Dell™ PowerEdge™ R720xd server consolidated five Dell PowerEdge 2950 III servers

$ Pays back your investment in as little as 5 months*

* if migrating from SQL Server 2008 R2 Enterprise licensed per processor to SQL Server Enterprise 2012 licensed per core

powered by the Intel® Xeon® processor E5-2600 series

Your database servers are doing their jobs, but your company is growing. Using virtualization to consolidate these servers onto a single more powerful server, such as the new Dell PowerEdge R720xd powered by the Intel Xeon processor E5-2600 series, can benefit your business in a number of ways. With a 26-disk capacity, the Dell PowerEdge R720xd server allows increased expansion flexibility over previous-generation servers. You can support your current load with less hardware and support even more users in the future.

To test this, we measured the database performance of two solutions: a three-to-four-year old Dell PowerEdge 2950 III running Microsoft® SQL Server® 2008 R2 and a Dell PowerEdge R720xd running the same workload in each of five virtual machines (VMs) with SQL Server 2012. The virtualized solution supported five workloads while delivering 461.7 percent more total performance than the legacy server's single workload.

The potential savings in hardware, maintenance, power, and cooling costs make the Dell PowerEdge R720xd a wise investment. In a scenario where this server replaces five Dell PowerEdge 2950 III servers, it can lower total cost of ownership (TCO) over three years by as much as $151,747.94. It can pay back the investment in hardware and the migration effort in as little as 5 months if migrating from SQL Server 2008 R2 Enterprise licensed per processor to SQL Server Enterprise 2012 licensed per core.

A PRINCIPLED TECHNOLOGIES TEST REPORT

Commissioned by Dell Inc.; March 2012

MEET YOUR GROWING DATABASE NEEDS WITH FEWER SERVERS

For testing, we compared the performance of a Dell PowerEdge 2950 III running SQL Server 2008 R2 (Enterprise Edition) with the performance of a Dell PowerEdge R720xd running SQL Server 2012 (Enterprise Edition) inside five virtual machines. We used test clients running DVD Store 2.1 (DS2) to execute the test workload.

As Figure 1 illustrates, the five VMs on the Dell PowerEdge R720xd solution, each running a single instance of SQL Server, delivered a total of 175,787 orders per minute. This is 461.7 percent more than the 31,295 OPM the single SQL Server instance on the Dell PowerEdge 2950 III delivered.

Figure 1: The Dell PowerEdge R720 delivered 461.7 percent greater SQL Server performance than the Dell PowerEdge 2950 III. Higher numbers are better.

Total database performance
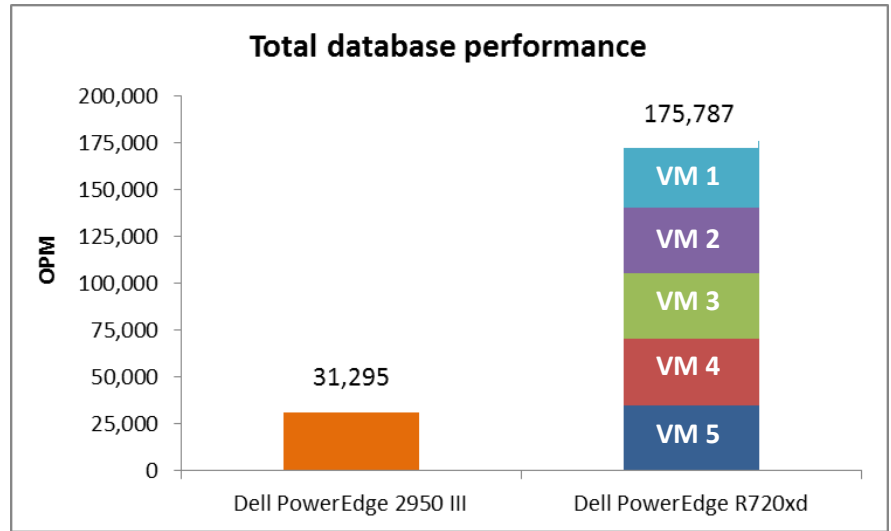
As Figure 2 illustrates, the Dell PowerEdge R720xd delivered dramatically greater performance per watt than the PowerEdge 2950 III: its 376.0 orders per minute per watt is almost four times greater than the legacy server's 95.2 OPM/watt.

Figure 2: The Dell PowerEdge R720xd delivered 294.8 percent greater database performance per watt than the Dell PowerEdge 2950 III. Higher numbers are better.

Database performance/watt
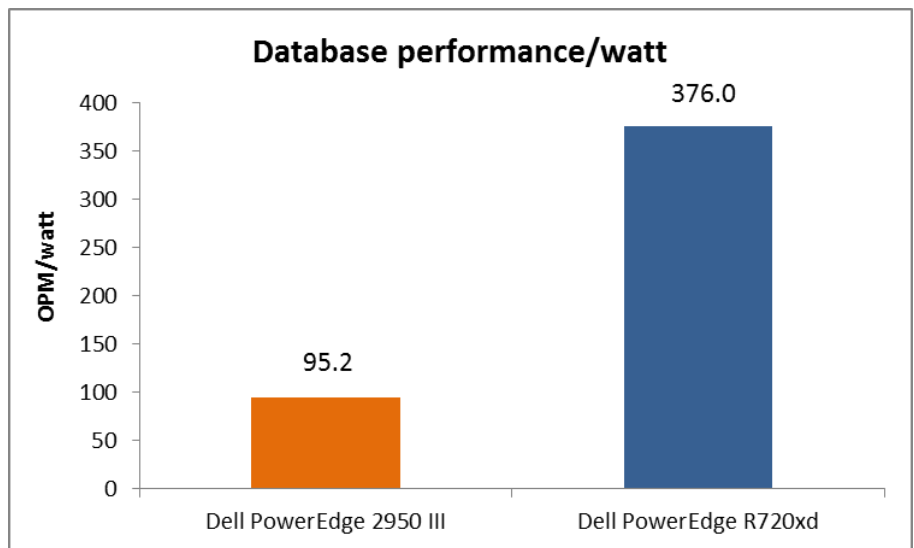
ACHIEVE PAYBACK IN AS LITTLE AS 5 MONTHS BY CONSOLIDATING THE DATABASE WORKLOAD OF FIVE DELL POWEREDGE 2950 III SERVERS

To illustrate the cost savings this 5:1 consolidation can provide, we compared costs for a hypothetical enterprise consolidating workloads on the Dell PowerEdge R720xd to the costs of retaining the existing solution. We found that, thanks to savings in software and hardware support, server administration, and data center costs for energy, ports, and space, the Dell PowerEdge R720xd can pay back the investment in hardware and the migration effort in as little as 5 months if migrating from SQL Server 2008 R2 Enterprise licensed per processor to SQL Server Enterprise 2012 licensed per core. If you do not consider SQL Server software costs and savings, payback can be achieved in 17 months. We explore this option in our second scenario.

TCO scenario 1: Including SQL Server software costs

Figure 3 summarizes the costs for the two solutions when we take into account SQL Server software expenses. In this analysis, the Dell PowerEdge R720xd solution saves $151,747.94 or 55 percent over the three years of our analysis. The enterprise will spend $122,249.86 for acquisition, migration, and operational costs for the single Dell PowerEdge R720xd vs. $273,997.80 in operational costs for the five existing servers.

Figure 3: Breakdown of acquisition and operational costs for the two solutions over three years.

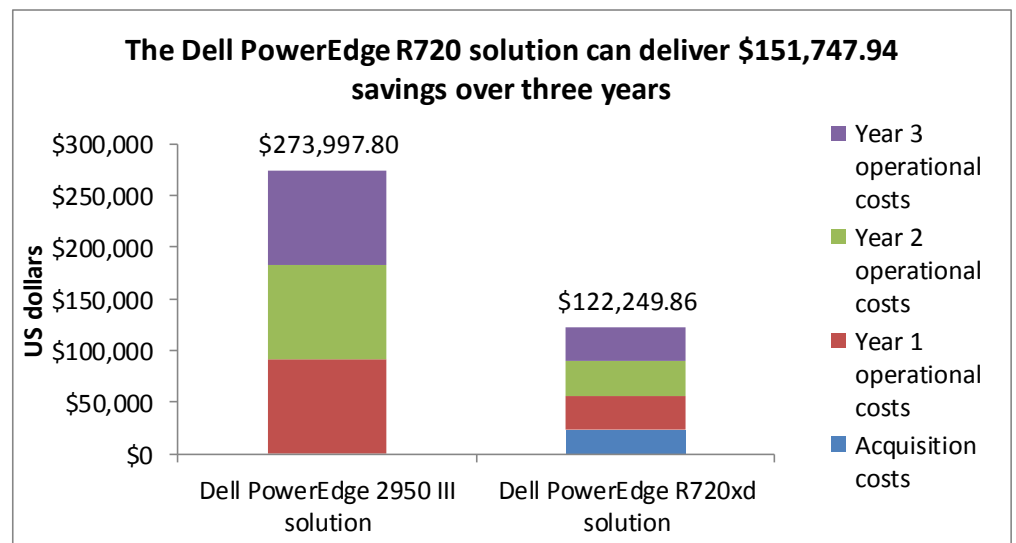The Dell PowerEdge R720 solution can deliver $151,747.94 savings over three years
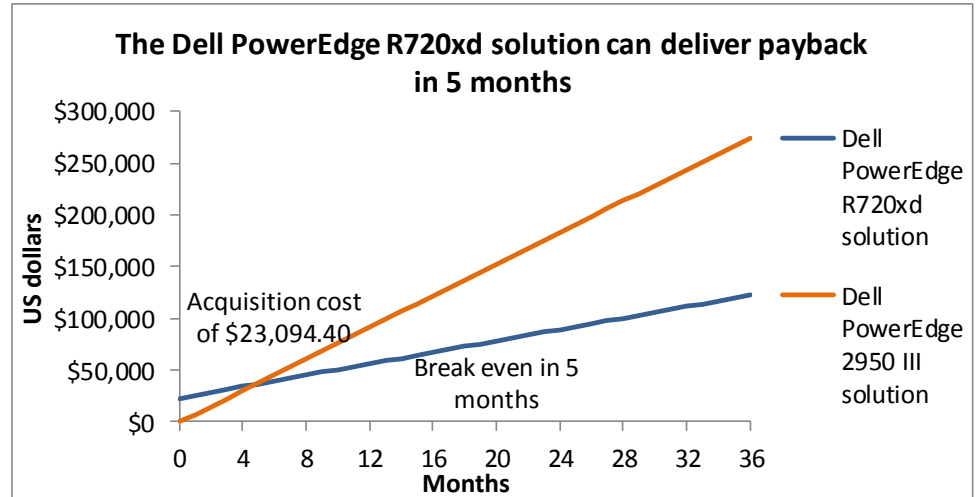
Figure 4 shows that the Dell PowerEdge R720xd solution can deliver payback in as little as 5 months when we include Microsoft SQL Server software costs.

The Dell PowerEdge R720xd solution can deliver payback in 5 months

Figure 4: Payback period for replacing five Dell PowerEdge2950 III servers with a single Dell PowerEdge R720xd server.

Our hypothetical enterprise is moving from Microsoft SQL Server 2008 R2 on the existing solution to Microsoft SQL Server 2012 Enterprise Edition on the Dell PowerEdge R720xd solution. There are many possible scenarios for this migration depending on choices of software editions, software-licensing model, and sales channel among other factors.

Microsoft SQL Server 2008 R2 is available in two core editions (Standard and Enterprise) plus various premium and specialized editions. Microsoft markets SQL Server 2008 R2 Standard Edition for small-to-midsize organizations. The more expensive Enterprise Edition aimed for large organizations expands on the feature set of the Standard Edition, providing higher levels of high availability, scalability, performance, manageability, and security.[1] It is designed for uses such as mission-critical databases and applications data warehousing.

Our hypothetical medium-to-large-sized enterprise could have chosen to license with either the Standard or Enterprise editions of SQL Server 2008 R2 for the Dell PowerEdge 2950 III solution. Both editions support the 4GB memory and two CPUs of those existing servers. The enterprise would select the Enterprise Edition for its expanded feature set or the pared down Standard Edition. We tested with the Enterprise Edition, so our consolidation results are for that edition.

SQL Server 2008 R2 Standard and Enterprise editions are licensed through Microsoft Volume Licensing using either the Per Processor software-licensing model or the Per Server/Client Access License (CAL) software-licensing model (per server). We assume the hypothetical enterprise uses the per-processor licensing model because a high enough user or device count makes per-processor licensing less expensive than the

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[1] For more information, see http://www.microsoft.com/sqlserver/en/us/product-info/compare.aspx

combined cost of Server licenses and CALs of the per-server model. That breakeven point is about 283 CAL licenses.

Licenses are available through various Microsoft sales channels including enterprise agreements (EA), Enrollment for Application Platform (EAP), Select License, Open Programs and through OEMs. Choice of channel influences cost and the ability to reassign licenses between servers and upgrade the software. Buyers under some channels can add Software Assurance (SA) agreements to their licenses at an annual cost of approximately 25 percent of the license cost. SA includes upgrade and Step-up rights among its benefits. Upgrade rights typically let you upgrade to the corresponding edition of the subsequent SQL Server release, for example Enterprise edition per-processor license to the newer release's Enterprise edition per-processor license with no additional license cost. A move to a higher edition such as from Standard to Enterprise requires purchase of a Step-up SKU, which saves over the full license price of the higher edition. SA can also offer additional benefits with new releases. For example, SQL Server 2008 R2 introduced a ceiling of four VMs covered by each license. However, customers using upgrade privileges under their SA agreements for SQL Server 2008, which had no such limit, had for a time the right to run SQL Server 2008 R2 in unlimited numbers of VMs.[2]

The SQL Server 2012 Standard Edition has a limit of 64GB RAM, less than the 128GB RAM on the Dell PowerEdge R720xd server, so we consider only the SQL Server 2012 Enterprise Edition for these migration scenarios. SQL Server 2012 replaces the per-processor pricing of the earlier edition with per-core pricing and phases out the per-server pricing option for the Enterprise Edition (except for a limited time for buyers with SA for the earlier versions).

Achieve payback in 5 months migrating from SQL Server 2008 R2 Enterprise Edition licensed per processor to SQL Server 2012 Enterprise Edition licensed per core

Our first scenario looks at costs for a migration from SQL Server 2008 R2 Enterprise Edition licensed per processor to SQL Server 2012 Enterprise Edition licensed per core. The existing solution requires 10 SQL Server 2008 R2 Enterprise licenses with associated annual Software Assurance costs of $68,737.50.

The Dell PowerEdge R720xd server will require 16 SQL Server 2012 core licenses for its two eight-core processors. This scenario includes $27,496.00 annual Software Assurance costs for 16 SQL Server 2012 Enterprise Edition per-core licenses for the Dell PowerEdge R720xd solution. Figure 5 includes these costs.

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[2] We intend this summary only to highlight some of the issues that affect the migration scenarios that we discuss. We believe it is accurate, but is certainly not comprehensive. We used the informative Microsoft SQL Server 2008 R2 Licensing Quick Reference Guide, a copy of which is available on the Dell site (http://i.dell.com/sites/content/business/solutions/brochures/en/Documents/sql-2008r2-licensing-reference.pdf), as our main source on licensing for the SQL Server 2008 R2 software. That document points you to legal documentation covering use rights for that software. Please consult those sources for licensing guidance.

In this migration, the Dell PowerEdge R720xd has impressive SQL Server Software Assurance savings because SQL Server 2012 Software Assurance costs for the 16-core server are almost the same as the Software Assurance costs of just four of the 10 SQL Server 2008 R2 licenses.

	Dell PowerEdge R720xd solution	Dell PowerEdge2950 III solution	Cost savings for Dell PowerEdge R720xd solution	Percentage savings
Acquisition costs				
Hardware cost	$17,194.00			
Migration cost	$5,900.40			
Total acquisition costs	$23,094.40			
Annual operational costs				
OS software support Software Assurance for Microsoft Windows Server® 2008 R2 Enterprise Edition (licensed per server)	$1,179.00	$2,947.50	$1,768.50	60%
DB Software support --SQL Server 2008 R2 Enterprise Edition (per proc) for legacy or SQL Server 2012 Enterprise Edition (per core)	$27,496.00	$68,737.50	$41,241.50	60%
Hardware support	$966.33	$2,000.00	$1,033.67	52%
Administration costs	$2,324.18	$12,783.00	$10,458.82	82%
Energy costs	$639.03	$2,628.20	$1,989.17	76%
Port costs	$250.00	$1,250.00	$1,000.00	80%
Data center space costs	$197.28	$986.40	$789.12	80%
Total annual operational costs	$33,051.82	$91,332.60	$58,280.78	64%
Total 3-year operational costs	$99,155.46	$273,997.80	$174,842.34	64%
Total 3-year costs	$122,249.86	$273,997.80	$151,747.94	55%

Figure 5: Cost savings for the Dell PowerEdge R720xd solution migrating from SQL Server 2008 R2 Enterprise Edition licensed per processor to SQL Server 2012 Enterprise Edition licensed per core.

TCO scenario 2: Excluding SQL Server software costs

Because so many different SQL Server versions, editions, licensing options, and payment plans are available, we also wanted to make a more generalizable analysis by omitting the Microsoft SQL Server costs. Figure 6 summarizes the costs for the two solutions. In this analysis, the Dell PowerEdge R720xd solution saves $28,023.44 or 41 percent over the three years of our analysis. The enterprise will spend $39,761.86 for acquisition, migration, and operational costs for the single Dell PowerEdge R720xd vs. $67,785.30 in operational costs for the five existing servers.

Figure 6: Breakdown of
acquisition and operational
costs for the two solutions
over three years excluding
costs for SQL Server
software.

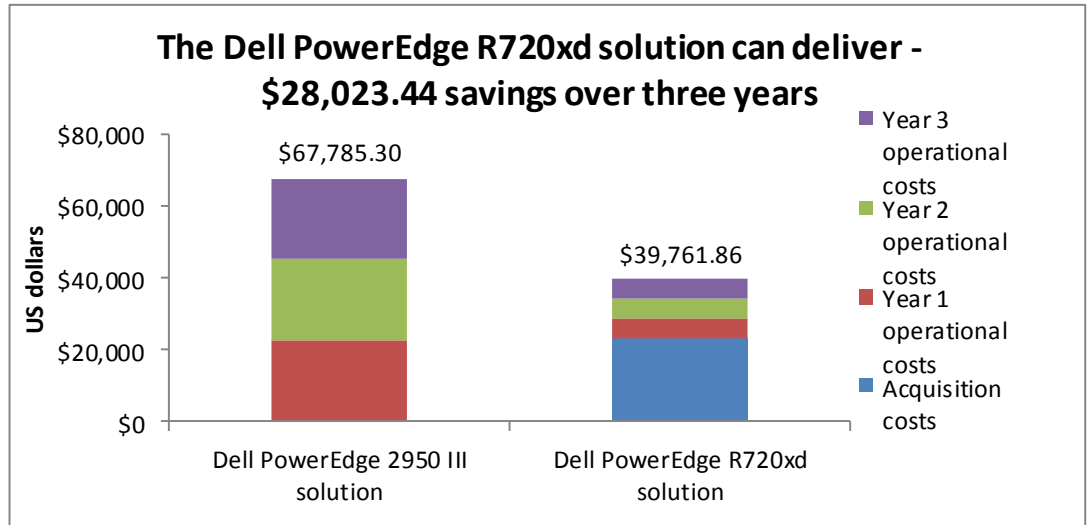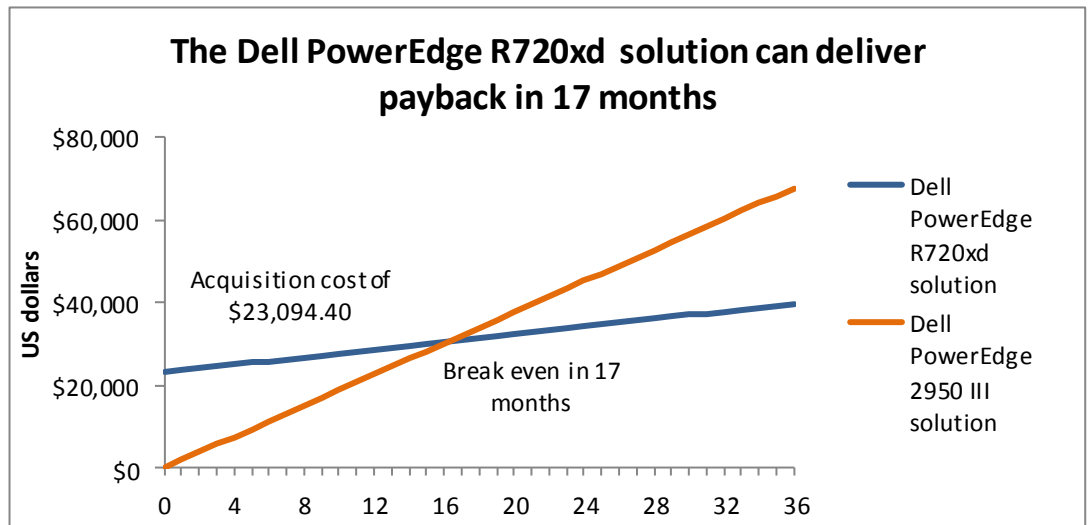**The Dell PowerEdge R720xd solution can deliver -$28,023.44 savings over three years**

Figure 7 shows that the Dell PowerEdge R720xd solution can deliver payback in as little as 17 months. Here we omit Microsoft SQL Server software costs.

Figure 7: Payback period for replacing five Dell PowerEdge2950 III servers with a single Dell PowerEdge R720xd server when excluding costs for SQL Server software.

The Dell PowerEdge R720xd solution can deliver payback in 17 months

The Dell PowerEdge R720xd solution can save up to 75.4 percent of the annual operating costs of the Dell PowerEdge2950 III solution

The Dell PowerEdge R720xd solution saves up to 75.4 percent of the annual operating costs of the Dell PowerEdge 2950 III solution through savings in operating system software and hardware support, server administration, and data center costs for energy, ports, and space.

Figure 8 summarizes the acquisition costs and annual operational costs of the two solutions and shows the operational cost savings for the Dell PowerEdge R720xd solution. We discuss some of the assumptions in the sections that follow. For additional assumptions, see Appendix D.

	Dell PowerEdge R720xd solution	Dell PowerEdge 2950 III solution	Cost savings for Dell PowerEdge R720xd solution	Percentage savings
Acquisition costs				
Hardware cost	$17,194.00			
Migration cost	$5,900.40			
Total acquisition costs	$23,094.40			
Annual operational costs				
OS software support Software Assurance for Windows Server 2008 R2 Enterprise Edition (licensed per server)	$1,179.00	$2,947.50	$1,768.50	60%
Hardware support	$966.33	$2,000.00	$1,033.67	52%
Administration costs	$2,324.18	$12,783.00	$10,458.82	82%
Energy costs	$639.03	$2,628.20	$1,989.17	76%
Port costs	$250.00	$1,250.00	$1,000.00	80%
Data center space costs	$197.28	$986.40	$789.12	80%
Total annual operational costs	$5,555.82	$22,595.10	$17,039.28	75%
Total 3-year operational costs	$16,667.46	$67,785.30	$51,117.84	75%
Total 3-year costs	$39,761.86	$67,785.30	$28,023.44	41%

Figure 8: Cost savings for the Dell PowerEdge R720xd solution excluding costs for SQL Server software.

The Dell PowerEdge R720xd solution requires fewer Windows Server licenses and saves 60 percent on Windows Server Software Assurance

The Dell PowerEdge R720xd solution consolidates the workloads of five Dell PowerEdge2950 III servers onto five VMs running under Microsoft Windows Server 2008 R2 with Hyper-V. We assume the enterprise migrates licenses from the existing solution to the Dell PowerEdge R720xd solution. Using the per-server with CAL licensing model, the Dell PowerEdge R720xd solution reduces the five Windows Server licenses on the existing solution to two licenses, each of which supports up to four of the five VMs on the solution. The Dell PowerEdge R720xd solution saves the annual Software Assurance costs for the three unused licenses.

The Dell PowerEdge R720xd solution can save up to 52 percent annually in hardware support costs

Hardware support costs for the Dell PowerEdge R720xd solution are considerably lower than for the five Dell PowerEdge2950 III servers it replaces. For the existing servers, which are three-to-four years old, we assume the enterprise has reached the end of a three-year support agreement with the vendor and moved support fully in house at an annual cost of $400 per server. For the Dell PowerEdge R720xd, we

use the costs of 3-Year ProSupport and Mission Critical 4HR 7x24 Onsite Pack provided to us by Dell and convert the three-year costs into annual costs. The hardware support costs for the single Dell PowerEdge R720xd server are 52 percent lower than for the five existing servers.

The Dell PowerEdge R720xd solution can save as much as 82 percent annually in server administration costs

Even in a one-to-one server comparison, the manageability improvements of the Dell PowerEdge R720xd, including agentless management, would yield savings in administration costs. We estimate that a single administrator could manage 44 Dell PowerEdge R720xd servers compared to 40 existing servers, saving 9 percent for a single PowerEdge R720xd server compared to one existing server. Savings reach 82 percent when comparing management costs of one Dell PowerEdge R720xd to that of five existing servers.

The Dell PowerEdge R720xd solution can save 75 percent annually in energy costs

We measured the power usage of the two server models and used those results to estimate energy costs for the two solutions. We measured power while the server ran the tested load and while the server was idle. See the Measuring power usage section in Appendix B for details.

We calculated a typical wattage that we use in calculating energy costs. Typical watts assumes the servers run full time, 20 percent of that time at the tested load are at idle the remaining time. Figure 9 shows the power measurements and our calculated typical watts for the two solutions. We measured the power on a single Dell PowerEdge 2950 III server, but multiply its results by the number of servers in the Dell PowerEdge 2950 III solution.

	Dell PowerEdge R720xd solution	Dell PowerEdge 2950 III solution
Active watts	467.5	8,760.0
Idle watts	370.7	1,643.0
Typical watts estimate	390.06	1,394.0

Figure 9: Power usage (in watts) measured under load, while the servers were idle, and estimated typical power usage.

We include costs for cooling as well as powering the servers. We assume the cost to cool existing servers is the same as the cost to power them, so we double the power cost to get the cost for power and cooling. We assume the cooling efficiencies of the PowerEdge R720xd would save on power for cooling; we multiply the power cost for the Dell PowerEdge R720xd by 1.8 to get the cost for power and cooling. We estimate a

per-kWh cost of 10.39 cents based on the US average commercial price for September 2011 as reported by the U.S. Energy Information Administration.[3]

The Dell PowerEdge R720xd solution save up to 75 percent annually in data center costs for ports and space

We assume the enterprise charges for rack space on a per-rack unit basis and for data center ports on a per-port basis. The five existing servers require five times the space of the Dell PowerEdge R720xd, 10 rack units vs. two rack units and require five times as many data center ports.

SQL SERVER 2012 – WHAT'S NEW

With each release of SQL Server, the flagship database management system from Microsoft, comes new features. SQL Server 2012 brings changes to the table in almost all areas: packaging, performance and availability features, and manageability.

First, to simplify and streamline planning and purchasing for the current virtualized and cloud-driven IT world, Microsoft has collapsed the number of editions to just three main editions:[4] Enterprise, Business Intelligence (BI), and Standard. Standard Edition includes the main features of the product, including the new support for server core installations, two-node clustering, and support for up to 16 cores. Enterprise edition, meant for larger organizations, includes all features of the product and contains the datacenter features from prior versions. BI edition includes a subset of SQL Server features aimed to enable self-service organizational BI, reporting, and analytics.

Secondly, almost every aspect of the product has new or improved features. Examples include:

- **Support for server core installations.** SQL Server can now be run on the Windows Server Core underlying operating system, reducing the server's operating system maintenance and security footprint.
- **AlwaysOn capabilities.** High availability with SQL Server becomes more robust than ever with AlwaysOn. AlwaysOn allows administrators to fail over and maintain Availability Groups – groups of databases that maintain their availability as a unit. When using AlwaysOn, multiple replicas of the applicable databases are maintained for maximum availability. In addition to Availability Groups, AlwaysOn brings the ability to have multi-subnet failover clusters and new granular control over checkpoints with indirect checkpoints.
- **Columnstore indexes.** SQL Server 2012 adds Columnstore indexing to its data engine optimizer and performance features. By storing data by

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[3] http://www.eia.gov/electricity/monthly/index.cfm (report epmxlfile5_6_b.xls)
[4] Developer, Express, and Compact editions are still available but not considered a main edition. Datacenter, Workgroup, and Small Business editions are being retired.

columns instead of the traditional row format, vast improvements in query times can be expected in business intelligence situations.

- **Contained databases.** In the past, the portability of databases with their associated users was a constant issue faced by database administrators—users would be "orphaned" from their instance-level login information. SQL Server 2012 introduces contained databases, which allow user information to travel seamlessly with the ported database, reducing management and consolidation issues.

CONCLUSION

Regardless of the age of the database servers in your data center, upgrading to the newer, more powerful Intel Xeon processor E5-2600 series-powered Dell PowerEdge R720xd server can boost the performance of your IT infrastructure and lower your total cost of ownership.

With a 24-disk capacity, the Dell PowerEdge R720xd server provides increased flexibility for your current needs and future expansion. As our tests results indicate, it consolidated five legacy servers running SQL Server databases, delivering greater performance and greater performance per watt.

Not only did the Intel Xeon processor E5-2600 series-based Dell PowerEdge R720 server outperform the Dell PowerEdge 2950 III, it also has the potential to reduce the cost of operating your data center. By lowering costs in a number of areas—Windows Server licensing, server administration, energy usage, and data center ports and space—the Dell PowerEdge R720 server pays back its initial investment in as little as 5 months.

APPENDIX A – SERVER CONFIGURATION INFORMATION

Figure 10 provides detailed configuration information for the test servers.

System	Dell PowerEdge R720xd	Dell PowerEdge 2950 III
Power supplies		
Total number	2	2
Vendor and model number	Dell D750E-S1	Z750P-00
Wattage of each (W)	750	750
Cooling fans		
Total number	6	4
Vendor and model number	AVC DBTC0638B2V	NMB-MAT-2415KL-04W-B96
Dimensions (h x w) of each	2.5" x 2.5"	2" x 2"
Volts	12	12
Amps	1.2	2.1
General		
Number of processor packages	2	2
Number of cores per processor	8	2
Number of hardware threads per core	16	2
System power management policy	Max Performance	Max Performance
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2680	X5440
Stepping	6	C0
Socket type	LGA2011	LGA771
Core frequency (GHz)	2.70	2.83
Bus frequency	8.0 GT/s	1,333 MHz
L1 cache	32 KB + 32 KB (per core)	128 KB
L2 cache	256 KB (per core)	12 MB
L3 cache (MB)	20	0
Platform		
Vendor and model number	Dell PowerEdge R720xd	Dell PowerEdge 2950
Motherboard model number	OM1GCR	0M332H
BIOS name and version	Dell 0.3.37	Dell 2.7.0
BIOS settings	Power profile set to Max Performance	Power profile set to Max Performance
Memory module(s)		
Total RAM in system (GB)	128	8
Vendor and model number	Hynix HMT31GR7BFR4A-H9	Samsung M395T5750EZ4-CE66
Type	PC3-10600R	PC2-5300F
Speed (MHz)	1,333	666
Speed running in the system (MHz)	1,333	666
Timing/Latency (tCL-tRCD-tRP-tRASmin)	9-9-9-36	5-5-5-15
Size (GB)	8	2

System	Dell PowerEdge R720xd	Dell PowerEdge 2950 III
Number of RAM module(s)	16	4
Chip organization	Double-sided	Double-sided
Rank	Dual	Dual
Operating system		
Name	Windows Server 2008 R2 SP1	Windows Server 2008 R2 SP1
Build number	7601	7601
File system	NTFS	NTFS
Kernel	ACPI x64-based PC	APCI x64-based PC
Language	English	English
Graphics		
Vendor and model number	Matrox® G200eR	ATI ES1000
Graphics memory (MB)	16	8
Driver	Matrox Graphics, Inc 2.3.3.0 (8/19/2011)	Microsoft 6.1.7600.16385
RAID controller		
Vendor and model number	PERC H710P Mini	Dell PERC 6/I Integrated RAID Controller
Firmware version	3.130.05-1311	1.22.32-1371
Driver version	Dell 5.1.90.64 (3/2/2011)	LSI Corporation 4.5.0.64
Cache size (GB)	1	0
Hard drive #1		
Vendor and model number	Dell ST9146852SS	Seagate ST373455SS
Number of disks in system	24	6
Size (GB)	146	73
Buffer size (MB)	16	16
RPM	15,000	15,000
Type	SAS	SAS
Hard drive #2		
Vendor and model number	Dell WD3000BKHG-18A29V0	N/A
Number of disks in system	2	N/A
Size (GB)	300	N/A
Buffer size (MB)	64	N/A
RPM	10,000	N/A
Type	SAS	N/A
Ethernet adapters		
Vendor and model number	Intel Gigabit 4P I350-t rNDC	Broadcom® BCM5708c NetXtreme® II GigE
Type	PCI-E	Integrated
Driver	Intel 11.14.48.0 (11/28/2011)	Broadcom 6.2.9.0 (2/4/2011)
Optical drive(s)		
Vendor and model number	TEAC DV-28SW	TEAC CD-224E-N
Type	DVD-ROM	CD-ROM

System	Dell PowerEdge R720xd	Dell PowerEdge 2950 III
USB ports		
Number	4 external, 1 internal	4 external, 1 internal
Type	2.0	2.0

Figure 10: Configuration details for the two test servers.

APPENDIX B – TEST PROCEDURE FOR THE DELL POWEREDGE R720XD

Figure 11 illustrates our Dell test bed setup. For comparison purposes, we configured each VM as a standalone SQL Server 2012 environment with all roles included on each. This approach allowed us a modular method to determine an exact increase in identical virtual machines. Results in your specific environment will vary. In Figure 11, VM1 uses client 1, VM2 uses client 2, and so forth.
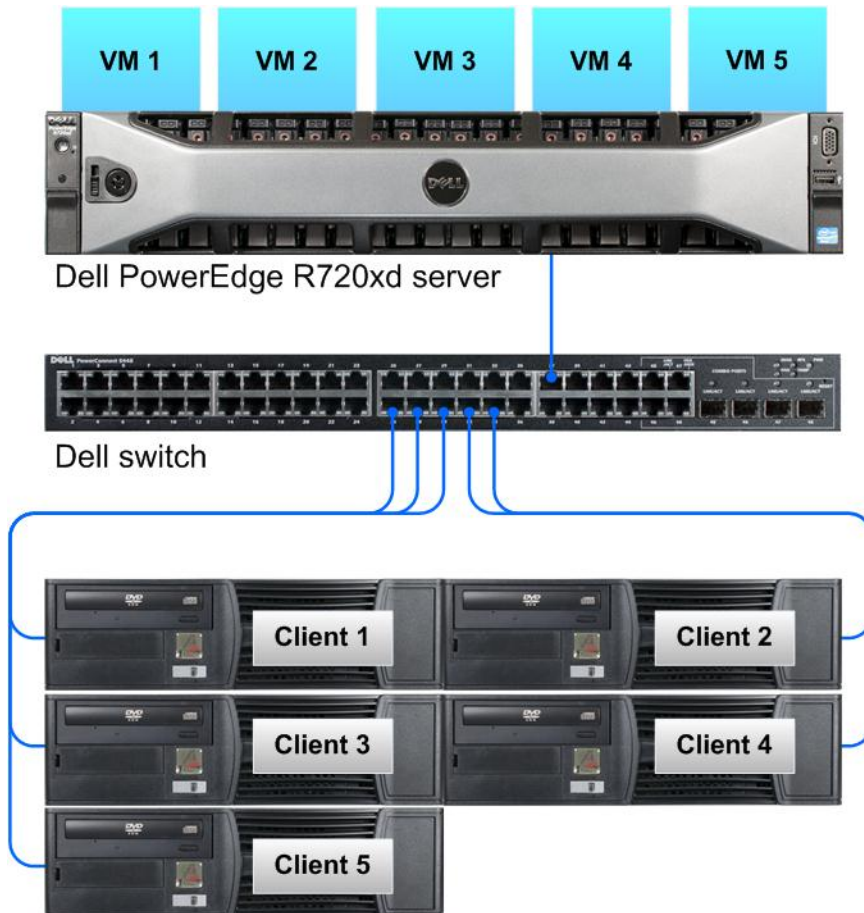
Figure 11: The Dell test bed we used.

Setting up the server – Hyper-V

Adjusting BIOS settings

We used the latest released BIOS updates on all systems, and adjusted the default BIOS settings. We changed the power profile to Max Performance.

Installing Windows Server 2008 R2 SP1 Enterprise Edition on R720xd

We used the BIOS RAID configuration utility to create our storage arrays. Our complete storage infrastructure consisted of 24 Dell Enterprise-Class 15K SAS disks and two Dell Enterprise-Class 10K SAS disks arranged as follows:

- Two RAID10 volumes using 10 Dell Enterprise-Class 15K SAS disks for SQL Server database usage
- One RAID10 volume using four Dell Enterprise-Class 15K SAS disks for SQL Server log usage
- One RAID1 volume using two Dell Enterprise-Class 10K SAS disks for the host operating system

Following the operating system installation, we installed all recommended Windows Updates through 2/15/2012.

1. Boot the server, and insert the Windows Server 2008 R2 SP1 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 Next.
8. At the User's password must be changed before logging on warning screen, click OK.
9. Enter the desired password for the administrator in both fields, and click the arrow to continue.
10. At the Your password has been changed screen, click OK.
11. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
12. Enable remote desktop access.
13. Change the hostname, and reboot when prompted.
14. Create a shared folder to store test script files. Set permissions as needed.
15. Set up networking:
    a. Click Start→Control Panel, right-click Network Connections, and choose Open.
    b. Right-click the testing network NIC, and choose Properties.
    c. Select TCP/IP (v4), and choose Properties.
    d. Set the IP address and subnet for the testing network NIC, which will handle testing network traffic. Click OK, and click Close.
16. Configure the storage:
    a. Click the Server Manager icon in the taskbar.
    b. In the left pane, expand Storage, and click Disk Management.
    c. Right-click the first volume, and choose Initialize Disk.
    d. In the right pane, right-click the volume, and choose New Simple Volume…
    e. At the welcome window, click Next.
    f. At the Specify Volume Size window, leave the default selection, and click Next.
    g. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
    h. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
    i. At the Completing the New Simple Volume Wizard window, click Finish.
    j. Repeat steps c through i for the remaining volumes.

Adding the Hyper-V R2 SP1 role

1. Open Server Manager, and click Roles.
2. Click Add Roles.
3. On the Before You Begin page, check the Skip this page by default box, and click Next.
4. Select Hyper-V, and click Next.
5. On the Hyper-V Introduction page, click Next.
6. On the Create Virtual Networks page, click Next.
7. Confirm installation selections, and click Install.
8. Once the installation is complete, click Close.
9. When the system prompts a restart, click Yes.
10. Allow the system to fully reboot, and log in using the administrator credentials.
11. Once the desktop loads, the Hyper-V Installation Results window will finish the installation.
12. Click Close. The Hyper-V role will now be available in Server Manager under Roles.

Configuring Virtual Network Manager

1. At the Hyper-V Manager screen, in the right pane, click Virtual Network Manager.
2. At the Virtual Network Manager screen, select Internal, and click Add.
3. At the Virtual Network Manager screen, click Apply, and click OK.

Configuring the VMs

We provide steps below for installing the operating system, Microsoft SQL Server, and configurations of the VMs.

Installing the VM operating system on the first VM

1. Connect to the ISO image of the installation DVD for Windows Server 2008 R2 SP1 Enterprise from the VM console. If the ISO image is not stored on the host, start the VM first and then connect to the ISO image.
2. Start the VM.
3. At the Language Selection screen, click Next.
4. Click Install Now.
5. Select Windows Server 2008 R2 Enterprise (Full Installation), and click Next.
6. Click the I accept the license terms check box, and click Next.
7. Click Custom.
8. Click Next.
9. At the User's password must be changed before logging on warning screen, click OK.
10. Enter the desired password for the administrator in both fields, and click the arrow to continue.
11. At the Your password has been changed screen, click OK.
12. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
13. Enable remote desktop access.
14. Change the hostname, and reboot when prompted.
15. Create a shared folder to store test script files. Set permissions as needed.
16. Set up networking:
    a. Click Start→Control Panel, right-click Network Connections, and choose Open.
    b. Right-click the VM traffic NIC, and choose Properties.
    c. Select TCP/IP (v4), and choose Properties.
    d. Set the IP address, subnet, gateway, and DNS server for the virtual NIC, which will handle outgoing server traffic. Click OK, and click Close.
17. In the VM, configure the VM storage:
    a. Click the Server Manager icon in the taskbar.
    b. In the left pane, expand Storage, and click Disk Management.
    c. Right-click the first volume, and choose Initialize Disk.
    d. In the right pane, right-click the volume, and choose New Simple Volume…
    e. At the welcome window, click Next.
    f. At the Specify Volume Size window, leave the default selection, and click Next.
    g. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
    h. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
    i. At the Completing the New Simple Volume Wizard window, click Finish.
    j. Repeat steps c through i for the remaining VM volumes.
18. Copy the pre-created DVD Store backup file to the backup virtual disk inside the first VM.

Installing SQL Server 2012 RC0 on the first VM

1. Open the Hyper-V console for the VM or connect to the VM with RDP.
2. Log into the virtual machine.

3. Connect to the ISO image of the installation DVD for SQL Server 2012 RC0 Enterprise from the VM console or the menu in the Hyper-V Client.
4. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2012 RC0 DVD, and double-click.
5. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
6. In the left pane, click Installation.
7. Click New installation or add features to an existing installation.
8. At the Setup Support Rules screen, wait for the check to complete. If there are no failures or relevant warnings, click OK.
9. Select the Enter the product key radio button, and enter the product key. Click Next.
10. Click the checkbox to accept the license terms, and click Next.
11. Click Install to install the setup support files.
12. If there are no failures displayed, click Next. You may see a Computer domain controller warning and a Windows Firewall warning. For now, ignore these.
13. At the Setup Role screen, choose SQL Server Feature Installation.
14. At the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools –Basic, and Management Tools – Complete. Click Next.
15. At the Installation Rules screen, click Next once the check completes.
16. At the Instance configuration screen, leave the default selection of default instance, and click Next.
17. At the Disk space requirements screen, click Next.
18. At the Server configuration screen, choose NT AUTHORITY\SYSTEM for SQL Server Agent, and choose NT AUTHORITY\SYSTEM for SQL Server Database Engine. Click Next.
19. At the Database Engine Configuration screen, select Mixed Mode.
20. Enter and confirm a password for the system administrator account.
21. Click Add Current user. This may take several seconds.
22. Click Next.
23. At the Error and usage reporting screen, click Next.
24. At the Installation Configuration rules screen, check that there are no failures or relevant warnings, and click Next.
25. At the Ready to Install screen, click Install.
26. After installation completes, click Next.
27. Click Close.
28. Create a SQL Server login for the ds2user (see the [Configuring the database server (DVD Store) section](#) for the specific script to use).
29. Copy the pre-created DVD Store backup to the specified backup VHD volume.
30. Click Start→All Programs→Microsoft SQL Server 2012 RC0→Configuration Tools, and click SQL Server Configuration Manager.
31. Expand SQL Server Network Configuration, and click Protocols for MSSQLSERVER.
32. Right-click TCP/IP, and select Enable.

Configuring additional VMs on Hyper-V

1. In Hyper-V, ensure VM1 is powered down.
2. Navigate to where the VHD is stored, and duplicate the file 5 times.
3. In Hyper-V, right-click the server→ New virtual machine, enter VM2 for the name, and click Next.
4. On the Assign Memory screen, select 24576, and click Next.
5. On the Configure networking screen, select the network you set up, and click Next.
6. At the connect Virtual Hard Disk screen, select Use an Existing, and browse to where you duplicated the original VM's main VHD.

7. Repeat these steps for VM3, VM4, and VM5.
8. Ensure in each VM that the necessary virtual disks are all online and the IP addressing is properly assigned.
9. Modify the SQL Server hostname of each VM using the instructions provided by Microsoft (http://msdn.microsoft.com/en-us/library/ms143799.aspx).
10. To configure automatic start for your specified number of VMs, right-click the VM, select settings, and click Virtual Machine Startup/Shutdown.

Configuring the database (DVD Store)

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 20GB database size and the database platform on which we ran: Microsoft SQL Server. We ran the Install.pl script on a utility system running Linux. The database schema was also generated by the Install.pl script.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2012 RC0. We built the 20GB database in SQL Server 2012 RC0, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore on both servers between test runs. We performed this procedure once, and used the same backup file for Hyper-V virtual machines.

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

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 20GB database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. We created database tables, stored procedures, and objects using the provided DVD Store scripts.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created a ds2user SQL Server login using the following Transact SQL (TSQL) script:

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

GO

9. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.
12. We then performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

Figure 12 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
Database files		
primary	PRIMARY	2
cust1	DS_CUST_FG	2,160
cust2	DS_CUST_FG	2,160
cust3	DS_CUST_FG	2,160
cust4	DS_CUST_FG	2,160
cust5	DS_CUST_FG	2,160
cust6	DS_CUST_FG	2,160
cust7	DS_CUST_FG	2,160
cust8	DS_CUST_FG	2,160
ind1	DS_IND_FG	1,280
ind2	DS_IND_FG	1,280
ind3	DS_IND_FG	1,280
ind4	DS_IND_FG	1,280
ind5	DS_IND_FG	1,280
ind6	DS_IND_FG	1,280
ind7	DS_IND_FG	1,280
ind8	DS_IND_FG	1,280
ds_misc1	DS_MISC_FG	256
ds_misc2	DS_MISC_FG	256
ds_misc3	DS_MISC_FG	256
ds_misc4	DS_MISC_FG	256
ds_misc5	DS_MISC_FG	256
ds_misc6	DS_MISC_FG	256
ds_misc7	DS_MISC_FG	256
ds_misc8	DS_MISC_FG	256
orders1	DS_ORDERS	1,536
orders2	DS_ORDERS	1,536
orders3	DS_ORDERS	1,536
orders4	DS_ORDERS	1,536
orders5	DS_ORDERS	1,536
orders6	DS_ORDERS	1,536
orders7	DS_ORDERS	1,536
orders8	DS_ORDERS	1,536
Log files		
ds_log	Not Applicable	20,480

Figure 12: Our initial file size modifications.

Editing the workload script – ds2xdriver.cs module

A new feature of DVD Store version 2.1 is the ability to target multiple targets from one source client. We used this functionality, and in order to record the orders-per-minute output from each specific database target, we modified the ds2xdriver to output this information to log files on each client system. To do this, we used the StreamWriter method to create a new text file on the client system, and the WriteLine and Flush methods to write the relevant outputs to the files during the tests.

After making these changes, we recompiled the ds2xdriver.cs and ds2sqlserverfns.cs module in Windows by following the instructions in the DVD Store documentation. Because the DS2 instructions were for compiling from the command line, we used the following steps on a system with Visual Studio installed:

1. Open a command prompt.
2. Use the `cd` command to change to the directory containing our sources.
3. Execute the following command:

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

Running the DVD Store tests

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

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

1. Clean up prior outputs from the host system and all client driver systems.
2. Drop all databases from all target VMs.
3. Restore all databases on all target VMs.
4. Shut down all VMs.
5. Reboot the host system and all client systems.
6. Wait for a ping response from the server under test (the hypervisor system), all client systems, and all VMs.
7. Let the test server idle for 20 minutes.
8. Start the DVD Store driver on all respective clients.
   We used the following DVD Store parameters for testing the virtual machines in this study:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --
n_threads=32 --db_size=20GB --think_time=0 --detailed_view=Y --warmup_time=5
```

Measuring power usage

To record each server'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 Intel processor-based PC, which we connected to the Power Analyzer via an RS-232 cable. We captured power consumption at one-second intervals.

To gauge the idle power usage, we recorded the power usage for two minutes while each system was running Hyper-V and the appropriate number of VMs, but otherwise idle, meaning they were not running any test workload.

We then recorded the power usage (in watts) for each system during the testing at one-second intervals. To compute the average power usage, we averaged the power usage during the time the system was producing its peak performance results. We call this time the power measurement interval.

APPENDIX C – TEST PROCEDURE FOR THE LEGACY SERVER (DELL POWEREDGE 2950 III)

Figure 13 illustrates our legacy server test bed setup.

Dell PowerEdge 2950 III server

Dell switch

Client
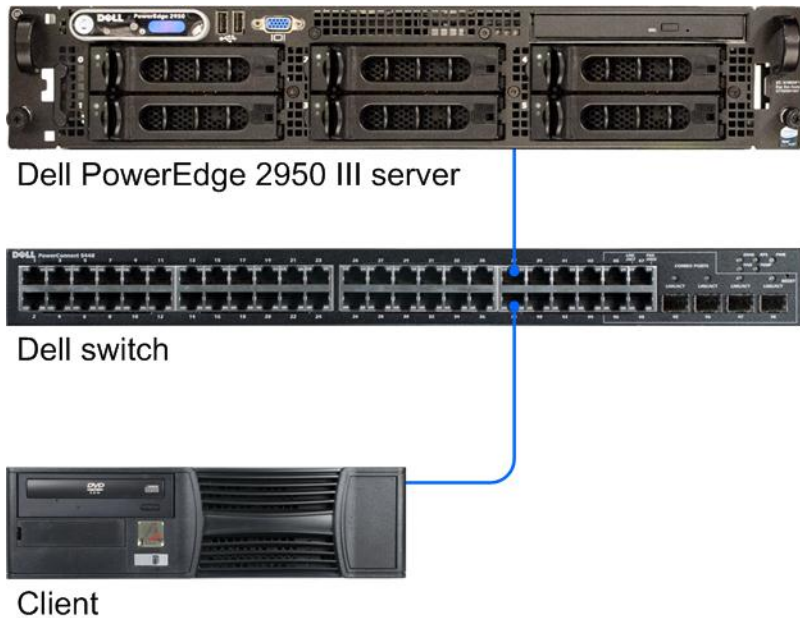
Figure 13: The legacy server test bed we used.

Adjusting BIOS settings

We used the latest released BIOS updates on all systems, and adjusted the default BIOS settings. We changed the power profile to Max Performance.

Installing Windows Server 2008 R2 SP1 Enterprise Edition on 2950 III

We used the BIOS RAID configuration utility to create two storage arrays. Following the operating system installation, we installed all recommended Windows Updates through 2/15/2012.

1. Boot the server, and insert the Windows Server 2008 R2 SP1 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 Next.
8. At the User's password must be changed before logging on warning screen, click OK.
9. Enter the desired password for the administrator in both fields, and click the arrow to continue.
10. At the Your password has been changed screen, click OK.
11. Connect the machine to the Internet, and install all available Windows updates. Restart as necessary.
12. Enable remote desktop access.
13. Change the hostname, and reboot when prompted.
14. Create a shared folder to store test script files. Set permissions as needed.
15. Set up networking:

a. Click Start→Control Panel, right-click Network Connections, and choose Open.
b. Right-click the testing network NIC, and choose Properties.
c. Select TCP/IP (v4), and choose Properties.
d. Set the IP address and subnet for the testing network NIC, which will handle testing network traffic. Click OK, and click Close.
16. Configure the storage:
a. Click the Server Manager icon in the taskbar.
b. In the left pane, expand Storage, and click Disk Management.
c. Right-click the first volume, and choose Initialize Disk.
d. In the right pane, right-click the volume, and choose New Simple Volume…
e. At the welcome window, click Next.
f. At the Specify Volume Size window, leave the default selection, and click Next.
g. At the Assign Drive Letter or Path window, choose a drive letter, and click Next.
h. At the Format Partition window, choose NTFS and 64K allocation unit size, and click Next.
i. At the Completing the New Simple Volume Wizard window, click Finish.
17. Copy the pre-created DVD Store backup file to the host.

Installing SQL Server 2008 R2 SP1 on the 2950 III

1. Insert the SQL Server 2008 R2 SP1 installation DVD in the DVD-ROM drive.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2008 R2 SP1 DVD, and double-click.
3. If the installer prompts you with a .NET installation prompt, click Yes to enable the .NET Framework Core role.
4. In the left pane, click Installation.
5. Click New installation or add features to an existing installation.
6. At the Setup Support Rules screen, wait for the check to complete. If there are no failures or relevant warnings, click OK.
7. Select the Enter the product key radio button, and enter the product key. Click Next.
8. Click the checkbox to accept the license terms, and click Next.
9. Click Install to install the setup support files.
10. If there are no failures displayed, click Next. You may see a Computer domain controller warning and a Windows Firewall warning. For now, ignore these.
11. At the Setup Role screen, choose SQL Server Feature Installation.
12. At the Feature Selection screen, select Database Engine Services, Full-Text Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools –Basic, and Management Tools – Complete. Click Next.
13. At the Installation Rules screen, click Next once the check completes.
14. At the Instance configuration screen, leave the default selection of default instance, and click Next.
15. At the Disk space requirements screen, click Next.
16. At the Server configuration screen, choose NT AUTHORITY\SYSTEM for SQL Server Agent, and choose NT AUTHORITY\SYSTEM for SQL Server Database Engine. Click Next.
17. At the Database Engine Configuration screen, select Mixed Mode.
18. Enter and confirm a password for the system administrator account.
19. Click Add Current user. This may take several seconds.
20. Click Next.
21. At the Error and usage reporting screen, click Next.
22. At the Installation Configuration rules screen, check that there are no failures or relevant warnings, and click Next.
23. At the Ready to Install screen, click Install.
24. After installation completes, click Next.

25. Click Close.
26. Create a SQL Server login for the ds2user (see the [Configuring the database server (DVD Store) section](#) for the specific script to use).
27. Copy the pre-created DVD Store backup to the specified backup VHD volume.
28. Click Start→All Programs→Microsoft SQL Server 2008 R2→Configuration Tools, and click SQL Server Configuration Manager.
29. Expand SQL Server Network Configuration, and click Protocols for MSSQLSERVER.
30. Right-click TCP/IP, and select Enable.

APPENDIX D - TCO DETAILS

This section provides details on the assumptions, costs, and formulas we used in these calculations. We focus the analysis on line-item costs of hardware costs, hardware and software support, staff time, energy costs, and data center chargeback for space and ports. In an analysis specific to your enterprise, you might also want to consider additional areas of savings and benefit such as reduced user downtime and other benefits that accrue from newer, more reliable hardware and database software. You may also want to add depreciation, amortization, or discounting to your analysis. We omit these accounting calculations, which can be highly variable and enterprise-specific and add unnecessary complexity in our generalized analysis.

Hardware costs

Dell provided us with hardware costs for the Dell PowerEdge R720xd, which had not been released at the time of this report. Our testing was on a pre-release model. Costs do not include discounts, shipping, or taxes. Dell quoted a price of $17,194.00for the following configuration of the Dell PowerEdge R720xd:

- 2x Intel Xeon processor E5-2680 (2.7 GHz)
- 128 GB (16 x 8GB) Dual Rank- PC3L-10600R
- PERC H710P Mini Controller
- 16 x 300GB 10K SAS 6Gbps drives
- Four-port 1GB NIC
- 8GB iDRAC SD Card, including iDRAC7 Enterprise

Migration costs

We assume that the migration from the existing servers to the Dell PowerEdge R720xd will take three weeks. Migration includes the staff costs of planning the migration, ordering the hardware, setting up the server, and migrating software and databases. We estimate 80 hours for the migration and 40 hours for the other tasks, with all tasks carried out by a server administrator or equivalent. We estimate this cost at $5,900.49 based on 120 hours of a server administrator with an hourly cost of $49.17. To calculate the hourly rate, we used the mean annual wage of $72,200 for a network and computer systems administrator as reported in the Bureau of Labor Statistics Occupational Employment and Wages for May 2010.[5] We added an additional 41.64 percent to cover benefits for total annual salary cost of $102,264.08, which would have an equivalent hourly full time wage equivalent of $49.17. We estimated the benefits rate using data in another Bureau of Labor Statistics report: Employer Costs for Employee Compensation – September 2011.[6]

Software licenses

For the legacy solution, we assume that the enterprise paid for their Microsoft Windows Server software up front, maintains current Microsoft Software Assurance agreements for the software, and that their licensing allows them to migrate the software between servers. We also assume they can renew the Software Assurance agreements for the

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[5] http://www.bls.gov/oes/current/oes151142.htm
[6] http://www.bls.gov/news.release/ecec.t05.htm, Bureau of Labor Statistics report: Employer Costs –September 2011, Table 5. Private industry, by major occupational group and bargaining status, Management, Professional and Related column. That report estimates that salary is 70.6 percent and benefits are 29.4 percent of total compensation for Management, Professional and Related employees in private industry. Using those numbers, we calculate benefits as 41.64% of salary.

three years in this analysis. We make the same assumptions about Microsoft Windows SQL Server software for the scenarios in which we include costs for this software. The enterprise will pay up front for any additional licenses required by the Dell PowerEdge R720xd solution and will budget for Software Assurance on the licenses on an annual basis.

Microsoft Windows Server 2008 R2 Enterprise Edition

Both solutions include Windows Server 2008 R2 Enterprise Edition operating systems priced using per-server licensing. We do not include CAL costs in this analysis because the number of users or devices and therefore Windows CALs would be the same for both solutions.

The existing environment needs one license per server. We include Software Assurance costs for those five licenses in the annual operating costs of the solution.

The five VMs in the Dell PowerEdge R720xd solution require two licenses, each of which supports one physical and up to four virtual operating system environments. This solution migrates two of the five licenses from the existing model and includes Software Assurance costs for them. It saves Software Assurance payments on the unused three licenses from the existing solution.

We used software pricing from the Microsoft License Advisor tool[7] and used the Quick Quote option there to find the single license price for a Microsoft Open License for corporate organizations with the No Level pricing level. The prices quoted there are $2,358 per Windows Server 2008 R2 Enterprise Edition. Annual Software Assurance cost is one-fourth the license cost.

Microsoft SQL Server 2008 R2 and Microsoft SQL Server 2012

The second scenario looks at costs for a migration from SQL Server 2008 R2 Enterprise Edition licensed per processor to SQL Server 2012 Enterprise Edition licensed per core. We calculate annual SQL Server 2008 R2 Enterprise edition Software Assurance cost at $6,873.75, one-fourth the $ 27,495.00 license cost under the Open No Level pricing model.[8] The existing solution requires 10 SQL Server 2008 R2 Enterprise licenses with associated annual Software Assurance costs of $68,737.50.

The Dell PowerEdge R720xd server will require 16 SQL Server 2012 core licenses for its two eight-core processors. Microsoft documentation for SQL Server 2012 shows that SQL Server 2008 R2 Enterprise edition processor license with SA will upgrade to a minimum of four SQL Server 2012 core licenses. If a processor has more than four cores, customers will have the option to prove the actual core count and get licenses needed to cover that number of cores. The Enterprise should be able to upgrade four of its SQL Server 2008 R2 Enterprise licenses covered by SA for the 16 core licenses and will not need to purchase any SQL Server 2012 licenses. We use a price of $6,874.00 for each SQL Server 2012 Enterprise edition core license and calculate annual Software Assurance cost at $1,719.50, one-fourth the license cost. This scenario includes $27,496.00 annual Software Assurance costs for 16 SQL Server 2012 Enterprise Edition licenses for the Dell PowerEdge R720xd solution.

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[7] http://www.microsoft.com/licensing/mla/default.aspx
[8] http://www.microsoft.com/sqlserver/en/us/get-sql-server/how-to-buy.aspx

Hardware support

We assume that the enterprise typically purchases three-year support and then handles support in-house. Dell provided a quote of $2,899 for three-year ProSupport and Mission Critical 4HR 7x24 support for the Dell PowerEdge R720xd server. We spread those costs across the three-year support period. We do not include vendor support for existing servers, which are more than three-years old. We estimate in-house support costs for the existing servers at $400 per server per year. Figure 14 shows the hardware support costs for each solution.

	3-year per server	1-year per server	Annual cost per solution	Percentage Dell PowerEdge R720xd solution savings
Existing solution: In-house support	$1,200.00	$400.00	$2,000.00	
Dell PowerEdge R720xd solution: 3-Year ProSupport and Mission Critical 4HR 7x24 Onsite Pack	$2,899.00	$966.33	$966.33	52%

Figure 14: Hardware support for the two solutions.

Energy costs

Figure 15 shows the calculations for the annual energy cost estimates.

Annual costs - Energy costs	Dell PowerEdge R720xd solution	Dell PowerEdge 2950 III solution
Cost per kWh	0.1039	0.1039
Typical watts	390.06	1443.8
Annual kWh	3416.93	12647.7
Multiplier for cooling	1.8	2.0
Total kWh for power and cooling	6150.5	25295.4
Annual energy cost	**$639.03**	**$2,628.19**

Figure 15: Energy cost calculations for the two solutions.

Rack and space costs

We assume each server has a single port out and that the data center charges an annual per-port cost of $250. We assume an annual data center per-rack cost of $2,170 or $98.64 per rack unit based on each rack holding 22u of servers.

ABOUT PRINCIPLED TECHNOLOGIES

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