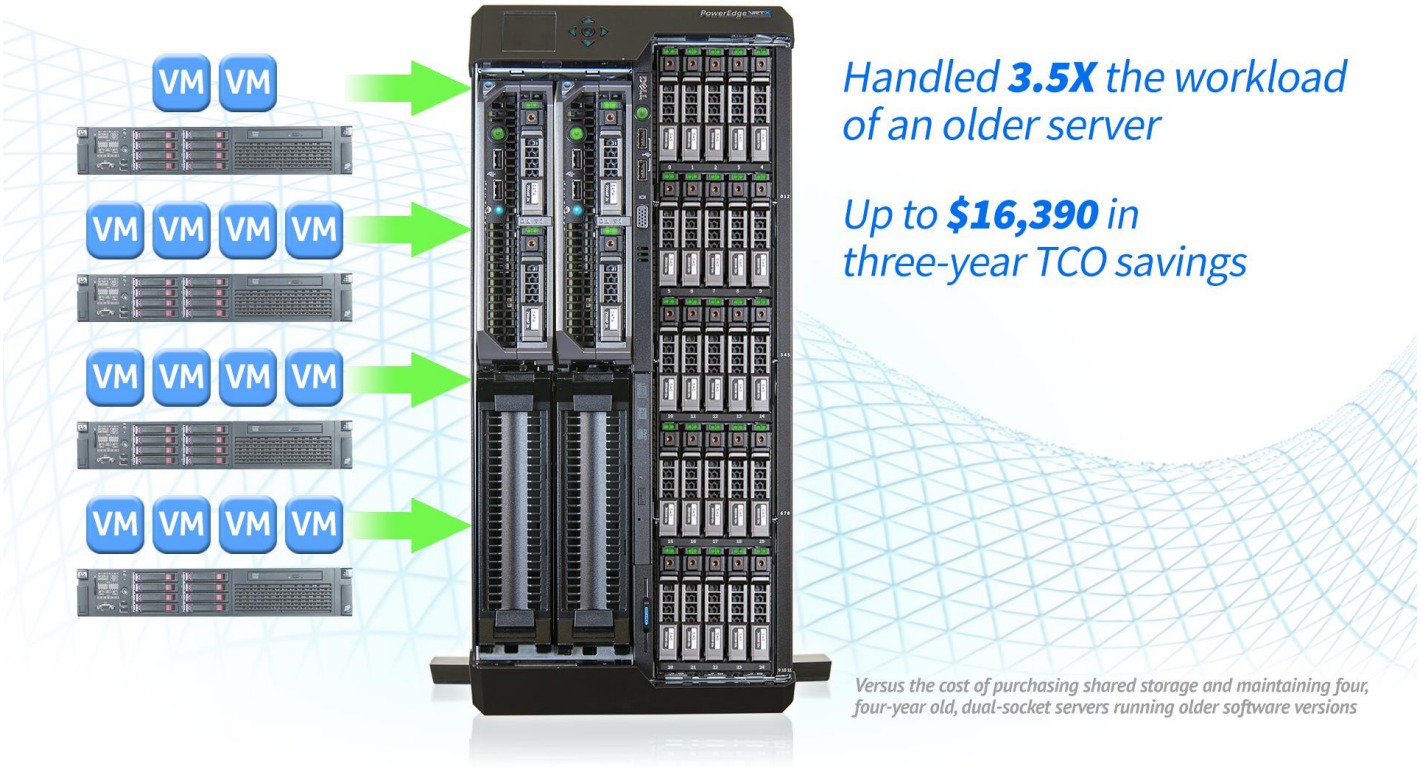
CONSOLIDATE AND UPGRADE: DELL POWEREDGE VRTX AND MICROSOFT SQL SERVER 2014

Dell™ PowerEdge™ VRTX using Microsoft® Windows Server® 2012 R2 with Hyper-V™ and SQL Server® 2014



No matter your line of business, technology implemented four years ago is likely near its end of life and may be underperforming as more users and more strenuous workloads stretch your resources thin. This means more VMs, which require more memory, disk, and processing power, but investing in new hardware for a server nearing end-of-life can be a poor business decision. Additionally, you wish to take advantage of proven clustering technologies that add high availability to your IT strategy. Given these factors, you have to either sink money into old technologies, or look to the future. Fortunately, the Dell PowerEdge VRTX, a shared infrastructure solution that includes compute, networking, and shared storage, allows you to consolidate older servers and gain clustering capabilities.

In the Principled Technologies labs, we tested the performance of a legacy server running older software versions and of the Dell PowerEdge VRTX using Microsoft Windows Server 2012 R2 with Hyper-V and SQL Server 2014. We found that the Dell VRTX solution achieved equivalent or greater performance per VM with 14 VMs than did a single four-year-old dual-socket server running four of the same VMs on Windows Server 2008 R2 and SQL Server 2008 R2.

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We also compared the cost of running these 14 VMs on the highly available VRTX to the cost of keeping the 14 VMs on older equipment and purchasing storage and networking hardware to retrofit the older solution for high availability. We found that replacing four of the four-year-old servers with the Dell PowerEdge VRTX solution could save a business $16,390 over three years.

The Dell PowerEdge VRTX combines servers, networking, and shared storage into an all-in-one solution. Consolidating four-year-old dual-socket servers onto a powerful virtualization platform such as the VRTX with Microsoft Windows Server 2012 R2 with Hyper-V running the latest SQL Server 2014 database platform can provide the performance, scalability, and high availability your business needs in order to grow and meet increased demand from your customers and end users.

HOW WE TESTED

We compared the performance of two solutions running different versions of SQL Server on these two solutions:

- **Dell PowerEdge VRTX** with two **Dell PowerEdge M620** blade servers, with Microsoft Windows Server 2012 R2 in a Hyper-V failover cluster that hosted 14 Windows Server 2012 R2 VMs each running SQL Server 2014.
- **A single four-year-old dual-socket server** with Windows Server 2008 R2 Hyper-V that hosted four Windows Server 2008 R2 VMs running SQL Server 2008 R2.

Our test configuration

As a growing business would have likely upgraded their aging server during its life span, we tested a four-year-old dual-socket server solution with upgrades over the stock configuration. Our configuration of the four-year-old dual-socket server included 48GB of memory and six-core processors. We created four VMs with 10GB memory and two vCPUs each to mimic a business that would have increased its VM count, and its VM configuration over time.

On the Dell PowerEdge VRTX solution, we configured a Windows Server 2012 R2 Hyper-V cluster for high availability using the shared storage contained in the Dell PowerEdge VRTX. We assigned each VM two vCPUs and 16GB memory to take advantage of the increased memory available in the Dell PowerEdge M620 servers.

All VMs in both environments used a 50GB VHD for the guest OS and two separate 30GB VHDs for the SQL database files and log files.

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 benchmarking tool. We used a 20ms think time for both servers to generate a database workload that achieved at least 15,000 orders per minute (OPM) per VM. The DVD Store 2.1 benchmark measured database performance with a 10GB Microsoft SQL

Server 2008 R2 database on the four-year-old dual-socket server and the same database upgraded to Microsoft SQL Server 2014 on the Dell PowerEdge VRTX server.

For detailed configuration information of the servers, see Appendix A. See Appendix B for detailed information on how we tested the servers.

Our test results

The Dell PowerEdge VRTX supported 14 VMs running heavy SQL Server 2014 database workloads, which was 3.5 times more than the four VMs on the four-year-old dual-socket server. Figure 1 shows the number of VMs each server supported. For OPM results per VM, see Appendix E.

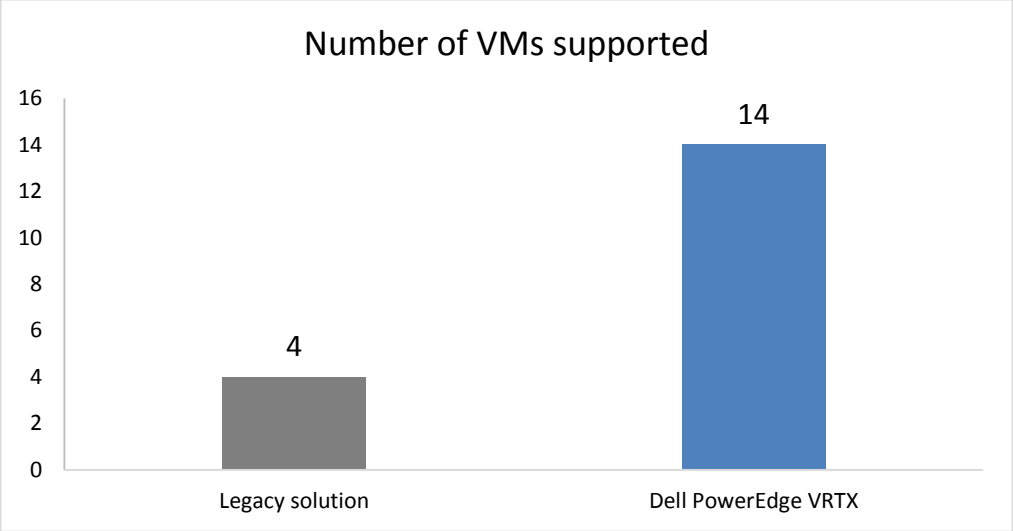

Figure 1: One Dell PowerEdge VRTX with just two nodes did 3.5x the work (14 VMs) of a single legacy solution (4 VMs), while maintain the same level of performance in each VM.

TCO with high availability

In addition to delivering the same performance of four four-year-old servers using just two blade servers, the Dell PowerEdge VRTX is also a converged-infrastructure solution, providing shared storage and networking to the enclosed blades for high availability. A high-availability solution safeguards against downtime or service outages and allows for VM mobility, leading to smoother maintenance windows for your hardware. The cost of downtime grows as more workloads become mission critical and as your business expands, so high availability can be an attractive option when upgrading. Adding high availability functionality to multiple older servers, however, can be a costly and illogical proposition, requiring you to pour thousands of dollars into old hardware.

For our cost comparison, we calculated the total cost of ownership (TCO) of a Dell PowerEdge VRTX with two blade servers running Microsoft Windows Server 2012 R2 and SQL Server 2014 against four four-year-old dual-socket servers running Windows Server 2008 R2 and SQL Server 2008 R2 with high availability upgrades factored in. We

added the cost to retrofit the legacy four-server solution for high availability, adding shared iSCSI storage and a 1GbE switch.

While the total number of VMs on the Dell PowerEdge VRTX was 3.5 times greater than that of the legacy single server, the number of servers replaced would be four – with three servers matching the older server we tested and running four VMs each, and a fourth server running the two additional VMs. Therefore, our cost calculation involves four older servers as this is what it would take to match the VM count of the Dell PowerEdge VRTX.

The Dell PowerEdge VRTX can save up to $16,390 over three years compared to continuing to run four four-year-old dual-socket servers and adding equipment to achieve high availability.

Figure 2 compares the total three-year costs of purchasing and running a Dell PowerEdge VRTX with Microsoft Windows Server 2012 R2 and SQL Server 2014 software to keeping the four four-year-old dual-socket servers with Windows Server 2008 R2 and SQL Server 2008 R2 and buying the 16-port switch and iSCSI storage array for high availability.

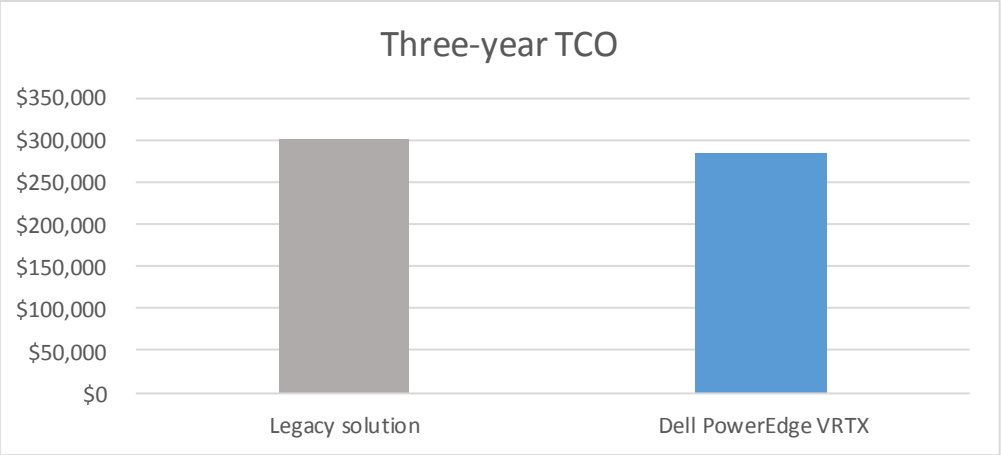

Figure 2: Three-year TCO comparison for four four-year-old dual-socket servers with upgraded shared storage components versus the all-inclusive Dell PowerEdge VRTX solution with two blade servers. Lower numbers are better.

Figure 3 summarizes the projected costs for operating the two solutions over three years. For details on how we arrived at these numbers, see Appendix D.

	Dell PowerEdge VRTX solution	Four-year-old dual-socket server solution	Dell PowerEdge VRTX solution savings
Hardware expenses			
VRTX hardware and support	$62,224	N/A	($62,224)
HP high availability (additional storage array and switch)	N/A	$28,214	$28,214
Support for existing HP servers	N/A	$10,344	$10,344
Software expenses			
SQL Server and Windows Server	$215,454	$245,310	$29,856
Labor expenses			
Deployment	$800	$200	($600)
Management	$5,400	$16,200	$10,800
Total three-year TCO	**$283,878**	**$300,268**	**$16,390**

Figure 3: Summary of three-year TCO for the Dell PowerEdge VRTX solution and the four-year-old dual-socket solution.

IN CONCLUSION

Your growing business shouldn't run on aging hardware and software until it fails. Adding memory and upgrading processors will not provide the same benefits to your infrastructure as a consolidation and upgrade can. Upgrading and consolidating your IT infrastructure to the Dell PowerEdge VRTX running Microsoft Windows Server 2012 R2 and SQL Server 2014 can improve performance while adding features such as high availability.

Based on our findings, a single Dell PowerEdge VRTX can replace four four-year-old dual-socket servers with VMs running heavy SQL database workloads. We found that consolidating four older servers onto a Dell PowerEdge VRTX and upgrading to Microsoft Windows Server 2012 R2 with Hyper-V and SQL Server 2014 could save up to $16,390 over three years, compared to keeping the four-year-old dual-socket servers and upgrading existing storage infrastructure. If your business runs older versions of Microsoft SQL Server on end-of-life dual-socket servers, the Dell PowerEdge VRTX with Microsoft Windows Server 2012 R2 with Hyper-V and SQL Server 2014 could save your company these costs while delivering better performance than the aging hardware and software.

APPENDIX A – SYSTEM CONFIGURATION INFORMATION

Figure 4 provides detailed configuration information for the test systems.

System	Dell PowerEdge M620	HP ProLiant DL380 G6
Power supplies		
Total number	4	2
Vendor and model number	Dell 80 Plus Platinum E1100E-S0 (P/N 0YT39Y)	HP 499249-001
Wattage of each (W)	1100	460
Cooling fans		
Total number	6	6
Vendor and model number	Delta Electronics, Inc.	Nidec V60E12BS1A7-09A032
Dimensions (h × w) of each	60mm × 60mm	76mm × 64mm
Volts	12	12
General		
Number of processor packages	2	2
Number of cores per processor	10	6
Number of hardware threads per core	2	2
System power management policy	Performance	Performance
CPU		
Vendor	Intel	Intel
Name	Xeon	Xeon
Model number	E5-2690 v2	X5670
Socket type	FCLGA2011	FCLGA1366
Core frequency (GHz)	3.00	2.93
Bus frequency	8 GT/s	6.4 GT/s
L1 cache	32 KB + 32 KB (per core)	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)	256 KB (per core)
L3 cache	25 MB	12 MB
Platform		
Vendor and model number	Dell PowerEdge M620	HP ProLiant DL380 G6
BIOS name and version	Dell 2.2.7	ProLiant P62
BIOS settings	Performance	Performance
Memory module(s)		
Total RAM in system (GB)	256	48
Vendor and model number	Kingston KVR16R11D4/16	Micron MT36JSZF51272PY
Type	PC3-12800R	PC3-10600R
Speed (MHz)	1,600	1,333
Speed running in the system (MHz)	1,600	1,333
Timing/Latency (tCL-tRCD-tRP-tRASmin)	11-11-11-35	9-9-9-24
Size (GB)	16	4
Number of RAM module(s)	16	12
Chip organization	Double-sided	Double-sided

System	Dell PowerEdge M620	HP ProLiant DL380 G6
Rank	Dual	Dual
Operating system		
Name	Microsoft Windows Server 2012 R2	Microsoft Windows Server 2008 R2
Build number	9600	7601
File system	NTFS	NTFS
Kernel	6.2.9600.16452	6.1.7601.18409
Language	English	English
Local RAID controller		
Vendor and model number	Dell PERC H710P	HP Smart Array P410i
Firmware version	21.2.1-0000	2.74
Driver version	6.802.19.0 12/5/2013	6.28.0.64 2/18/2014
Cache size (MB)	1024	1024
Shared RAID controller (VRTX)		
Vendor and model number	Shared PERC8	N/A
Firmware version	23.8.12-0061	N/A
Driver version	6.802.19.0 12/5/2013	N/A
Cache size (MB)	N/A	N/A
Local hard drives		
Vendor and model number	Dell 0NWH7V	EH0146FARWD / Seagate ST900205SS
Number of drives	2	6 (Data) / 2 (OS)
Size (GB)	300	146GB / 600GB
RPM	15k	15k / 10k
Type	SAS	SAS / SAS
Shared hard drives (VRTX)		
Drive type 1		
Vendor and model number	Dell 0NWH7V	N/A
Number of drives	20	N/A
Size (GB)	300	N/A
RPM	15k	N/A
Type	SAS	N/A
Drive type 2		
Vendor and model number	Dell 0T6TWN	N/A
Number of drives	5	N/A
Size (TB)	1.2	N/A
RPM	10k	N/A
Type	SAS	N/A
Ethernet adapters		
Vendor and model number	Broadcom 57810S 10GbE 2-port	HP NC382i 1GbE 2-port
Type	Integrated	Integrated
Driver	6.802.19.0 12/5/2013	7.10.6.0 3/11/2014

Figure 4: System configuration information for the test systems.

APPENDIX B – HOW WE TESTED

Our test configuration consisted of one HP ProLiant DL380 G6 representing the legacy solution, and one Dell PowerEdge VRTX with two Dell PowerEdge M620 blade servers representing the Dell solution. On the legacy solution, we used Windows Server 2008 R2 on the host and VMs, and SQL Server 2008 R2 as the database software. On the Dell solution, we used Windows Server 2012 R2 on the host and VMs, and SQL Server 2008 R2 as the database software. We used local storage on the legacy solution to create a RAID10 volume for the VMs. On the Dell solution, we used the shared storage to provide RAID10 and RAID5 volumes for the VM data and OS drives, respectively.

We used a separate server with 18 VMs for database access clients. We used a Dell PowerConnect S4810 switch for client traffic.

Configuring the VRTX

Configuring the VRTX networking

These steps outline how we set up the networking on the Dell PowerEdge VRTX. The VRTX has a 10GbE switch that spans all server nodes. There are several options for logically dividing the networking – in this study, we used VLANs to separate the three networks: Management/Client = VLAN 100, Live Migration = VLAN 300, Cluster = VLAN 400. On the VRTX switch, there are 8 external ports and 16 internal ports. We used one external port to connect management and client machines. The internal ports are in groups of four, with each group assigned to one server slot. Of those four ports, we used one for management/client traffic and connected it with the external port. We then set two of the internal ports in each group to the Live Migration and the Cluster networks, so that this traffic would stay within the VRTX.

1. Connect the Chassis Management Controller (CMC) to your management network. This connection will not have any VLAN assigned.
2. Use the LED screen on the front of the VRTX to find the CMC IP address.
3. Navigate to the CMC IP address using a Web browser. Log in with your credentials.
4. Click I/O Module Overview and then click Launch I/O Module GUI.
5. Enter your credentials for the I/O Module GUI, select Advanced from the drop-down list, and click Submit.
6. Click OK at the warning.
7. Expand the Switching section and then expand the VLAN section.
8. Click VLAN Membership.
9. Click Add.
10. Enter a VLAN ID and Name. We used `100` and `Management`
11. Click Apply.
12. Repeat the last two steps for the Live Migration (300) and Cluster (400) VLANs.
13. On the left pane, click Port Settings.
14. Click Edit.
15. Choose an external port to use for management and client traffic. Set the Port VLAN Mode to Access. Add the management/client VLAN ID (100 in our case) and leave the membership in Tagged mode. Click Apply.

16. Choose an internal port mapped to Server Slot 1 (it will be named gi1/x). Set the Port VLAN Mode to Trunk. Add the management/client VLAN ID and leave the membership in Tagged mode. Click Apply.
17. Repeat the last step for a port mapped to Server Slot 2 (it will be named gi2/x).
18. Repeat the last two steps, but choose a different port and add the VLAN ID for Live Migration (300).
19. Repeat again, but choose a different port and add the VLAN ID for Cluster (400).

Configuring the VRTX storage

These steps outline how we configured the shared storage in the VRTX. In our testing, we had 20 lower-capacity, high-speed drives (300GB at 15k RPM) and five high-capacity, medium-speed drives (1.2 TB at 10k RPM). We created two RAID10 virtual disks using the 300GB drives to host our SQL data and log VHDs (14 drives and 6 drives, respectively). We used four of the 1.2TB drives to create a RAID5 virtual disk for hosting the OS VHDs. We used the remaining 1.2TB drive in a RAID0 virtual disk as our quorum witness for the Hyper-V cluster.

1. Expand the Chassis Overview section and then expand the Storage section. Click Setup.
2. Under Assignment Mode, select the radio button for Multiple Assignment, and click Apply.
3. Click OK to confirm Operation Successful.
4. Click Virtual Disks.
5. At the top of the screen, click Create.
6. Choose the appropriate RAID level for the virtual disk. We used RAID10 for our Data and Logs, RAID5 for our OS, and RAID0 for the quorum virtual disks.
7. Select the appropriate physical disks. We used fourteen 300GB drives for Data, six 300GB drives for Logs, four 1.2TB drives for OS, and one 1.2TB drive for Quorum.
8. Set the size of the virtual disk (we used the maximum available for each RAID configuration).
9. Click Create Virtual Disk.
10. Click OK to confirm Operation Successful.
11. Repeat steps 5-10 to create the remaining virtual disks.

Installing Microsoft Windows Server 2012 R2

These steps outline how we installed Microsoft Windows Server 2012 R2 onto the Dell PowerEdge M620 blades as well as on the VMs used in testing.

1. Attach the installation media to the host or VM. On the Dell PowerEdge M620s, this is possible via the shared optical drive, an external USB optical drive, or by attaching a virtual disk through the CMC. On the VM, attach a disk image to the virtual DVD drive.
2. Power on the host or VM and boot into the Windows installer.
3. Once the installation files have been copied into memory, select the appropriate language, time and currency format, and keyboard layout, and click Next.
4. Click Install Now.
5. Enter the product key, and click Next.

6. Choose Windows Server 2012 R2 Datacenter (Server with a GUI), and click Next.
7. Check the I accept the license terms box, and click Next.
8. Choose Custom: Install Windows only (advanced).
9. Select the OS hard drive from the list, and click Next. This will begin the installation.
10. On both servers, give the management NIC the appropriate VLAN ID and set a static IP address on the management subnet.
11. Run Windows Update on each server until the operating systems are completely up to date.

Building the Microsoft Windows Hyper-V Failover Cluster

These steps outline how we clustered the two Dell PowerEdge M620 servers together for high availability, using the Failover Cluster feature built into Microsoft Windows Server 2012 R2.

1. Use Server Manager to add the Hyper-V role on each server.
2. After adding the Hyper-V role, open Disk Management on each server.
3. For each offline disk, complete the following steps:
   a. Initialize all disks with GPT partitioning.
   b. Right-click the disk, and click New Simple Volume.
   c. Complete the New Simple Volume wizard and choose the Do not assign a drive letter option.
4. Connect both servers to a domain. We used a Microsoft Windows Server 2012 R2 VM on a separate server as our Active Directory Domain Controller.
5. Use Hyper-V Manager to create a virtual switch for the Management, Live Migration, and Cluster networks on each server. Each network's virtual switch must have the same name on both servers. This is necessary later for clustering.
6. Add the Failover Clustering feature to each server using Server Manager.
7. On each server, open regedit, and navigate to HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\ClusDisk\Parameters.
8. Add a new DWORD called `AllowBusTypeRAID` and set the value to `1`
9. Open the Failover Cluster Manager on one of the servers.
10. Run the Failover Cluster Validation tool and add the names of both servers. Run all the tests.
11. After the validation completes successfully, check the Create a cluster now checkbox, and click Finish.
12. Use the wizard to create a cluster. Give the cluster an IP address on the management network and choose to add all eligible storage to the cluster.
13. In the Failover Cluster Manager, connect to your cluster, and click More Actions→Configure Cluster Quorum Settings. Perform the following steps:
    a. Click Next.
    b. Select Advanced quorum configuration and witness selection, and click Next.
    c. Select All nodes, and click Next.

d. Leave the Allow cluster to dynamically manage the assignment of node votes checkbox checked, and click Next.
e. Select Configure a disk witness, and click Next.
f. Select the disk to be used for quorum, and click Next.
g. Click Next.
h. Click Finish.

14. In the Failover Cluster Manager, click Storage→Disks. Add all the disks except for the quorum disk to Cluster Shared Volumes.

Building the virtual machines

1. Use the Failover Cluster Manager to create a new virtual machine with two vCPUs and 16GB of memory (on the legacy solution, use Hyper-V Manager and give the VM 10GB of memory). Give the OS VHD 50GB and place it in a location on the OS virtual disk.
2. Create two more VHDs with 30GB each for data and logs. Place them on the data and log partitions, respectively, and attach them to the VM.
3. Create a virtual switch connected to the client network and attach it to the VM.
4. Attach the OS installation media to the VM and install the guest OS.

Installing Microsoft SQL Server 2014

These steps describe how we installed Microsoft SQL Server 2014 onto the test VMs.

1. Attach the installation media to the virtual optical drive for the VM.
2. Connect to the VM and launch setup.exe from the installation media.
3. Choose the Installation section on the left, and click New SQL Server stand-alone installation or add features to an existing installation.
4. At the Product Key screen, enter the product key, and click Next.
5. At the License Terms screen, check the I accept the license terms box, and click Next.
6. At the Global Rules screen, allow the Global Rules check to finish, and click Next.
7. At the Microsoft Update screen, check the use Microsoft Update to check for updates (recommended) box, and click Next.
8. Once the updates have been downloaded and installed, click Next.
9. At the Install Setup Files screen, allow the setup files to install, and click Next.
10. At the Install Rules screen, allow the Install Rules check to run, and click Next.
11. At the Setup Role screen, select the SQL Server Feature Installation radio button, and click Next.
12. At the Feature Selection screen, select the features required for your installation. We selected Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tool Backwards Compatibility, Management Tools - Basic, and Management Tools - Complete.
13. At the Feature Rules screen, allow the Feature Rules check to run, and click Next.

14. At the Instance Configuration screen, click Next to use the default instance named MSSQLSERVER.
15. At the Server Configuration screen, click Next.
16. At the Database Engine Configuration screen, select the radio button for Mixed Mode (SQL Server authentication and Windows authentication) and enter a password for the SQL Server system administrator (sa) account.
17. Click the Add Current User button.
18. In the Data Directories tab, enter the directories to be used for SQL data and logs. We used E:\ and F:\, respectively, to place the data and logs on their appropriate VHDs. Click Next.
19. At the Feature Configuration Rules screen, allow the Feature Configuration Rules check to finish, and click Next.
20. At the Ready to Install screen, click Install.
21. After the installation has completed, close the wizard.

Configuring the legacy server

Installing Windows Server 2008 R2

Prior to installing Windows Server 2008 R2 on the HP ProLiant DL380 G6 we used the Smart Array configuration utility to create a RAID10 drive pair for the operating system and used the remaining six drives in RAID10 for the VM VHDs.

1. Insert the installation DVD for Windows Server 2008 R2 SP1 Enterprise into the DVD drive or attach the disk image to the VM and boot into the installation media.
2. At the Language Selection Screen, click Next.
3. Click Install Now.
4. Select Windows Server 2008 R2 Datacenter (Full Installation), and click Next.
5. Click the I accept the license terms checkbox, 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.

Installing SQL Server 2008 R2

1. Attach the installation media to the VM.
2. In the VM guest operating system, run setup.exe.
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 SQL Server stand-alone installation or add features to an existing installation.
6. At the Setup Support Rules screen, wait for the rule check to complete. If there are no failures or relevant warnings, click OK.

7. Enter your license key, and click Next.
8. Choose to accept the license terms, and click Next.
9. If no failures are displayed after the setup support files are installed, click Next.
10. At the Setup Role screen, choose SQL Server Feature Installation.
11. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, Client Tools Backwards Compatibility, Management Tools – Basic, and Management Tools – Complete. Click Next.
12. At the Installation Rules screen, click Next after the check completes.
13. At the Instance configuration screen, leave the default selection of default instance, and click Next.
14. At the Disk Space Requirements screen, click Next.
15. At the Server Configuration screen, check that NT AUTHORITY\SYSTEM is selected for SQL Server Agent and SQL Server Database Engine. Click Next.
16. Assuming there are no failures, 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 the Data Directories tab, and enter the appropriate drive and folders for database and logs.
21. Click Next.
22. At the Error and usage reporting screen, click Next.
23. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
24. At the Ready to Install screen, click Install.
25. After installation completes, click Close.

Configuring the database

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 10GB 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 Install.pl script generated the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server. We built the 10GB database in SQL Server, and then performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

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. Other than this file size modification, we created and loaded the database in accordance to the DVD Store documentation. Specifically, we followed these steps:

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 10GB database, and made 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.

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 following general steps:

1. Clean up prior outputs from the target system and the client driver system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the host and client system.
6. Wait for a ping response from the server under test (the hypervisor system), the client system, and the target.
7. Let the test server idle for 20 minutes.
8. Start the DVD Store driver on the client.

We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --
n_threads=28 --db_size=10GB --think_time=0.02 --detailed_view=Y --
warmup_time=5 --csv_output=<drive path>
```

APPENDIX C – WHAT WE TESTED

About the Dell PowerEdge VRTX

The Dell PowerEdge VRTX is a compact, all-in-one solution in a 5U rack-able tower chassis. Designed to be quiet under normal operating conditions, the Dell PowerEdge VRTX can be stowed under a desk in a small office. Its four bays house M520 or M620 compute nodes, providing a space-saving alternative to four separate tower or rack servers. In addition to space savings, the Dell PowerEdge VRTX provides administrators with a unified interface, the Chassis Management Controller, for performing routine systems management tasks. The Dell PowerEdge VRTX chassis supports up to 48 TB of shared internal storage that is presentable as virtual drives to single or multiple compute nodes, and provides optional pass-through and eight PCIe slots for additional device connectivity. The chassis integrated storage can be configured with 25 bays for 2.5-inch drives or with 12 bays for 3.5-inch drives. The Dell PowerEdge VRTX integrated switch contains multiple external network ports for easy expansion or integration into any computing environment.

For more information about the Dell PowerEdge VRTX, visit www.Dell.com/PowerEdge/VRTX.

About the Intel Xeon processor E5 family

The new Intel Xeon processor E5 family, which comes standard in new Dell PowerEdge servers, incorporates new technology and features to meet the computing demands of the present and future. The Intel Xeon processor E5 family delivers intelligent and adaptive performance using such features as Intel Turbo Boost Technology 2.0, Intel Advanced Vector Extension, Intel Integrated I/O, and Intel Data Direct I/O Technology. These new processors also feature Intel Trusted Execution Technology (Intel TXT) and utilize Intel Advance Encryption Standard New Instructions (Intel AES-NI) to help keep your data safe.

For more information about the Intel Xeon processor E5 family, visit www.intel.com.

About Microsoft Windows Server 2012

Windows Server 2012, the latest release of this server OS from Microsoft, includes many new features and enhancements. According to Microsoft, Windows Server 2012 focuses on four core areas:

- **Beyond virtualization.** Windows Server 2012 provides a robust and dynamic virtualization platform through Hyper-V, and includes new features that provide flexible options for delivering cloud services.
- **The power of many servers, the simplicity of one.** Windows Server 2012 offers features that allow for high availability and ease of management for multiple-server infrastructures.
- **Every app, any cloud.** Windows Server 2012 delivers a scalable and flexible Web and application platform by providing a consistent and open set of tools and frameworks that apply to applications on premises, in the cloud, or in a hybrid environment.
- **Modern work style, enabled.** Microsoft Windows Server 2012 empowers users and IT staff with remote access to data, applications, and simpler management tools while strengthening security and compliance.

About Microsoft SQL Server 2014

This latest iteration of the Microsoft SQL Server family is a next-generation data platform that includes many new features oriented to enterprise users focused on transactional performance and speed, time-to-insight, business analytics, high availability, and integration of their data streams into public and private cloud environments. Microsoft highlights the following key features:

Support for in-memory OLTP, via a memory and OLTP-optimized database engine integrated into the platform's data engine, and enhancements to the in-memory column store already present in Microsoft SQL 2012.

Ease of integration with Microsoft Azure, making SQL Server 2014 a platform for hybrid cloud, supporting scenarios such as cloud backup and cloud disaster recovery.

Better redundancy with AlwaysOn Availability Groups, allowing up to eight secondary replicas to be placed in different locations for high availability, read-access efficiency, and backup and data recovery.

For more information about Microsoft SQL Server 2014, visit www.microsoft.com/en-us/sqlserver/default.aspx.

About DVD Store Version 2.1

To create our real-world ecommerce workload, we used the DVD Store Version 2.1 benchmarking tool. DS2 models an online DVD store, where customers log in, search for movies, and make purchases. DS2 reports these actions in orders per minute that the system could handle. The DS2 workload also performs other actions, such as adding new customers, to exercise the wide range of database functions you would need to run your ecommerce environment.

APPENDIX D – PRICING DETAILS

To calculate the cost of consolidating with the Dell PowerEdge VRTX compared to adding high availability and upgrading an existing four-year-old dual-socket server, we used the following costs:

Hardware

We used the MSRP for a Dell PowerEdge VRTX with two Dell PowerEdge M620 blade servers with the following upgrades:

- PowerEdge VRTX Rack Configuration for 2.5 inch Hard Drives
- PowerEdge VRTX 1Gb Switch Module, Internal 16 ports to External 8 ports
- PowerEdge VRTX 2.5 HDD Dual Expander for Single Controller
- PowerEdge VRTX 2.5 HDD HotPlug Backplane with Single Controller and Expander
- 5 x 1.2TB 10K RPM SAS 6Gbps 2.5in Hot-plug Hard Drive
- 20 x 300GB 15K RPM SAS 6Gbps 2.5in Hot-plug Hard Drive
- 2 x Dell PowerEdge M620 blade servers with:
- VFlash, 8GB SD Card for iDRAC Enterprise
- 2 x Intel Xeon E5-2690 v2 processors
- 16 x 16GB RDIMM 1600MT/s
- 2 x 300GB 15K RPM SAS 6Gbps 2.5in Hot-plug Hard Drive
- ProSupport Plus: Mission Critical 4-Hour 7x24 On-Site Service with Emergency Dispatch for 3 years

For the high availability addition to the legacy solution, we used the MSRP for the following hardware and support:

- HP P2000 G3 iSCSI MSA 2-Controller SFF Array-BK831B
- 20 x 300GB 6G SAS 15K SFF hard drives
- 4 x 1.2TB 6G SAS 10K SFF hard drives
- HP V1910-16G switch
- HP 4-hour 24x7 MSA 2000 G3 HW Support for 3 years

We also included post-warranty support costs over three years for the four four-year-old dual-socket servers. Figure 5 shows the hardware costs for the configurations.

	Dell PowerEdge VRTX solution	Four-year-old dual-socket server	Dell PowerEdge VRTX solution savings
VRTX hardware and support	$62,224	N/A	N/A
HP high availability (additional storage array and switch)	N/A	$28,214	N/A
Support for existing HP servers	N/A	$10,344	N/A
Total hardware expenses	**$62,224**	**$38,558**	**$23,666**

Figure 5: Summary of hardware and hardware support costs for the Dell PowerEdge VRTX solution and the four-year-old dual-socket solution.

Software

The Dell PowerEdge VRTX with two blade servers consolidated solution contained 40 cores. The legacy solution we tested had 48 cores, though in the fourth server we licensed only a portion of the cores. Similarly, the Dell PowerEdge VRTX solution contained four processors, while the legacy solution contained eight. Figure 6 shows a summary of these costs.

	Cost per unit	Four older servers with two 6-core processors each		Dell VRTX with two M620 servers with two 10-core processors each	
		Number	Total	Number	Total
Microsoft SQL Server Enterprise Software Assurance, 2-core pack[1]	$6,874	22	$151,228	20	$137,480
Microsoft Windows Server Datacenter Software Assurance, 2-processor pack	$3,078	4	$12,312	2	$6,156
Two-year total			$163,540		$143,636
Three-year total (1.5*2 year total)			$245,310		$215,454
Three-year savings for the Dell VRTX solution					**$29,856**

Figure 6: Summary of software and software support costs for the Dell PowerEdge VRTX solution and the four-year-old dual-socket solution.

Labor

For management costs, we estimated the time required for each and multiplied it by a typical hourly cost. Figure 7 shows a summary of these costs.

Management	Hours per month per server	Number servers	Total	Annual total	Cost per hour	Annual cost	Three-year cost
HP legacy servers	2	4	8	96	$50	$4,800	$14,400
New storage array for HP	1	1	1	12	$50	$600	$1,800
Total for HP							**$16,200**
VRTX	1.5	2	3	36	$50	$1,800	**$5,400**
Savings							**$10,800**

Figure 7: Summary of management costs for the Dell PowerEdge VRTX solution and the four-year-old dual-socket solution.

For deployment costs, we estimated 16 hours required to deploy the Dell PowerEdge VRTX and 4 hours to deploy the additional storage array and network switch for the legacy solution. We estimated the hourly cost at $50 per hour, coming to $800 for the Dell PowerEdge VRTX and $200 for the legacy solution.

[1] We license all cores in the Dell PowerEdge VRTX. We licensed all cores in the three HP legacy servers that held four VMs each. In the fourth HP legacy server, we license four cores in for each of the two VMs, for a total of eight.

APPENDIX E – PERFORMANCE RESULTS

During our performance testing, we set a goal of achieving at least 15,000 OPM per VM in order to reflect an even level of workload distribution and service. Figure 8 lists the OPM results for each VM on each solution.

	Dell PowerEdge VRTX	Legacy solution
VM1	18,938	16,608
VM2	16,488	17,001
VM3	17,515	17,109
VM4	16,370	15,757
VM5	16,675	N/A
VM6	18,003	N/A
VM7	18,515	N/A
VM8	16,798	N/A
VM9	17,927	N/A
VM10	17,525	N/A
VM11	17,494	N/A
VM12	17,823	N/A
VM13	15,962	N/A
VM14	16,134	N/A

Figure 8: DVD Store 2 results for each VM in each solution. Higher numbers are better.

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
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