)	Intel SHW4.0.86B.P.12.00.0076.02 1520071719 (2/15/2007)
BIOS settings	Default	Default	Default

Servers	Intel Xeon Processor X7560-based server	AMD Opteron 8222 SE Processor-based server	Intel Xeon Processor 7140M-based server
Memory modules			
Vendor and model number	Samsung M393B1K70BH1-CH9	Hynix HYMP525P72BP4-Y5	Kingston KVR400D2D4R3/2G
Type	PC3-10600R DDR3	PC2-5300P DDR2	PC2-3200 DDR2
Speed (MHz)	1,333	667	400
Speed in the system currently running @ (MHz)	1,066	667	400
Timing/Latency (tCL-tRCD-iRP-tRASmin)	9-9-9-27	5-5-5-15	3-3-3-8
Size (GB)	512	32	32
Number of RAM modules	64 x 8 GB	16 x 2 GB	16 x 2 GB
Chip organization	Double-sided	Double-sided	Double-sided
Hard disk			
Vendor and model number	Seagate ST9146802SS	HP DH072ABAA6	Hitachi HUS151414VL3800
Number of disks in system	2	8	4 internal, 4 external
Size (GB)	146	72	146
Buffer size (MB)	16	16	16
RPM	10,000	15,000	15,000
Type	SAS 3GB/s	SAS 3GB/s	SCSI
Controller	Intel RAID Controller RS2BL080	HP Smart Array P400 Controller	PowerEdge PERC 4/DC
Operating system			
Name	Windows Server 2008 R2 Enterprise	Windows Server 2008 R2 Enterprise	Windows Server 2008 R2 Enterprise
Build number	7600	7600	7600
File system	NTFS	NTFS	NTFS
Language	English	English	English
Network card/subsystem			
Vendor and model number	Intel 82576NS	HP NC371i Multifunction Gigabit Server Adapter	Broadcom BCM5704 NetXtreme Gigabit Adapter
Type	Integrated	Integrated	Integrated

Servers	Intel Xeon Processor X7560-based server	AMD Opteron 8222 SE Processor-based server	Intel Xeon Processor 7140M-based server
Fibre adapter			
Vendor and Model number	QLogic QLE2462 dual port controller	N/A	N/A
Type	PCI Express	N/A	N/A
USB ports			
Number	5	4	4
Type	USB 2.0	USB 2.0	USB 2.0

Figure 7: Detailed configuration information for the test servers.

ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.
1007 Slater Road, Suite 250
Durham, NC, 27703
www.principledtechnologies.com

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

Principled Technologies is a registered trademark of Principled Technologies, Inc.
All other product names are the trademarks of their respective owners.

Disclaimer of Warranties; Limitation of Liability:

PRINCIPLED TECHNOLOGIES, INC. HAS MADE REASONABLE EFFORTS TO ENSURE THE ACCURACY AND VALIDITY OF ITS TESTING, HOWEVER, PRINCIPLED TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS ANY WARRANTY, EXPRESSED OR IMPLIED, RELATING TO THE TEST RESULTS AND ANALYSIS, THEIR ACCURACY, COMPLETENESS OR QUALITY, INCLUDING ANY IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE. ALL PERSONS OR ENTITIES RELYING ON THE RESULTS OF ANY TESTING DO SO AT THEIR OWN RISK, AND AGREE THAT PRINCIPLED TECHNOLOGIES, INC., ITS EMPLOYEES AND ITS SUBCONTRACTORS SHALL HAVE NO LIABILITY WHATSOEVER FROM ANY CLAIM OF LOSS OR DAMAGE ON ACCOUNT OF ANY ALLEGED ERROR OR DEFECT IN ANY TESTING PROCEDURE OR RESULT.

IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC. BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS TESTING, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC.'S LIABILITY, INCLUDING FOR DIRECT DAMAGES, EXCEED THE AMOUNTS PAID IN CONNECTION WITH PRINCIPLED TECHNOLOGIES, INC.'S TESTING. CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES ARE AS SET FORTH HEREIN.
