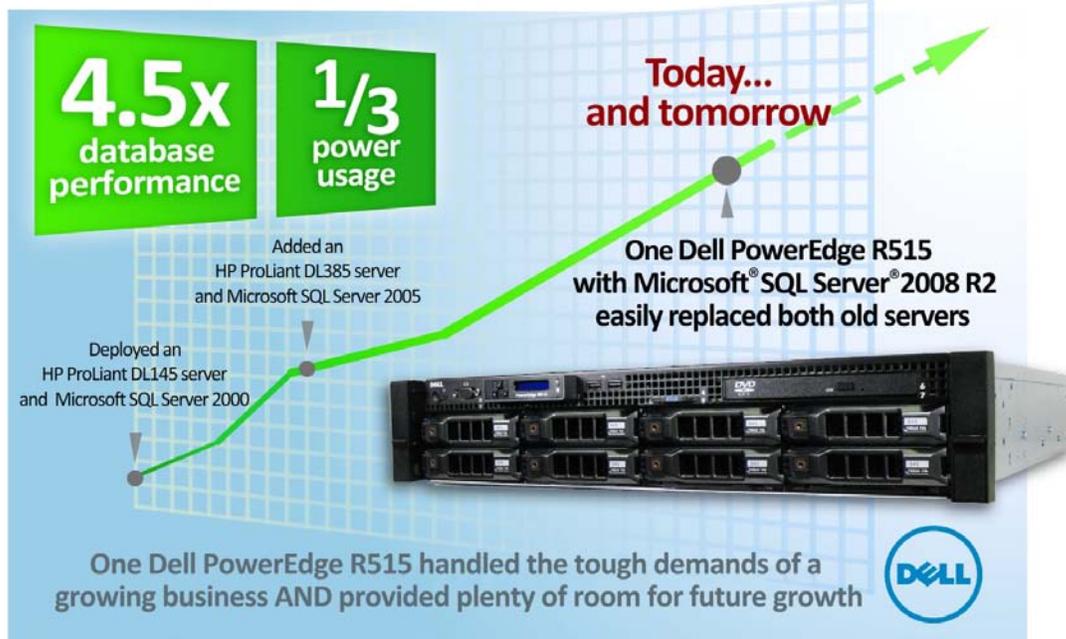


Dell™ PowerEdge™ R515 outperformed two legacy database servers



OUR FINDINGS

Small to medium businesses (SMBs) can dramatically improve performance by replacing multiple aging servers with one new Dell server. In Principled Technologies' tests in our labs, a Dell PowerEdge R515 server with the latest AMD Opteron™ 4100 Series processors running two Microsoft Windows Server® 2008 R2 Hyper-V™ virtual machines with Microsoft SQL Server 2008 R2 achieved over four times the database performance of two legacy HP servers. It did so while using roughly one-third the power and leaving two-thirds of its virtual processors and plenty of RAM available. Given the remaining processor cores, the SMB has readily available processing resources to meet its growth needs in the future.

OUR PROCESS

To simulate a typically evolving SMB application environment, we built two custom “in-house” databases—one containing customer details and one containing order information—and loaded those databases with appropriate data. We designed a set of procedures to stress the environment and then used Quest Software® Benchmark Factory® for Databases as a test engine. We ran individual workloads in the older servers, and combined those workloads on the newer, virtualized environment, measuring the performance and power usage of both the new and old environments. The Dell PowerEdge R515 server ran two virtual machines using Hyper-V, with updated operating system and database software.

PROJECT OVERVIEW

Small to medium businesses with legacy servers, such as older HP ProLiant systems, can find themselves running out of server capacity and at a crossroads. Do they continue with the status quo, almost guaranteeing increased hardware failures, lost revenue, and time, or do they migrate to newer and more powerful servers with the new four- or six-core AMD Opteron 4100 Series processors? To determine which course of action would yield the most benefits, we tested the following two-socket servers and processors:

- New Dell PowerEdge R515 server with AMD Opteron processors Model 4180 running virtualized SQL Server 2008 R2 instances on Windows Server 2008 R2 with Hyper-V
- Legacy (5-year-old) HP ProLiant DL145 server with AMD Opteron processors Model 250 running SQL Server 2000 SP4 on Windows Server 2003 R2 SP2
- Legacy (4-year-old) HP ProLiant DL385 server with AMD Opteron processors Model 254 running SQL Server 2005 SP3 on Windows Server 2003 R2 SP2 and using external HP StorageWorks 30 Modular Smart Array (HP MSA30) for storage

For this study, we chose Hyper-V due to the appeal it would have to the typical SMB. Hyper-V meets the needs of this typical SMB, giving it a flexible, cost-effective, and powerful solution, as we show in this report and in the accompanying reports for this study.

For testing, each of the two legacy HP ProLiant servers ran a single instance of SQL Server with one

database. The HP ProLiant DL145 with SQL Server 2000 ran the customer workload, while the HP ProLiant DL385 with SQL Server 2005 ran the order workload. The new Dell PowerEdge R515, with Hyper-V as the

Our hypothetical SMB replacing multiple older HP servers with a single Dell PowerEdge R515 server running Hyper-V with Microsoft SQL Server 2008 R2 benefits in several ways:

- Significant performance increase
- Total cost of investment (TCO) and return on investment (ROI) within 19 months
- Easy migration process

This report addresses the performance increase and energy savings. To learn more about the TCO and ROI, see our [TCO/ROI report](#). To learn more about the migration process, see our [how-to migration guide](#).

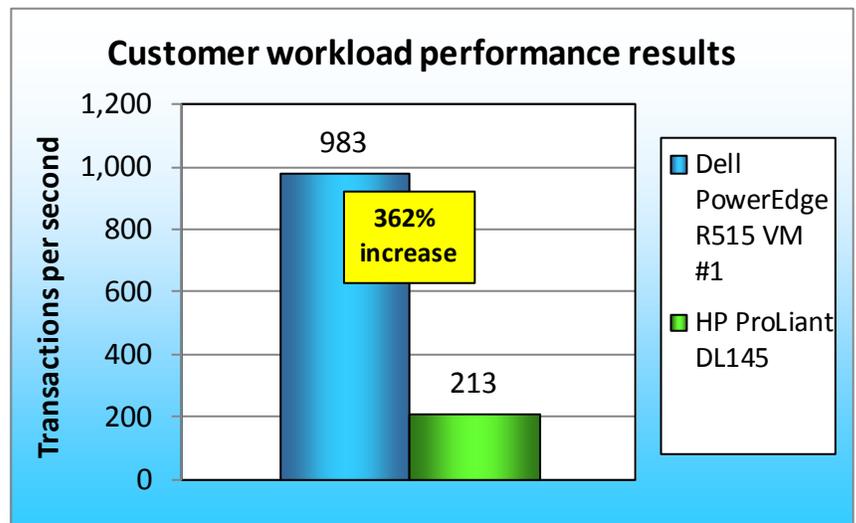


Figure 1: Customer workload performance results, in transactions per second, for the test server in a Dell-powered virtualized environment versus a legacy physical environment. Higher numbers are better.

hypervisor, ran two virtual machines (VMs), both with SQL Server 2008 R2. One VM ran the customer workload and the other ran the order workload.

Our Dell PowerEdge R515 had 12 virtual processors and 16 GB of RAM. Each of the two VMs in our testing used only two virtual processors and 6 GB of RAM. This leaves the server with eight virtual processors and 4 GB of RAM for future growth and expansion. With eight virtual processors remaining, the SMB has powerful resources remaining for future virtualized growth. For example, several more VMs could be added to the configuration to support virtualized file servers, web servers, or Active Directory® servers.

Figures 1 and 2 show the performance gains achieved with the virtualized single-server solution. As Figure 1 shows, the Dell PowerEdge R515

server achieved a score of 983 transactions per second (TPS) in the VM containing the customer database, 4.6 times the HP ProLiant DL145 server's score of 213 TPS, for a performance increase of 362 percent.

As Figure 2 shows, the Dell PowerEdge R515 server achieved a score of 3,517 TPS in the VM containing the order database, over 4.5 times the HP ProLiant DL385 server's score of 776 TPS, for a performance increase of 353 percent.

Figure 3 shows the active power usage, in watts, for the Dell PowerEdge R515 server versus the combined power usage results of the HP ProLiant DL145 server and the HP ProLiant DL385 server running with

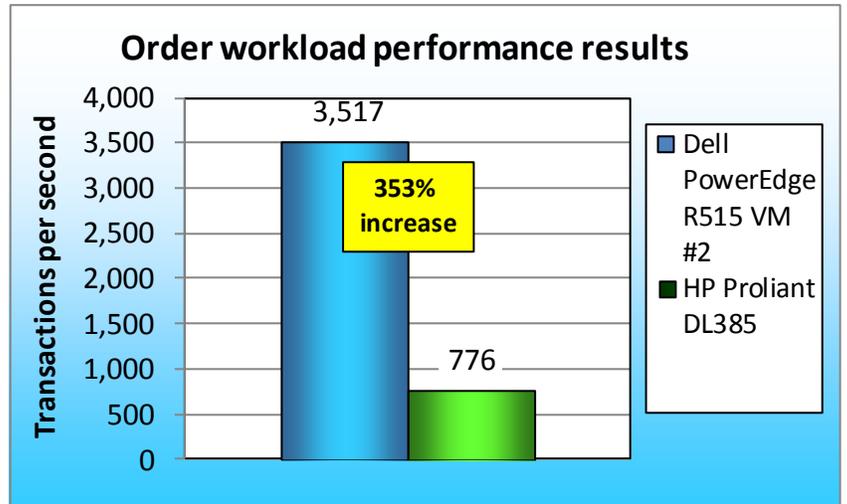


Figure 2: Order workload performance results, in transactions per second, for the test server in a Dell-powered virtualized environment versus a legacy physical environment. Higher numbers are better.

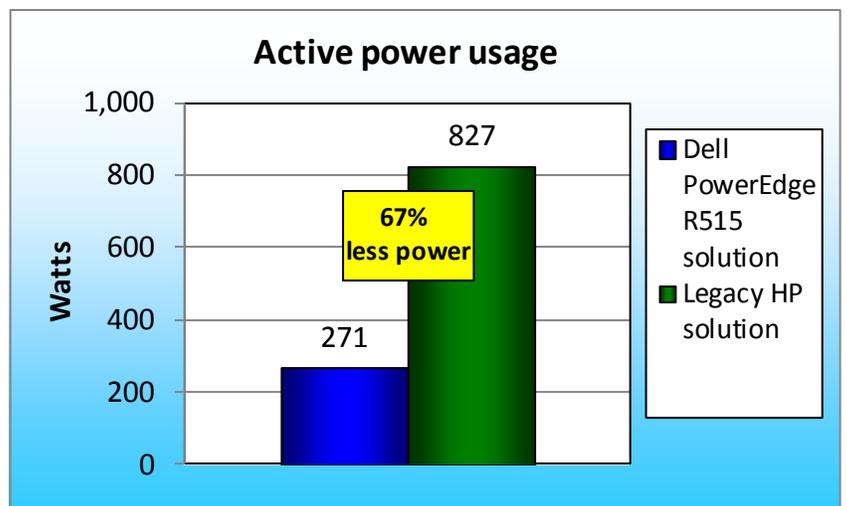


Figure 3: Power, in watts, the two solutions used while active. Lower numbers are better.

HP MSA30 external storage. Lower power usage numbers are better. The Dell PowerEdge R515 server used 67.2 percent less power than the legacy HP solution when both solutions were active.

The What we found section provides more detail on our findings.

WHAT WE TESTED

To build the workload, we designed two database schemas, one simulating a customer database and one simulating an order database. Both simulated an online transaction processing (OLTP) design typical of a hypothetical SMB that would use these two applications. We filled both the customer and order databases with relevant data and filled each table to have appropriate cardinalities based on real-world database design experience. We used the most common features of relational database management systems (RDBMS), including tables, indexes, foreign keys, and stored procedures. We assume, as most businesses do, that business rules logic falls outside the scope of the database application layer.

The customer database ran within SQL Server 2000 on the HP ProLiant DL145 with only internal storage in the legacy physical environment, and within SQL Server 2008 R2 on a Windows Server 2008 R2 Hyper-V virtual machine on the new Dell PowerEdge R515 server. This database modeled a customer relationship management (CRM) application, where the SMB staff manages new opportunities, future projects, customer contacts, customer meetings, and staff assignments. In the customer database, we wrote stored procedures to handle the core customer application functions we present in Figure 4.

The order database ran within SQL Server 2005 on the HP ProLiant DL385 and HP MSA30 external storage on the legacy physical environment, and within SQL Server 2008 R2 on a Windows Server 2008 R2 Hyper-V virtual machine on the new Dell PowerEdge R515 server. This database modeled an order application, where the SMB fulfills orders, through either a call center or Web interface. In the order database, we wrote stored procedures to handle the core order application functions we present in Figure 4.

We used Red Gate® SQL Data Generator to generate appropriate data for each database on the legacy systems, and then we used the custom load scenario feature of Benchmark Factory to stress the legacy HP servers. We then migrated our two databases from the two legacy HP servers to VMs on the new Dell PowerEdge R515 and ran both workloads at the same time with Benchmark Factory.

In Benchmark Factory, we imported our stored procedure definitions into the custom load scenario, and provided parameters to the stored procedures using ODBC bind parameter functionality. We then defined a mix workload approximating a 70-75 percent read (select) and 25-30 percent write (updates, inserts,

deletes) mix, typical of most standard OLTP applications. Figure 4 shows how we weighted the procedures for each database.

Procedure	Percentage
Customer workload	
View sales contact information, such as contact and address info, and company name	17.3
View meeting and call activity information for a specific sales contact	17.0
Insert new activity/task, such as a phone call or follow-up email, for a salesperson	12.7
View the "home page" of the app, which lets us see the most relevant details for a salesperson, such as basic data, assigned customers (grouped and sorted), and upcoming tasks (top 10 by date)	17.0
View an "opportunity" report, which selects each department and manager and sums the dollar amount for all the opportunities	6.3
Update customer address	12.7
View the information for a particular customer	17.0
Order workload	
Show general status for a particular order	10.5
Show detailed information, line items, and estimated dates for a particular order	26.6
Show the most recent five orders a particular customer has placed	5.2
Update an order's status	10.5
Show detailed shipping information for an order	26.3
Place a new order	15.7
Process/fulfill an order from inventory	5.2

Figure 4: Procedure percentage table.

Benchmark Factory measures transactions per second, with each stored procedure execution equaling one transaction. We ran the workload and measured transactions per second on both solutions for the customer and order databases, and show those in this report. In addition, we measured system statistics on each system, as well as power consumption during the test runs, and report those as well.

We used two controller machines running Benchmark Factory, simulating an intense system load. The controller machines ran with no think time, sending requests as quickly as the servers could handle them. We ran only the one relevant workload against each legacy HP ProLiant DL145 or DL385 server, but on the Dell PowerEdge R515 VMs, we ran both workloads simultaneously to simulate a true concurrent virtualized hardware environment.

For more details about the Benchmark Factory software, see <http://www.quest.com/benchmark-factory/>.

For more details about the SQL Data Generator software, see http://www.red-gate.com/products/SQL_Data_Generator/.

Our companion migration guide¹ provides detail on the ease of migration to the Dell PowerEdge R515 running SQL Server 2008 R2 and Hyper-V. Our companion TCO/ROI report² provides details on the cost savings that our hypothetical SMB could achieve with the migration.

SYSTEM COMPARISON

Figure 5 shows a side-by-side comparison of the key hardware specifications of the test servers.

Appendix A presents detailed system configuration information.

Hardware specifications	Dell PowerEdge R515	HP ProLiant DL145	HP ProLiant DL385
CPU	AMD Opteron 4180	AMD Opteron 250	AMD Opteron 254
CPU speed (GHz)	2.60	2.40	2.80
Number of processor packages	2	2	2
Number of cores per processor package	6	1	1
Number of hardware threads per core	1	1	1
Memory type	PC3-10600	PC-2700	PC-3200
Total memory (GB)	16	4	4

Figure 5: Key hardware specifications of the test servers.

Figure 6 shows the key settings we used on the Dell PowerEdge R515 VMs for testing. Refer to the How we tested section for detailed steps of how we set up the VMs.

VM specifications	VM #1	VM #2
Number of vCPUs	2	2
Memory (GB)	6	6
Number of virtual disks	4	4

Figure 6: Configuration information for the Dell PowerEdge R515 VMs.

¹ "Migrating to a Dell PowerEdge R515 from two legacy database servers"
http://principledtechnologies.com/clients/reports/Dell/R515_migration_guide.pdf

² "Dell PowerEdge R515 offers savings over two legacy database servers"
http://principledtechnologies.com/clients/reports/Dell/R515_TCO_ROI.pdf.

WHAT WE FOUND

Figure 7 shows the performance results, in transactions per second, for the two solutions. The Dell PowerEdge R515 server processed over 4.5 times the number of workload operations in our sample customer and order workloads than the legacy systems in a fixed time window. It did so while running both workloads simultaneously on the same hardware via virtualization.

Benchmark Factory performance score	
Customer workload	
Dell PowerEdge R515 VM #1	983
HP ProLiant DL145	213
Order workload	
Dell PowerEdge R515 VM #2	3,517
HP ProLiant DL385 + HP MSA30 storage	776

Figure 7: Transactions per second for the two solutions. Higher scores are better.

Figure 8 shows the active and idle power usage results, in watts, for the Dell PowerEdge R515 server versus the combined power usage results of the HP ProLiant DL145 server and the HP ProLiant DL385 server running with HP MSA30 external storage. Lower power usage numbers are better. The Dell PowerEdge R515 server used 67.2 percent less power than the legacy HP solution when active and 75.2 percent less power when idle.

Power usage	Active power (W)	Idle power (W)
Dell PowerEdge R515 solution	271	198
Legacy HP solution	827	798
Percentage savings from Dell PowerEdge R515 solution	67.2%	75.2%

Figure 8: Power consumption, when active and idle, for the two solutions. Lower power usage numbers are better.

HOW WE TESTED

Setting up the sample workload databases

We used SQL Server Management Studio, an integrated management environment that Microsoft includes with SQL Server, to design and implement our customer and order databases. Each database had 10 or more tables, had seven stored procedures, and was between 4GB and 6GB in size. We used published best practices in our database design and normalized our data design to a reasonable extent. We used SQL Data Generator to load data and Benchmark Factory to drive the workload. Below, we provide details on the full setup.

Installing and configuring utility software

Installing SQL Data Generator

1. Download the SQL Toolbelt file.
2. Once the file has finished downloading, double-click the SQL Toolbelt.exe file.
3. In the Selecting the Tools to install box, uncheck all of the boxes, and click Next.
4. On the new page, uncheck everything **except** SQL Data Generator 1.2, and click Next.
5. Uncheck all of the boxes, and click Next.
6. Check the I accept the terms in the license agreement box, and click Next.
7. Install the program into the default location.
8. When the program is finished installing, click Close.

Generating the database sample data

We used SQL Data Generator to create the data for the database tables that we created with SQL Server Management Studio. We used the SQL Data Generator tool for the following tasks:

- Specifying the number of rows in each table, either by exact count, or proportional to other tables
- Creating data using generators. SQL Data Generator includes built-in regex functionality to generate common data such as name data, address data, email address data, and Web addresses. We used this functionality where possible.
- Where logical, changing the generators for certain columns, assigning dates within certain minimum and maximum bounds, and creating custom regex patterns for others
- For longer text storage, substituting a longer English source text so that indexed searches of those fields would be more realistic
- Running a pre-load and post-load custom SQL action. We used this feature to force some dependencies among databases, tables, and fields.

Installing Benchmark Factory

1. Double-click the downloaded MSI installation file.
2. On the Welcome Screen, click Next.
3. On the license agreement screen, click I accept the terms in the license agreement, and click Next.
4. Accept the default location for the program installation, and click Next.
5. On the final screen, select Yes, install the default repository database, and click Install.
6. After the installation completes, click Finish.

Configuring Benchmark Factory for workload operation

We used the Benchmark Factory configuration editor to model typical operations on the customer and order databases. We imported stored procedures from our database design to incur activity against both the customer and order databases. We assigned a weight to each stored procedure so that the ratio of procedures performing read-like operations to those performing write-like operations approximated that of a typical customer-center application. Our goal was to achieve approximately a 70 percent read and 30 percent write ratio for each database, as this is common for most OLTP database applications. We defined parameters to pass to each procedure that Benchmark Factory generated from numerical values or passed from a

randomized predefined file. To simulate a business of 100-500 people, with a Web presence, we kept think time for the transactions at zero and assigned the user count down to 25 virtual Benchmark Factory users. This provided suitable system stress in a compressed testing time window. We ran each simulation for 20 minutes, as each environment had reached steady state within that time period. We ran this simulation three times on each configuration and collected data for this report, reporting the median outputs.

Setting up the servers

On the Dell PowerEdge R515 server, we installed a fresh copy of Windows Server 2008 R2 Standard Edition and enabled Hyper-V. On the HP ProLiant DL145 and the HP ProLiant DL385, we installed a fresh copy of Windows Server 2003 R2 Standard Edition. Below, we cover specific Windows and SQL Server setup details for each system.

Setting up and configuring the Dell PowerEdge R515 server

Configuring the internal storage on the Dell PowerEdge R515

1. Boot the server, and when prompted by the system, press Ctrl+R to enter the PERC BIOS Configuration Utility.
2. Highlight the PERC H700, press F2, and choose Create New Virtual Disk.
3. Highlight the RAID level option, and press Enter. Choose RAID 1.
4. Select the first two disks.
5. Press tab to navigate to the OK button, and press Enter.
6. Repeat steps 2 through 5 to create the second volume, this time selecting RAID 10 for the RAID level, and the remaining disks in the system.
7. Highlight each virtual disk, and press F2, Initialization, Start Init.
8. When the initialization completes, reboot the system.

Installing Windows Server 2008 R2 Standard Edition on the Dell PowerEdge R515

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 Standard (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. At 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 the Dell PowerEdge R515 server using the Windows® Update feature:

- Security Update for Windows Server 2008 R2 x64 Edition (KB977894)
- Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2398632)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB980195)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2347290)
- 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)
- Update for Windows Server 2008 R2 x64 Edition (KB976662)
- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979482)
- Security Update for .NET Framework 3.5.1 on Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB983590)
- 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 (KB2160329)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2032276)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2079403)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2183461)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978886)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981852)
- 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)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980218)
- Windows Malicious Software Removal Tool x64 - September 2010 (KB890830)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978542)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2286198)

- Security Update for Windows Server 2008 R2 x64 Edition (KB978601)
- Security Update for Windows Server 2008 R2 x64 Edition (KB982799)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981332)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980436)
- Update for Windows Server 2008 R2 x64 Edition (KB980408)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)
- Security Update for Windows Server 2008 R2 x64 Edition (KB982214)

Enabling the Hyper-V role in Windows Server 2008 R2

1. Click Start→Administrative Tools→Server Manager.
2. Click Roles.
3. Click Add Roles.
4. Click Next.
5. Select the Hyper-V role by checking the box beside it, and click Next.
6. Check the box beside the Ethernet Card you wish to use for client/server traffic, and click Next.
7. Click Install to begin the Hyper-V installation.
8. When the installation finishes, click Close.
9. When the installer prompts you to restart now, click Yes.
10. Follow the prompt to log onto the system.
11. Enter the password, and click the arrow to continue. The Resuming Configuration Wizard should start automatically.
12. Once the Resuming Configuration Wizard completes, the installation results should appear with a message that the installation succeeded.
13. Click Close.

Creating the Hyper-V virtual machines

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 host E: volume. Use this VHD for VM operating system storage.
5. From the Action menu, select New→Virtual Hard Disk.
6. Choose Fixed Size, assign 30GB for size, and place the VHD in the appropriate VM folder on the host E: volume. Use this VHD for SQL Server transaction logs.
7. From the Action menu, select New→Virtual Hard Disk.
8. Choose Fixed Size, assign 30GB for size, and place the VHD in the appropriate VM folder on the host E: volume. Use this VHD for SQL Server data files.
9. From the Action menu, select New→Virtual Hard Disk.
10. Choose Fixed Size, assign 30GB for size, and place the VHD in the appropriate VM folder on the host E: volume. Use this VHD for backup and utility files.
11. From the Action menu, select New→Virtual Machine.
12. On the Before You Begin page, click Next.
13. On the Specify Name and Location page, enter the name for your new virtual machine. Place the virtual machine configuration in the relevant folder, and click Next.
14. On the Assign Memory page, enter 6GB of RAM.

15. On the Configure Networking, choose the network assigned to client/server traffic, and click Next.
16. Choose to add a virtual hard disk later.
17. On the Installation Options page, accept the default of Install an operating system later, and click Next.
18. On the Completing the New Virtual Machine Wizard page, click Finish.
19. Right-click the virtual machine, and choose Settings.
20. Click Processors, and choose 2 virtual processors.
21. Click the virtual IDE controller 0.
22. Click Add, and click Hard Drive.
23. Browse to the VHD you created in Step 4, and choose that VHD for the guest OS VHD.
24. Click Apply.
25. Click the SCSI Controller.
26. Click Add, and click Hard Drive.
27. Browse to the VHD you created in Step 6, and choose that VHD for the guest SQL Server log VHD.
28. Click Apply.
29. Click Add, and click Hard Drive.
30. Browse to the VHD you created in Step 8, and choose that VHD for the guest SQL Server data VHD.
31. Click Apply.
32. Click Add, and click Hard Drive.
33. Browse to the VHD you created in Step 10, and choose that VHD for the guest SQL Server data VHD.
34. Click Apply.
35. Repeat steps 3 through 34 for the second VM.

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 Standard (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.
17. Repeat the installation for the remaining VM.

Setting up network configuration on the VM

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. At 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.
6. Repeat steps 1 through 5 for the remaining VM.

Installing system updates in Windows Server 2008 R2 in the VMs

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

- Security Update for Windows Server 2008 R2 x64 Edition (KB977894)
- Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2398632)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2008 R2 x64 Edition (KB980195)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2347290)
- 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)
- Update for Windows Server 2008 R2 x64 Edition (KB976662)
- Security Update for Windows Server 2008 R2 x64 Edition (KB974571)
- Security Update for Windows Server 2008 R2 x64 Edition (KB979482)
- Security Update for .NET Framework 3.5.1 on Windows 7 and Windows Server 2008 R2 for x64-based Systems (KB983590)
- 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 (KB2160329)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2032276)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2079403)
- Cumulative Security Update for Internet Explorer 8 for Windows Server 2008 R2 x64 Edition (KB2183461)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978886)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981852)
- 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)
- Security Update for Windows Server 2008 R2 x64 Edition (KB980218)
- Windows Malicious Software Removal Tool x64 - September 2010 (KB890830)
- Update for Windows Server 2008 R2 x64 Edition (KB974431)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978542)
- Security Update for Windows Server 2008 R2 x64 Edition (KB2286198)
- Security Update for Windows Server 2008 R2 x64 Edition (KB978601)
- Security Update for Windows Server 2008 R2 x64 Edition (KB982799)
- Security Update for Windows Server 2008 R2 x64 Edition (KB981332)

- Security Update for Windows Server 2008 R2 x64 Edition (KB980436)
- Update for Windows Server 2008 R2 x64 Edition (KB980408)
- Security Update for Windows Server 2008 R2 x64 Edition (KB975467)
- Security Update for Windows Server 2008 R2 x64 Edition (KB982214)

Installing SQL Server 2008 R2 Standard Edition on the VMs

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 key or choose free Enterprise edition evaluation, and click Next. Note we used and assumed Standard edition for our testing.
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, 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. Repeat steps 1 through 30 for the remaining VM.

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 the second VM.

Setting up and configuring the HP ProLiant servers and HP MSA30 storage

Configuring the storage on the HP ProLiant DL145

In the HP ProLiant DL145, we used both internal disk bays and configured the internal volume as a RAID 1 mirror by installing an HP Smart Array 6400 storage adapter. We installed Windows Server 2003 R2 Standard Edition and SQL Server 2000 Standard Edition software on the internal volume. We also configured the SQL Server transaction logs and SQL Server database data files on the internal volume. We used the /3GB boot.ini switch to allow the SQL Server database engine access to 1GB additional RAM.

Configuring the storage on the HP ProLiant DL385

We installed six internal drives in the HP ProLiant DL385. We attached the server to an HP MSA30, cabling the HP MSA30 to the Smart Array 6400 storage adapter in the server via one SCSI cable. The I/O module on the HP MSA30 was a single-port I/O module. The array contained 14 drives, all used by the HP ProLiant DL385.

We configured the first two internal drives in a RAID 1 volume. We configured the remaining four drives in a RAID 10 volume. The HP MSA30 contained 14 146GB 10,000RPM U320 SCSI drives. As we note above, using the single-port I/O module, the entirety of the HP MSA30 disk count was devoted to the HP ProLiant DL385 server. We configured the HP MSA30 volume in a RAID 5 array, resulting in approximately a 1.7TB volume at the operating system level, which we then partitioned, using a 50GB partition for SQL Server data on the external storage. We used a 15GB partition for SQL Server logs on the second internal volume.

We installed Windows Server 2003 R2 Standard Edition and SQL Server 2005 Standard Edition software on the first mirrored internal volume, configured the SQL Server transaction logs on the second internal volume, and placed the SQL Server database data on the HP MSA30 volume. We used the /3GB boot.ini switch to allow the SQL Server database engine access to 1GB additional RAM.

Setting up the internal storage for operating system installation (both HP ProLiant servers)

1. Enter the RAID controller BIOS by pressing F8 at the HP Smart Array Controller prompts.
2. Select Create Logical Drive.
3. Select the drives to use for this RAID volume.
4. Press F8 to save this configuration.
5. Press Enter to continue.
6. Press Escape to return to the boot sequence.
7. Repeat for the remaining internal volume and external volume.

Installing Windows Server 2003 R2 Standard Edition with Service Pack 2 (both HP ProLiant servers)

1. Boot the server, and insert the Windows Server 2003 R2 Standard Edition installation CD in the DVD-ROM drive.
2. At the Welcome to Setup screen, press Enter to begin the installation.
3. At the Windows Licensing Agreement screen, press F8 to agree to the terms.
4. Press Enter to install in the default location.
5. Select Format the partition using the NTFS file system (Quick), and press Enter to continue.
6. At the Regional and Language Options screen, click Next.
7. Enter Name and Organization, and click Next. Note: Organization is an optional field, while username is required.
8. At the Your Product Key screen, enter your product key, and click Next.
9. At the Licensing Modes screen, click Next.
10. At the Computer Name and Administrator Password screen, type Password1 as the new password in both fields, and click Next.
11. At the Date and Time Settings screen, change the Date & Time and Time Zone if appropriate, and click Next.
12. After the system restarts automatically, follow the prompt to log into the server.
13. At the Windows Setup screen, the installer prompts you to insert the second installation CD. Insert the appropriate CD, and click OK.
14. At the Windows Server 2003 R2 Setup Wizard Welcome screen, click Next.
15. At the Windows Server 2003 R2 Setup Wizard Summary screen, click Next.
16. When the installer prompts you, click Finish to end the installation.

Setting up network configuration on the server (both HP ProLiant servers)

1. Click Start→Control Panel→Network Connections→Local Area Connection.
2. Click Properties.
3. Select Internet Protocol (TCP/IP), and click Properties.
4. In the Internet Protocol (TCP/IP) Properties screen, select the Use the following IP address radio button.
5. Enter a valid static IP address, subnet mask, and default gateway.
6. Select the Use the following DNS server addresses radio button, and enter at least one valid DNS server address.
7. Click OK, and click OK to exit.

Installing system updates in Windows Server 2003 R2 Standard Edition (both HP ProLiant Servers)

We installed the following updates on the HP ProLiant DL385 using the Microsoft Windows Update feature:

- Update for Windows Server 2003 (KB2141007)
- Security Update for Windows Server 2003 (KB981332)
- Update for Windows Server 2003 (KB976662)
- Update for Windows Server 2003 (KB971737)
- Update for Windows Server 2003 (KB970430)
- Security Update for Jscript 5.8 for Windows Server 2003 (KB971961)
- Windows Malicious Software Removal Tool - September 2010 (KB890830)
- Security Update for Windows Server 2003 (KB2347290)
- Security Update for Windows Server 2003 (KB2121546)
- Security Update for Windows Server 2003 (KB982802)
- Security Update for Windows Server 2003 (KB975558)
- Security Update for Windows Server 2003 (KB981322)
- Security Update for Windows Server 2003 (KB2259922)
- Security Update for Windows Server 2003 (KB2286198)
- Security Update for Windows Server 2003 (KB980436)
- Security Update for Windows Server 2003 (KB2079403)
- Security Update for Windows Server 2003 (KB982214)
- Security Update for Windows Server 2003 (KB2115168)
- Security Update for Windows Server 2003 (KB2160329)
- Cumulative Security Update for Internet Explorer 6 for Windows Server 2003 (KB2183461)
- Security Update for Windows Server 2003 (KB2229593)
- Security Update for Windows Server 2003 (KB975562)
- Microsoft .NET Framework 1.1 SP1 Security Update for Windows Server 2003 x86 and Windows Server 2003 R2 x86 (KB979907)
- Security Update for Windows Server 2003 (KB979482)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2003 (KB980195)
- Security Update for Windows Media Format Runtime 9.5 for Windows Server 2003 (KB978695)
- Security Update for Windows Server 2003 (KB980218)
- Update for Windows Server 2003 (KB981793)
- Security Update for Windows Server 2003 (KB978542)
- Security Update for Windows Server 2003 (KB978601)
- Security Update for Windows Server 2003 (KB979683)
- Security Update for Windows Server 2003 (KB978338)
- Security Update for Windows Server 2003 (KB979309)
- Security Update for Windows Server 2003 (KB981350)
- Security Update for Windows Server 2003 (KB977816)
- Security Update for Windows Server 2003 (KB980232)
- Security Update for Windows Server 2003 (KB978706)

- Security Update for Windows Server 2003 (KB977914)
- Security Update for Windows Server 2003 (KB975560)
- Security Update for Windows Server 2003 (KB978037)
- Security Update for Windows Server 2003 (KB975713)
- Security Update for Windows Server 2003 (KB972270)
- Security Update for Windows Server 2003 (KB973904)
- Update for Windows Server 2003 (KB955759)
- Security Update for Windows Server 2003 (KB974392)
- Security Update for Windows Server 2003 (KB974318)
- Update for Windows Server 2003 (KB968389)
- Microsoft .NET Framework 1.1 Service Pack 1 Security Update for Windows Server 2003 x86 and Windows Server 2003 R2 x86 (KB953298)
- Security Update for Windows Server 2003 (KB969059)
- Security Update for Windows Server 2003 (KB958869)
- Security Update for Windows Server 2003 (KB974112)
- Security Update for Windows Server 2003 (KB974571)
- Security Update for Windows Server 2003 (KB975025)
- Security Update for Windows Media Format Runtime 9.5 for Windows Server 2003 (KB954155)
- Security Update for Jscript 5.6 for Windows Server 2003 (KB971961)
- Security Update for Windows Server 2003 (KB967723)
- Security Update for Windows Server 2003 (KB956844)
- Internet Explorer 8 for Windows Server 2003
- Security Update for Windows Server 2003 (KB971657)
- Security Update for Windows Server 2003 (KB973815)
- Security Update for Windows Server 2003 (KB960859)
- Security Update for Windows Server 2003 (KB973507)
- Security Update for Windows Server 2003 (KB958469)
- Security Update for Windows Server 2003 (KB973869)
- Security Update for Windows Server 2003 (KB973540)
- Security Update for Windows Server 2003 (KB971032)
- Security Update for Windows Server 2003 (KB961501)
- Security Update for Windows Server 2003 (KB923561)
- Security Update for Windows Server 2003 (KB959426)
- Security Update for Windows Server 2003 (KB960803)
- Security Update for Windows Server 2003 (KB952004)
- Security Update for Windows Server 2003 (KB956572)
- Update for Windows Server 2003 (KB967715)
- Security Update for Windows Server 2003 (KB956803)
- Security Update for Windows Server 2003 (KB925902)
- Security Update for Windows Server 2003 (KB956802)
- Security Update for Windows Server 2003 (KB952069)
- Security Update for Windows Server 2003 (KB958644)

- Security Update for Windows Server 2003 (KB944338)
- Security Update for Windows Server 2003 (KB950974)
- Security Update for Windows Server 2003 (KB952954)
- Security Update for Windows Server 2003 (KB951748)
- Security Update for Windows Server 2003 (KB950762)
- Cumulative Security Update for ActiveX Killbits for Windows Server 2003 (KB950760)
- Security Update for Windows Server 2003 (KB945553)
- Update for Windows Server 2003 (KB948496)
- Security Update for Windows Server 2003 (KB943055)
- Security Update for Windows Server 2003 (KB946026)
- Security Update for Windows Server 2003 (KB941569)
- Security Update for Windows Server 2003 (KB944653)
- Security Update for Microsoft .NET Framework, Version 1.1 Service Pack 1 (KB933854)
- Security Update for Windows Server 2003 (KB938127)
- Security Update for Windows Server 2003 (KB926122)
- Security Update for Windows Media Player 6.4 (KB925398)
- Cumulative Security Update for Outlook Express for Windows Server 2003 (KB929123)
- Security Update for Windows Server 2003 (KB924667)
- Update for Windows Server 2003 (KB927891)
- Security Update for Windows Server 2003 (KB932168)

Connecting the storage array to the server (HP ProLiant DL385 only)

We attached the database volume on the HP MSA30 storage to the HP ProLiant DL385 server by using a SCSI cable connected from the Smart Array 6400 Controller in the server to one SCSI connector on the back of the HP MSA30 single-port I/O module.

Configuring additional volumes via the DiskPart utility and Disk Management Utility (HP ProLiant DL385 only)

1. Click Start→Run, type `cmd` and press Enter.
2. Type `diskpart`
3. Type `list disk`
4. Type `select disk #` (where # is the disk number of the internal volume).
5. Type `create partition primary size=15360 align=1024`
6. Type `assign letter=E` for the internal volume.
7. Type `list disk`
8. Type `select disk #` (where # is the disk number of the external HP MSA30 volume).
9. Type `create partition primary size=51200 align=1024`
10. Type `assign letter=F` for the external volume.
11. Exit the command prompt.
12. Click Start→Administrative Tools→Computer Management.
13. Click Disk Management.

14. Right-click the volume, and select Format. Choose 64KB allocation unit size, NTFS file system, select Perform Quick Format, and press OK.
15. Repeat Step 14 for the external HP MSA30 volume.
16. Create the folders necessary for the database. We used E:\SQLData for the SQL Server database volume and F:\SQLLog for the SQL Server transaction log volume.

Installing SQL Server 2000 Standard Edition (HP ProLiant DL145 only)

1. Insert the Microsoft SQL Server 2000 install CD into the CD/DVD drive.
2. In Windows Explorer, browse to the CD drive, and double-click setup.bat.
3. Click SQL Server 2000 Components.
4. Select Install Database Server.
5. On the Welcome screen, click Next.
6. On the Computer Name screen, select Local Computer, and click Next.
7. Select Create a new instance of SQL Server, or install Client Tools, and click Next.
8. On the User Information Screen, click Next
9. On the Software Agreement Screen, click Yes.
10. On the Installation Definition Screen, select Server and Client Tools, and click Next.
11. On the next screen, click Default, and click Next.
12. On the Setup Type screen, select Typical, and click Next.
13. On the Service accounts screen, select Use the same account for each service. Choose to Auto start the SQL Server Service and to use the Local System Account, and click Next.
14. On the Authentication mode screen, select Mixed Mode, enter a password for the sa account, and click Next.
15. On the Choose Licensing Mode screen, select Processor License for 2 processors, and click Continue.
16. After the installation completes, click Yes I want to restart my computer now, and click Finish.

Installing SQL Server 2000 Standard Edition SP4 (HP ProLiant DL145 only)

1. Download the executable for Microsoft SQL Server 2000 SP4 from <http://www.microsoft.com/downloads/details.aspx?familyid=8e2dfc8d-c20e-4446-99a9-b7f0213f8bc5&displaylang=en>.
2. Double-click the SQL2000-KB884525-SP4-x86-ENU.EXE file.
3. On the license agreement screen, click I accept the terms in the license agreement, and click Next.
4. Accept the default location for the files to extract, and click Next.
5. In Windows Explorer, browse to C:\SQL2KSP4\, and double-click setup.bat.
6. On the Welcome screen, click Next.
7. On the Software License Agreement screen, click Yes.
8. On the Instance Name screen, click Next.
9. On the Connect to Server screen, select The Windows account information I use to log on to my computer with (Windows authentication), and click Next.
10. On the SQL Server 2000 Service Pack 4 Setup screen, select Upgrade Microsoft Search and apply SQL Server 2000 SP4 (required), and click Continue.
11. On the Error reporting screen, click OK.
12. On the Start copying files screen, click Next. The install begins.

13. When the installation finishes, a screen appears saying to backup the master and msdb databases. Click OK.
14. Click Yes I want to restart my computer now, and click Finish.

Installing SQL Server 2005 Standard Edition (HP ProLiant DL385 only)

1. Navigate to the SQL Server 2005 CD, and double-click. Choose Standard Edition if the installer prompts you with a menu.
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. For this installation, ignore the possible warning regarding IIS, as it is unnecessary for this configuration.
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, uncheck Replication, 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.
22. Reboot the server before installing SQL Server SP3.

Installing Service Pack 3 for Microsoft SQL Server 2005 (HP ProLiant DL385 only)

Service Pack 3 for Microsoft SQL Server 2005 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.

Power measurement procedure

To record each server and storage system's power consumption during each test, we used an Extech® Instruments (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. 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 captured power consumption at 1-second intervals. We report the median of three results.

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 Benchmark Factory workload run. We call this time the power measurement interval. See Figure 8 for the results of these measurements. We report the power from the run with the median TPS.

APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 9 provides detailed configuration information about the test servers.

System	Dell PowerEdge R515	HP ProLiant DL145	HP ProLiant DL385
Power supplies			
Total number	2	1	2
Wattage of each (W)	750	500	575
Cooling fans			
Total number	5	5	7
Dimensions (h x w) of each	2-1/2" x 1-1/2"	1-1/2" x 1-1/4"	2.5" x 2.5"
Volts	12	12	12
Amps	1.68	0.54	1.10
General			
Number of processor packages	2	2	2
Number of cores per processor	6	1	1
Number of hardware threads per core	1	1	1
CPU			
Vendor	AMD	AMD	AMD
Name	Opteron	Opteron	Opteron
Model number	4180	250	254
Stepping	HY-D1	A	E4
Socket type	Socket C32	Socket 940	Socket 940
Core frequency (GHz)	2.60	2.40	2.80
Bus frequency	6,400 GT/s	2,000 MHz	2,000 MHz
L1 cache	64 KB + 64 KB (per core)	64 KB + 64 KB (per core)	64 KB + 64 KB (per core)
L2 cache	512 KB (per core)	1,024 KB	1,024 KB
L3 cache	6 MB (shared)	N/A	N/A
Platform			
Vendor and model number	Dell PowerEdge R515	HP ProLiant DL145	HP ProLiant DL385
Motherboard model number	03X0MN	PCBA Serenade-3 V0100219-300	4K0585
BIOS name and version	Dell Inc. 1.0.0	American Megatrends Inc. 080008	HP A05
BIOS settings	Default	Default	Default

System	Dell PowerEdge R515	HP ProLiant DL145	HP ProLiant DL385
Memory module(s)			
Total RAM in system (GB)	16	4	4
Vendor and model number	Samsung M391B5273CH0-CH9	Infineon 72D128320GBR6C	Hynix HYMD512G726CFP4Q-D43
Type	PC3-10600E	PC2-2700	PC-3200
Speed (MHz)	1,333	333	400
Speed running in the system (MHz)	1,333	333	400
Timing/latency (tCL-tRCD-iRP-tRASmin)	9-9-9-24	2.5-3-3-7	3-3-3-8
Number of RAM module(s)	4	4	4
Chip organization	4 x 4GB	4 x 1GB	4 x 1GB
Rank	Double-sided	Double-sided	Double-sided
Hard disk			
Vendor and model number	Hitachi Ultrastar HUS156060VLS600	HP BD07287B4C HP BD072863B2	HP BF072863BA
Number of disks in system	8	2	4
Size (GB)	600	72	72
Buffer size (MB)	64	32	8
RPM	15,000	10,000	15,000
Type	SAS 6Gbps	Wide ULTRA320	U320 SCSI
Disk controller			
Vendor and model	LSI PERC H700 Integrated	HP Smart Array 6400	Smart Array 6i/Smart Array 6400 (external)
Controller cache (MB)	512	192	64/192
Controller driver	LSI 4.5.0.64	Microsoft 5.2.3790.3959	HP 5.60.0.32/HP 5.60.0.32
Controller firmware	2.30.03-0872	2.84	2.84/2.84
RAID configuration	2 disk RAID 1 + 6 disk RAID 10	2 disk RAID 1	2 disk RAID 1 + 4 disk RAID 10/14 disk RAID 5
Operating system			
Name	Windows Server 2008 R2	Windows Server 2003 R2	Windows Server 2003 R2
Build number	7600	3790	3790
Service pack	Service Pack 1	Service Pack 2	Service Pack 2
File system	NTFS	NTFS	NTFS
Kernel	ACPI x64-based PC	ACPI Multiprocessor PC	ACPI Multiprocessor PC
Language	English	English	English

System	Dell PowerEdge R515	HP ProLiant DL145	HP ProLiant DL385
Ethernet			
Vendor and model number	Broadcom® BCM5716C NetXtreme® II GigE	Broadcom NetXtreme Gigabit Ethernet	HP NC7782 Gigabit Server Adapter
Type	Integrated	Integrated	Integrated
Driver	Microsoft Corporation 4.8.4.1 (12/23/2008)	Broadcom 6.34.0.0 (02/17/2003)	HP 14.0.0.7 (2/9/2010)
Ethernet #2			
Vendor and model number	Intel® Gigabit ET Quad Port	N/A	N/A
Type	Discreet	N/A	N/A
Driver	Intel 11.7.32.0 (7/8/2010)	N/A	N/A
Optical drive(s)			
Vendor and model number	TEAC DVD-ROM DV-28SW ATA Device	N/A	Compaq CD-ROM SN-124
Type	DVD-ROM	N/A	CD-ROM
USB ports			
Number	4	2	3
Type	2.0	1.1	1.1

Figure 9: Configuration information for the test servers.

APPENDIX B – TEST STORAGE INFORMATION

Figure 10 presents detailed information for the external storage we used on the HP ProLiant DL385 server.

Enclosure	HP StorageWorks MSA30
Height (inches)	5.20
Width (inches)	19.0
Depth (inches)	16.5
U size in server rack	3
Power supplies	
Total number	2
Wattage of each	499
Fans	
Total number	2
Dimensions (H x W) of each (inches)	4 x 4
Voltage (V)	12.5
Amps (A)	2.0
Disks	
Vendor and model number	HP BD14685A26 HP BD1468856B HP BD14686225 HP BD146863B3
Number of disks in system	14
Size (GB)	146
Buffer size (MB)	8
RPM	10,000
Type	SCSI U320
Other	
Storage connectivity (Fibre Channel, SAS, SATA, iSCSI, SCSI)	SCSI U320
Firmware revision	N/A
Storage cache (GB)	N/A
Number of storage controllers	1
Number of storage ports	1
Maximum network bandwidth of storage connectivity to host	N/A
Switch type/model/firmware revision	N/A

Figure 10: Configuration information for the test storage.

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