

# 1 Dell™ PowerEdge™ R815 server

**49%**  
better  
price-performance

delivered better performance  
than **2** HP ProLiant DL380  
G7 servers.

**11%**  
lower  
active power



Dell PowerEdge R815 server with  
AMD Opteron™ processors Model 6174

2 HP ProLiant DL380 G7 servers  
with Intel® Xeon® Processor X5670s

## OUR FINDINGS

Multi-socket servers using multi-core processors coupled with the latest virtualization technologies enable companies to consolidate large numbers of production database servers onto a small number of physical systems. In Principled Technologies' tests in our labs, a four-socket Dell PowerEdge R815 server with AMD Opteron processors Model 6174 demonstrated significantly better virtualized database price-performance than a pair of two-socket HP ProLiant DL380 G7 servers with Intel Xeon Processor X5670s, with lower price, better performance, and lower active power.<sup>1</sup>

## OUR PROCESS

We used the open-source DVD Store Version 2 benchmark to provide a workload representative of many real-world database applications. With it, we measured the performance and power of the two servers, each of which was running Microsoft® Windows Server® 2008 R2 Enterprise Edition with Microsoft SQL Server® 2008 R2. Each server ran 48 virtual machines (VMs) using Hyper-V™. We measured the performance and energy consumption of both servers, then used the list prices of the systems to develop a price-performance metric.

<sup>1</sup> Based on DVD Store Version 2 testing conducted by Principled Technologies, Inc., and reported in "Virtualized database performance comparison: Dell PowerEdge R815 vs. two HP ProLiant DL380 G7s," comparing Dell PowerEdge R815 server with AMD Opteron processors Model 6174 and HP ProLiant DL380 G7 servers with Intel Xeon Processor X5670s, (tested one physical HP ProLiant DL380 G7 and doubled its results to represent a configuration of two servers), an August 2010 report commissioned by Dell Inc. For details, see [http://principledtechnologies.com/clients/reports/Dell/PowerEdge\\_R815\\_vs\\_HP\\_virt\\_database\\_0810.pdf](http://principledtechnologies.com/clients/reports/Dell/PowerEdge_R815_vs_HP_virt_database_0810.pdf).



## PROJECT OVERVIEW

We tested the following servers and processors:

- Four-socket Dell PowerEdge R815 server with AMD Opteron processors Model 6174
- Two-socket HP ProLiant DL380 G7 server with Intel Xeon Processor X5670s

For testing, each server ran 48 virtual machines with Microsoft Windows Server 2008 R2 Enterprise Edition with Microsoft SQL Server 2008 R2. The goal of this report is to show the virtualized performance difference, the active power usage difference, and the price-performance difference one can expect between the Dell PowerEdge R815 server and two HP ProLiant DL380 G7 servers.

Note that we tested only one physical HP ProLiant DL380 G7. We then doubled its results to represent a configuration of two servers.

## WHAT WE TESTED

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. Each server under test ran one Microsoft SQL Server 2008 R2 instance per VM. We configured each SQL Server 2008 R2 instance with a 2.5GB database. By combining multiple virtual machines, all running a CPU, memory, and disk-intensive workload, the test placed a heavy load on both servers' CPUs. Thus, it measured the performance of the server, especially as it relates to an active online transaction processing (OLTP) environment.

The main DS2 metric is average orders per minute (OPM) over the duration of the test, which the driver program calculates and reports via the Windows Performance Monitor utility and the command-line output 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 Setting up DVD Store 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 by using the last recorded OPM amount displayed by each client. We ran this workload on the both servers' virtual machines simultaneously for 30 minutes.

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 between the test servers. Note that the Dell PowerEdge R815 server supports 512 GB of RAM, double that of an HP ProLiant DL380 G7 server. Appendix A presents detailed system information.

Hardware specifications	Dell PowerEdge R815	HP ProLiant DL380 G7
CPU	AMD	Intel
CPU speed (GHz)	2.20	2.93
Number of processor packages	4	2
Number of cores per processor package	12	6
Number of hardware threads per core	1	2
Memory type	PC3-10600R	PC3-10600R
Total memory (GB)	256	144
Maximum supported memory (GB)	512	256

Figure 1: Key hardware differences between the two test servers.

Figure 2 shows the settings we used on the VMs for testing. Refer to the How we tested section below for detailed steps of how we set up the VMs.

VM specifications	Dell PowerEdge R815	HP ProLiant DL380 G7
Number of vCPUs	1	1
Memory (GB)	5	5
Number of virtual disks	4	4

Figure 2: VM configuration information for the test servers.

## WHAT WE FOUND

As Figure 3 shows, in a virtualized environment, the four-socket Dell PowerEdge R815 server achieved a DVD Store Version 2 score of 418,103 orders per minute (OPM), an 11.9 percent increase over the two HP ProLiant DL380 G7 two-socket servers, which achieved a combined score of 373,538 OPM.<sup>2</sup>

Figure 4 shows the OPM results, by VM, for the Dell PowerEdge R815 server and for the two HP ProLiant DL380 G7 servers. The Dell PowerEdge R815 four-socket server results show that 48 virtual machines (VMs) on the Dell PowerEdge R815 server achieved a higher OPM score than 48 VMs on the two HP ProLiant DL380 G7 two-socket servers.<sup>3</sup>

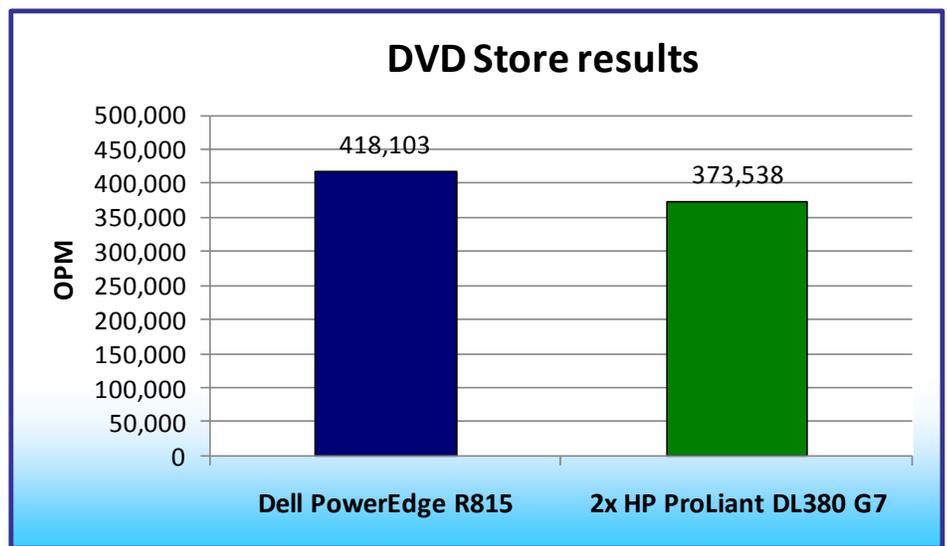


Figure 3: DVD Store Version 2 performance results, in OPM, for the test servers in a virtualized environment. Higher numbers are better.

<sup>2</sup> Based on DVD Store Version 2 testing conducted by Principled Technologies, Inc., and reported in “Virtualized database performance comparison: Dell PowerEdge R815 vs. two HP ProLiant DL380 G7s,” comparing Dell PowerEdge R815 server with AMD Opteron processors Model 6174 and HP ProLiant DL380 G7 servers with Intel Xeon Processor X5670s, (tested one physical HP ProLiant DL380 G7 and doubled its results to represent a configuration of two servers), an August 2010 report commissioned by Dell Inc.

<sup>3</sup> *Ibid.*

OPM	Dell PowerEdge R815	2x HP ProLiant DL380 G7
Virtual machine 1	9,301	8,347
Virtual machine 2	9,372	7,032
Virtual machine 3	8,970	8,225
Virtual machine 4	8,817	6,617
Virtual machine 5	8,569	8,203
Virtual machine 6	9,180	7,171
Virtual machine 7	9,457	8,274
Virtual machine 8	6,207	7,010
Virtual machine 9	9,313	8,421
Virtual machine 10	9,523	8,392
Virtual machine 11	8,997	8,467
Virtual machine 12	8,858	6,979
Virtual machine 13	7,593	8,084
Virtual machine 14	9,139	6,740
Virtual machine 15	9,395	8,324
Virtual machine 16	6,142	7,137
Virtual machine 17	9,529	8,203
Virtual machine 18	9,292	7,380
Virtual machine 19	9,142	7,230
Virtual machine 20	8,997	8,094
Virtual machine 21	8,848	8,108
Virtual machine 22	9,288	8,226
Virtual machine 23	9,233	7,647
Virtual machine 24	6,223	8,458
Virtual machine 25	9,303	
Virtual machine 26	9,501	
Virtual machine 27	8,935	
Virtual machine 28	8,790	
Virtual machine 29	8,819	
Virtual machine 30	9,311	
Virtual machine 31	9,368	
Virtual machine 32	5,844	
Virtual machine 33	9,250	
Virtual machine 34	9,464	
Virtual machine 35	8,821	
Virtual machine 36	8,819	
Virtual machine 37	8,750	
Virtual machine 38	9,009	
Virtual machine 39	9,215	
Virtual machine 40	7,947	
Virtual machine 41	9,367	

OPM	Dell PowerEdge R815	2x HP ProLiant DL380 G7
Virtual machine 42	9,101	
Virtual machine 43	8,963	
Virtual machine 44	8,477	
Virtual machine 45	8,459	
Virtual machine 46	8,801	
Virtual machine 47	8,908	
Virtual machine 48	5,496	
<b>Total OPM</b>	<b>418,103</b>	<b>186,769 for one server, or 373,538 for two servers</b>

Figure 4: OPM from the median run for each virtual machine for the test servers. Higher numbers are better.

To make our price-performance comparison, we gathered retail pricing data from the Dell and HP Web sites as of July 30, 2010. The Dell PowerEdge R815 cost \$25,953, while the two HP ProLiant DL380 G7s cost \$34,698. To determine price-performance for each server, we divided the servers' OPM scores by the price of the respective servers to see how many OPM per dollar each server returned.

As Figure 5 shows, the four-socket Dell PowerEdge R815 server, with a price-performance score of 16.1, achieved 49 percent better price-performance than the two HP ProLiant DL380 G7 two-socket servers, which had a price-performance score of 10.8.<sup>4</sup>

Figure 6 shows the active and idle power usage results, by

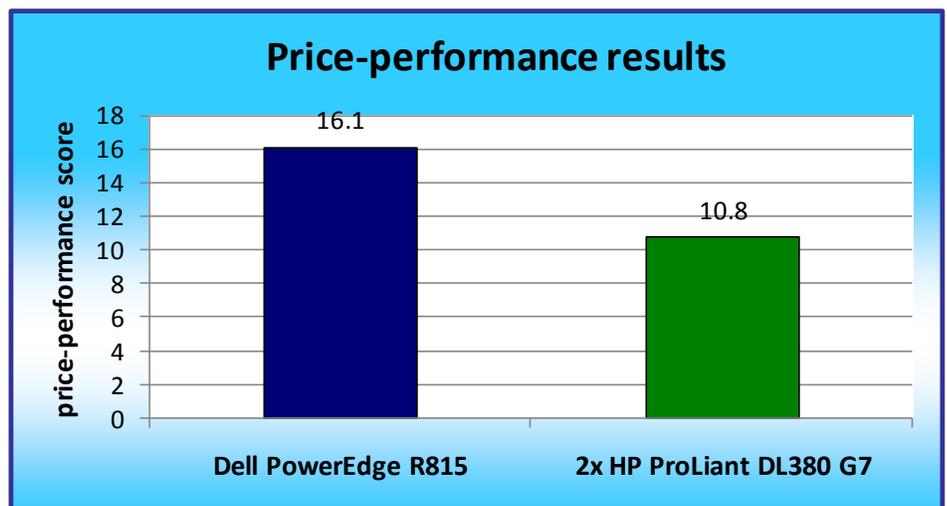


Figure 5: Price-performance scores for the test servers. Higher numbers are better.

<sup>4</sup> Based on DVD Store Version 2 testing conducted by Principled Technologies, Inc., and reported in "Virtualized database performance comparison: Dell PowerEdge R815 vs. two HP ProLiant DL380 G7s," comparing Dell PowerEdge R815 server with AMD Opteron processors Model 6174 and HP ProLiant DL380 G7 servers with Intel Xeon Processor X5670s, (tested one physical HP ProLiant DL380 G7 and doubled its results to represent a configuration of two servers), an August 2010 report commissioned by Dell Inc.

watts, for the Dell PowerEdge R815 server and for the two HP ProLiant DL380 G7 servers. Lower numbers are better. The Dell PowerEdge R815 four-socket server had 11.6 percent lower active power than the two HP ProLiant DL380 G7 two-socket servers<sup>5</sup>.

Power usage	Dell PowerEdge R815	2x HP ProLiant DL380 G7
Active power (W)	716	810
Idle power (W)	284	254

Figure 6: Power usage results, in watts, for the test servers. Lower numbers are better.

## HOW WE TESTED

### Setting up and configuring the Dell storage

We used six Dell EqualLogic™ PS5000XV storage arrays with 16 disks each for this testing. Each array was equipped with a Dell EqualLogic Control Module 4 with three Ethernet ports. We cabled each of the three Ethernet ports to a Dell PowerConnect™ 6248. We used an Intel PRO/1000 PT quad-port NIC in each server for testing. We cabled all four Ethernet ports to the Dell PowerConnect 6248.

We ran multiple SQL Server 2008 R2 instances on the test servers. We created two storage pools with three storage arrays per pool. In each storage pool, we created two volumes for the SQL Server 2008 R2 instances, one 329GB volume for data and one 1.13TB volume for logs.

### Setting up the servers

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

### 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.

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<sup>5</sup> Based on DVD Store Version 2 testing conducted by Principled Technologies, Inc., and reported in "Virtualized database performance comparison: Dell PowerEdge R815 vs. two HP ProLiant DL380 G7s," comparing Dell PowerEdge R815 server with AMD Opteron processors Model 6174 and HP ProLiant DL380 G7 servers with Intel Xeon Processor X5670s, (tested one physical HP ProLiant DL380 G7 and doubled its results to represent a configuration of two servers), an August 2010 report commissioned by Dell Inc.

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:

- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB980195)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB982381)
- Update for Windows Server 2008 R2 x64 Edition (KB977074)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979309)
- Security Update for Windows Server 2008 R2 x64 Edition (KB972270)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980232)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979683)
- Update for Windows Server 2008 R2 x64 Edition (KB976662)
- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Windows Malicious Software Removal Tool x64 - July 2010 (KB890830)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979482)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979559)
- Update for Best Practices Analyzer for Application Server for Windows Server 2008 R2 x64 Edition (KB981392)
- Update for Best Practices Analyzer for File Services for Windows Server 2008 R2 x64 Edition (KB981111)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975560)
- Microsoft .NET Framework 3.5 SP1 Security Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB979916)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2032276)
- Update for Best Practices Analyzer for HYPER-V for Windows Server 2008 R2 x64 Edition (KB977238)
- Security Update for Windows Server 2008 R2 x64 Edition (KB971468)
- Microsoft .NET Framework 3.5 SP1 Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB982526)
- Update for Windows Server 2008 R2 x64 Edition (KB981793)
- Microsoft .NET Framework 4 for Windows Server 2008 R2 x64-based Systems (KB982671)

- Update for Best Practices Analyzer for DHCP Server for Windows Server 2008 R2 x64 Edition (KB977236)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980218)
- Update for Windows Server 2008 R2 x64 Edition (KB982519)
- Update for Best Practices Analyzer for Network Policy and Access Services for Windows Server 2008 R2 x64 Edition (NPAS) (KB977239)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Intel - Network - Intel(R) PRO/1000 PT Quad Port LP Server Adapter
- Update for Windows Server 2008 R2 x64 Edition (KB980846)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978542)
- Update for Windows Server 2008 R2 x64 Edition (KB978637)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978601)
- Update for Best Practices Analyzer for Windows Server Update Services for Windows Server 2008 R2 x64 Edition (KB981390)
- Update for Rights Management Services Client for Windows Server 2008 R2 x64 Edition (KB979099)
- Update for Best Practices Analyzer for Active Directory Rights Management Services for Windows Server 2008 R2 x64 Edition (KB981391)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981332)
- Update for Windows Server 2008 R2 x64 Edition (KB976422)
- Update for Windows Server 2008 R2 x64 Edition (KB980408)
- Update for Internet Explorer 8 Compatibility View List for Windows Server 2008 R2 x64 Edition (KB982632)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)

### Connecting the storage to the host

We attached the volumes that we used for VHD storage on the EqualLogic PS5000XV storage with an Intel PRO/1000 PT quad-port NIC.

### 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 15GB 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 5GB 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 1 virtual processor.
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:

- Microsoft .NET Framework 3.5 SP1 Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB982526)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB980195)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB982381)
- Update for Windows Server 2008 R2 x64 Edition (KB977074)
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- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Windows Malicious Software Removal Tool x64 - July 2010 (KB890830)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979482)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979559)
- Update for Best Practices Analyzer for Application Server for Windows Server 2008 R2 x64 Edition (KB981392)
- Update for Best Practices Analyzer for File Services for Windows Server 2008 R2 x64 Edition (KB981111)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975560)
- Microsoft .NET Framework 3.5 SP1 Security Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB979916)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2032276)

- Update for Best Practices Analyzer for HYPER-V for Windows Server 2008 R2 x64 Edition (KB977238)
- Security Update for Windows Server 2008 R2 x64 Edition (KB971468)
- Microsoft .NET Framework 3.5 SP1 Update for Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB982526)
- Update for Windows Server 2008 R2 x64 Edition (KB981793)
- Microsoft .NET Framework 4 for Windows Server 2008 R2 x64-based Systems (KB982671)
- Update for Best Practices Analyzer for DHCP Server for Windows Server 2008 R2 x64 Edition (KB977236)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980218)
- Update for Windows Server 2008 R2 x64 Edition (KB982519)
- Update for Best Practices Analyzer for Network Policy and Access Services for Windows Server 2008 R2 x64 Edition (NPAS) (KB977239)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Update for Windows Server 2008 R2 x64 Edition (KB980846)
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- Update for Windows Server 2008 R2 x64 Edition (KB978637)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978601)
- Update for Best Practices Analyzer for Windows Server Update Services for Windows Server 2008 R2 x64 Edition (KB981390)
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- Security Update for Windows Server 2008 R2 x64 Edition (KB981332)
- Update for Windows Server 2008 R2 x64 Edition (KB976422)
- Update for Windows Server 2008 R2 x64 Edition (KB980408)
- Update for Internet Explorer 8 Compatibility View List for Windows Server 2008 R2 x64 Edition (KB982632)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)

### Installing SQL Server 2008 R2 on the VM

1. Insert the installation DVD for SQL Server 2008 R2 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, enter a password if necessary, and click Next.
21. At the Database Engine Configuration screen, select Mixed Mode, enter 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→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 returned. 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.
9. Assign a valid IP address and subnet mask.

### Setting up DVD Store

#### 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 2.5 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 2.5GB 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 P for the 2.5GB 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 2.5GB 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 P for the 2.5GB 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 2.5GB 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 2.5GB 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 2.5GB 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 2.5GB database:

1. ds2\_create\_orders\_2.5gb.sh
2. ds2\_create\_inv\_2.5gb.sh
3. ds2\_create\_prod\_2.5gb.sh
4. ds2\_create\_cust\_2.5gb.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 2.5GB database version for SQL Server 2008 R2 and then used that master copy to restore our test database to the 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 2.5GB 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.
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 2008 R2 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 core. We used 1 file per filegroup on all servers.
- 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.
- 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 2.5GB database we created earlier, we had to change the following constants:

- In the routine Controller(), we changed the string sizes. We added the P option for the 2.5GB 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 system 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
```

## Testing procedure

To perform the test, we used a series of batch files. We stored batch files on each client, 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. Restart the MSSQLSERVER service on each VM.
2. Wait 10 minutes for any background tasks to complete.
3. Start recording power, and record 2 minutes of idle power.
4. Start the workload for all 48 VMs with 2.5GB databases on the servers.
5. When the workload finishes after 30 minutes, stop recording power.
6. Record the OPM results from each output file on the clients.
7. Drop the database on each VM.
8. Restore the database on each VM.

## Power measurement procedure

To record each server's power consumption during each test, we used an Extech® Instruments ([www.extech.com](http://www.extech.com)) 380803 Power Analyzer/Datalogger. We connected the power cord from the server under test to the Power Analyzer's output load power outlet. We then plugged the power cord from the Power Analyzer's input voltage connection into a power outlet.

We used the Power Analyzer's Data Acquisition Software (Version 2.11) to capture all recordings. We installed the software on a separate PC, which we connected to the Power Analyzer via an RS-232 cable. We captured power consumption at 1-second intervals.

To gauge the idle power usage, we recorded the power usage for 2 minutes while each server was running the operating system but otherwise idle.

We then recorded the power usage (in watts) for each server during the testing at 1-second intervals. To compute the average power usage, we averaged the power usage during the entire DVD Store Version 2 run. We call this time the power measurement interval. See Figure 6 for the results of these measurements.

## APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 7 provides detailed configuration information about the test servers.

System	Dell PowerEdge R815	HP ProLiant DL380 G7
<b>Power supplies</b>		
Total number	2	2
Vendor and model number	Dell L1100A-S0	HP DPS-750RB A
Wattage of each (W)	1,100	750
<b>Cooling fans</b>		
Total number	6	6
Vendor and model number	San Ace 60 9GA0612P1K611	Nidec UltraFlo V60E12BS1A7-09A032
Dimensions (h x w) of each	2-3/8" x 2-1/2"	2-3/8" x 2-19/32"
Volts	12	12
Amps	0.95	2.45
<b>General</b>		
Number of processor packages	4	2
Number of cores per processor	12	6
Number of hardware threads per core	1	2
System power management policy	OS Control, with Windows Server set to Balanced	OS Control, with Windows Server set to Balanced
<b>CPU</b>		
Vendor	AMD	Intel
Name	Opteron	Xeon
Model number	6174	X5670
Stepping	1	B1
Socket type	Socket G34	Socket LGA1366
Core frequency (GHz)	2.20	2.93
Bus frequency (GT/s)	6.4	6.4
L1 cache	64 KB + 64 KB (per core)	32 KB + 32 KB (per core)
L2 cache	512 KB (per core)	256 KB (per core)
L3 cache	12 MB (shared)	12 MB (shared)
<b>Platform</b>		
Vendor and model number	Dell PowerEdge R815	HP ProLiant DL380 G7

System	Dell PowerEdge R815	HP ProLiant DL380 G7
Motherboard model number	Dell Inc. 06JC9T	599038-001
Motherboard chipset	AMD SR5650	Intel 5520
BIOS name and version	Dell Inc. 1.1.9 (07/2010)	HP P67 (05/14/2010)
BIOS settings	Default	Default
<b>Memory module(s)</b>		
Total RAM in system (GB)	256	144
Vendor and model number	Samsung M393B1K70BH1-CH9	Samsung M393B1K70BH1-CH9
Type	PC3-10600R	PC3-10600R
Speed (MHz)	1,333	1,333
Speed running in the system (MHz)	1,333	800
Size (GB)	8	8
Number of RAM module(s)	32 x 8 GB	18 x 8 GB
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual
<b>Hard disk</b>		
Vendor and model number	Dell ST9146852SS	HP EH0146FAWJB
Number of disks in system	2	2
Size (GB)	146	146
Buffer size (MB)	16	16
RPM	15,000	15,000
Type	6Gb/s SAS	6Gb/s SAS
<b>Disk Controller</b>		
Vendor and model	Dell PERC H700 Integrated	HP Smart Array P410i
Controller cache (MB)	512	0
Controller driver	Dell 4.17.2.64 (09/28/2009)	HP 6.20.0.64 (02/22/2010)
Controller firmware	12.0.1-0091	3.30
RAID configuration	RAID 1	RAID 1
<b>Operating system</b>		
Name	Windows Server 2008 R2 Enterprise	Windows Server 2008 R2 Enterprise
Build number	7600	7600
Service pack	N/A	N/A
File system	NTFS	NTFS
Kernel	ACPI x64-based PC	ACPI x64-based PC

System	Dell PowerEdge R815	HP ProLiant DL380 G7
Language	English	English
<b>Graphics</b>		
Vendor and model number	Matrox G200eW	ATI ES1000
Graphics memory (MB)	8	64
Driver	Microsoft 6.1.7600.16385 (06/21/2006)	Microsoft 6.1.7600.16385 (06/21/2006)
<b>Ethernet</b>		
Vendor and model number	Broadcom BCM5709C NetXtreme II GigE	HP NC382i DP Multifunction Gigabit Server Adapter
Type	Integrated	Integrated
Driver	Broadcom 5.2.14.0 (12/17/2009)	HP 5.2.14.0 (12/17/2009)
<b>Ethernet 2</b>		
Vendor and model number	Intel PRO/1000 PT Quad Port LP Server Adapter	Intel PRO/1000 PT Quad Port LP Server Adapter
Type	PCI Express	PCI Express
Driver	Intel 9.13.41.0 (03/26/2010)	Intel 9.13.41.0 (03/26/2010)
<b>Optical drive(s)</b>		
Vendor and model number	TEAC DV-28SW	N/A
Type	DVD-ROM	N/A
<b>USB ports</b>		
Number	6	4
Type	2.0	2.0
<b>Server price</b>		
Price (US dollars)	\$25,953	\$17,349 per server; \$34,698 for two servers

Figure 7: Configuration information for the test servers.

## ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.  
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