



Dell EMC PowerEdge R740xd
powered by the Intel Xeon Scalable processor

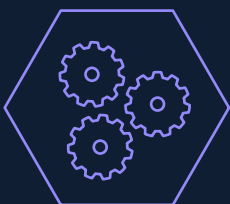
Faster, more powerful handling of database workloads

The new Intel processor-based Dell EMC PowerEdge R740xd offers better virtualized database performance compared to the legacy PowerEdge R720

The pace of business is lightning fast. Technology runs faster—and customers want service even faster still. To keep up with the demands of a company in this age, you need hardware infrastructure capable of supporting large amounts of work with a more responsive customer experience. Our work in the Principled Technologies datacenter showed that the 14th generation Dell EMC™ PowerEdge™ R740xd, with Intel processors and VMware products, could deliver just that.

We ran an online transaction processing (OLTP) workload on a cluster of PowerEdge R740xd servers with VMware® vSphere® 6.5, VMware vSAN™ storage, and the Intel® Xeon® Scalable processor. We then compared its performance to that of a 12th generation PowerEdge R720 server cluster using traditional HDD storage. We measured three key metrics: database orders processed per minute (OPM), input/output operations per second (IOPS), and storage latency.

In all our database performance testing, the Dell EMC PowerEdge R740xd far surpassed the PowerEdge R720, showing results that could help your business serve users better.



Process
8x the database
operations
per minute



Process database
operations
98.46% faster



Support more
database
transactions with
12x the input/
output operations
per second



Time to refresh

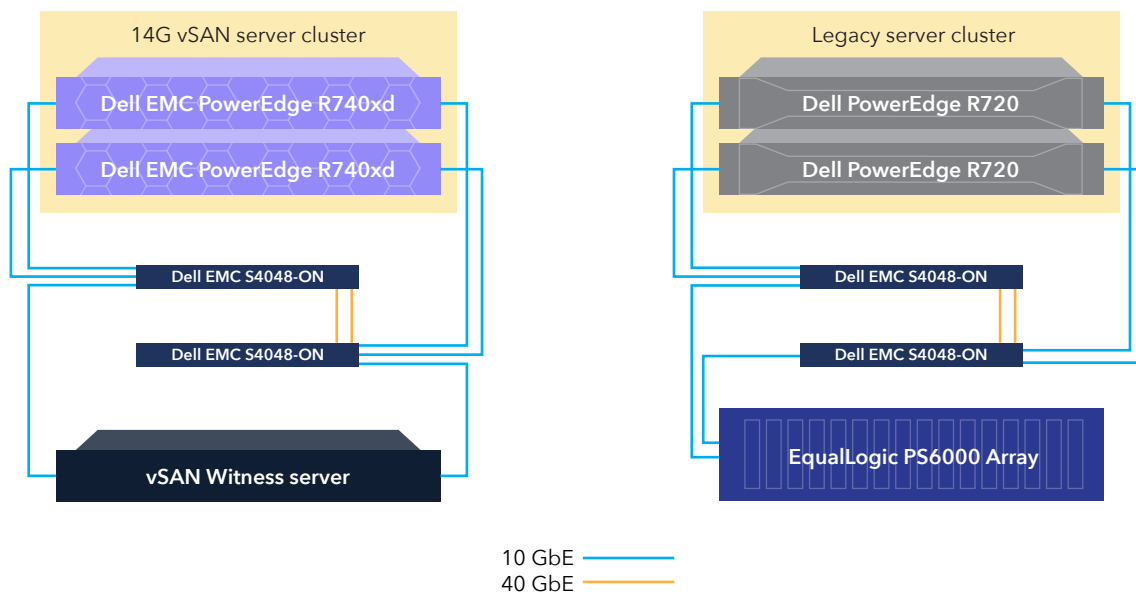
Future-looking organizations know the value of being prepared. Your business may get on fine with your current infrastructure—but a new product launch, an unexpected influx of new customers, or a routine expansion of services could interrupt business as usual and leave your customers with a poor level of service. That's why it's important for businesses to invest in new technologies that can help elevate the level of your work and keep operations running smoothly.

Compared to legacy 12th generation PowerEdge R720 servers, the Intel Xeon Scalable processor-based 14th generation PowerEdge R740xd offers superior performance that can enable you to better serve your demanding applications.

How we tested

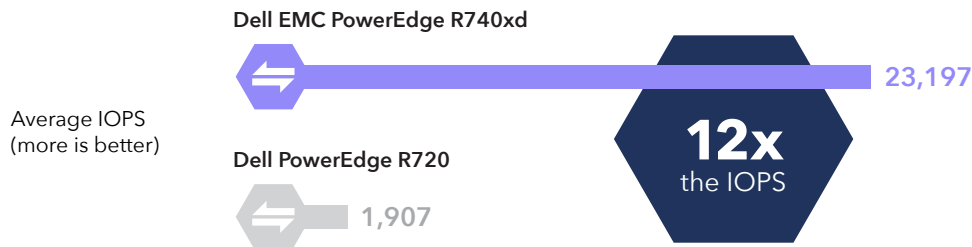
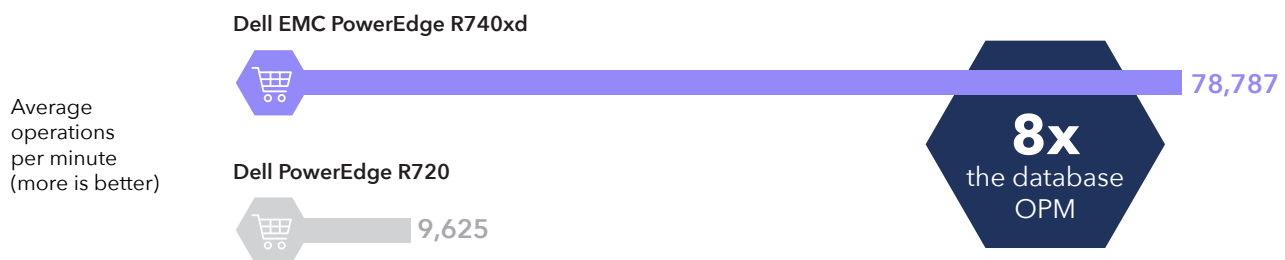
We compared the new 14th generation Dell EMC PowerEdge R740xd to the 12th generation PowerEdge R720 in a series of tests designed to assess how much data each system is able to process, and how an end-user's experience is affected while the system is under stress.

We tested two separate ESXi® server clusters, each comprised of two hosts. The PowerEdge R740xd cluster used VMware vSAN for storage, with PCIe SSDs as the caching tier and read-intensive SAS SSDs as the capacity tier. The legacy PowerEdge R720 server cluster used a HDD-based SAN storage array, which is a configuration typical for its time. We used DVD Store 2, a database-intensive ecommerce test application, to assess each server cluster's performance while processing a simulated online transaction processing (OLTP) workload. See [Appendix B](#) for detailed testbed information.



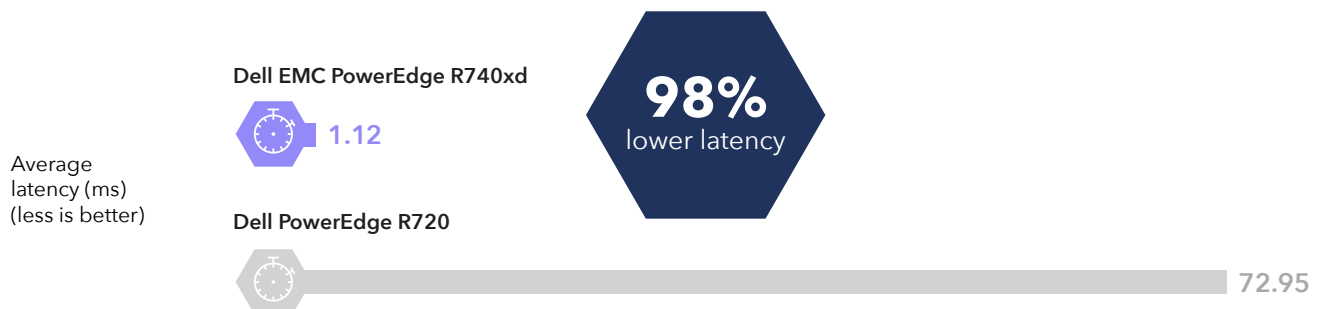
Expand your work with the PowerEdge R740xd

Serving customers is key for any business. With the speed of its NVMe SSD-driven VMware vSAN storage, and using the latest-generation Intel Xeon Scalable processor, the PowerEdge R740xd cluster running VMware vSphere 6.5 processed 78,787 database operations per minute (OPM). The PowerEdge R720 server cluster, also running VMware vSphere 6.5, only managed 9,625 OPM. With servers capable of fulfilling eight times the customer operations, you'll be able to increase the performance of your hypervisors while keeping up with the speed of business, leading to a better experience for your users. Your organization could also cut down on its datacenter footprint by purchasing fewer servers to support your current workload. But you also have the opportunity to invest in more hardware and plan for inevitable future work. Furthermore, the 14th generation servers running VMware vSphere 6.5 with vSAN processed 12 times the IOPS of the older PowerEdge server. Having better raw IOPS could mean being able to support even tougher workloads when your company needs them.



Serve customers better with fast response times

Many business operations need to happen quickly. Failing to meet these expectations can lead to customer dissatisfaction or even loss. That's why it's critical to ensure your servers can communicate and process information as fast as possible, without lag or delay. The Dell EMC PowerEdge R740xd solution had 98.46 percent lower storage latency than the PowerEdge R720, making for a smoother, more responsive user experience.





Conclusion: Refresh to drive your business further

Your datacenter may be working fine to support your business operations—but after several years, a refresh could help you propel your company's level of work forward. In our hands-on tests, the Dell EMC PowerEdge R740xd combined with the latest generation of Intel Xeon Scalable processors proved to be a workhorse. In a VMware vSAN cluster, the PowerEdge R740xd processed eight times the OPM and 12 times the IOPS with 98.46% lower latency than the 12th generation PowerEdge R720. Our results show that purchasing newer, more powerful servers can enable you to better serve your current users and make room for more in the future.



On May 12, 2017, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on June 5, 2017.

Appendix A: System configuration information

Server configuration information	Dell EMC PowerEdge R740xd	Dell PowerEdge R720
BIOS name and version	Dell EMC 0.4.8	Dell EMC 2.5.4
Operating system name and version/build number	VMware ESXi™ 6.5 4564106	VMware ESXi™ 6.5 4564106
Date of last OS updates/patches applied	4/27/17	4/27/17
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6134	Intel® Xeon® CPU E5-2697 v2
Core count (per processor)	8	12
Core frequency (GHz)	3.2	2.7
Memory module(s)		
Total memory in system (GB)	192	192
Number of memory modules	12	12
Vendor and model	Hynix HMA82GR7AFR8N-VK	Hynix HMT42GR7MFR4C-PB
Size (GB)	16	16
Type	PC4-2666 Dual Rank	PC3-12800 Dual Rank
Speed (MHz)	2,666	1,600
Local storage #1		
Number of drives	12	2
Drive vendor and model	Dell P/N 0XCRDV (PX05SRB384Y)	Seagate ST300MM0006
Drive size	3.84 TB (used as a capacity tier)	300 GB (used as an OS drive)
Drive information (speed, interface, type)	12Gbps SAS SSD	6Gbps 10K SAS HDD
Local storage #2		
Number of drives	3	N/A
Drive vendor and model	Dell P/N 0JD6CH (PM1725a) PCIe NVMe	N/A
Drive size	1.6 TB (used as a caching tier)	N/A
Drive information (speed, interface, type)	NVMe PCIe SSD	N/A



Server configuration information	Dell EMC PowerEdge R740xd	Dell PowerEdge R720
Network adapter #1		
Vendor and model	Dell P/N 0G8RPD (BCM57800)	Intel® GbE 4P I350-t rNDC
Number and type of ports	2 x 10GbE, 2 x 1GbE	4 x 1GbE
Driver version	lgb / ixgbe	lgb / ixgbe
Network adapter #2		
Vendor and model	N/A	Intel® 82599 10 Gigabit Dual Port
Number and type of ports	N/A	2 x 10GbE
Driver version	N/A	lgb / ixgbe
Cooling fans		
Vendor and model	Nidec UltraFlo 4VXP3-X30	AVC DBTC0638B2U
Number of cooling fans	6	6
Power Supplies		
Vendor and model	Dell 750W D750E-S6	Dell EMC 750W D750E-S6
Number of power supplies	2	2
Wattage of each (W)	750	750



Appendix B: How we tested

We installed and configured the latest available version of VMware vSphere 6.5 on both –the Dell 14G server cluster which used two Dell EMC PowerEdge R740xd servers, and the Legacy cluster which used two Dell PowerEdge R720 servers. On the Dell EMC PowerEdge R740xd servers, the hypervisors were installed using the redundant dual SD modules. On the Dell PowerEdge R720 servers the hypervisors were installed on two 300GB HDD configured on RAID1 pair.

We used the two Dell EMC PowerEdge R740xd servers and a witness server to create a two-node vSAN cluster with 3 disk groups per server. Each disk group was composed of one 1.6TB NVMe SSD drive as a cache device and four 3.84TB SAS SSDs as capacity devices. We also used the default vSAN storage policy, which uses the following settings:

- Number of failures to tolerate = 1
- Number of disk stripes per object = 1
- Object space reservation = 0%
- Flash read cache reservation = 0%
- Force provisioning = NO

We configured the two Dell PowerEdge R720 to use an EqualLogic PS6000 SAN storage array which was setup using 16x 600GB HDD on a RAID6 configuration, and provisioned one NFS datastore using all the available storage on the array.

	Dell EMC PowerEdge R740xd with VMware vSAN	EqualLogic PS6000
Number of controllers	N/A	2 (active-passive)
RAID level	Automatically managed by vSAN	RAID6
Number of drives, type 1	6 (used as cache tier)	16
Vendor and model number	Dell P/N 0JD6CH (PM1725a)	Seagate ST3600057SS
Drive size	1.6TB	600GB
Drive type	PCIe NVMe SSD	SAS HDD
Number of drives, type 2	24 (used as capacity tier)	N/A
Vendor and model number	Dell P/N 0XCRDV (PX05SRB384Y)	N/A
Drive size (GB)	3.84	N/A
Drive type	12Gbps SAS SSD	N/A

Table 1: Detailed storage specifications.

We cabled together two Dell EMC S4048-ON switches using two 40GbE ports on each switch and created management, vSAN, vMotion, NFS traffic, and VM Private traffic VLANs over all the available 10GbE ports across both switches. All the server under test used dual-port 10GbE connections for networking.

For the Dell EMC PowerEdge R740xd cluster, we configured 6 large SQL VMs with Windows Server 2016 and SQL server 2016. For the legacy cluster, we configured 6 large SQL VMs with Windows Server 2012 R2 and SQL 2012. All the VMs under test had 8GB of memory, four vCPUs, an 80GB drive for OS, a 50GB drive for database files, and a 30GB drive for database logs.

We used DVD Store Version 2.1 as a test harness to simulate an online store where customers log in, search for products, and make purchases. It also performs other actions, such as adding new customers, to exercise a wide range of everyday database functions. Our DVD Store 2 tests consisted of a 15-minute warm-up period followed by a 60-minute test period.

Installing VMware ESXi 6.5

1. Attach the installation media.
2. Boot the server.
3. At the VMware Installer screen, press Enter.
4. At the EULA screen, to Accept and Continue, press F11.
5. Under Storage Devices, select the appropriate virtual disk, and press Enter.
6. As the keyboard layout, select US, and press Enter.



7. Enter the root password twice, and press Enter.
8. To start installation, press F11.
9. After the server reboots, press F2, and enter root credentials
10. Select Configure Management Network, and press Enter.
11. Select the appropriate network adapter, and select OK.
12. Select IPv4 settings, and enter the desired IP address, subnet mask, and gateway for the server.
13. Select OK, and restart the management network.
14. Repeat steps 1 through 13 on the rest of the servers.

Deploying the VMware vCenter Server 6.5

1. On a Windows server or VM, locate the VMware-VCSA installer image.
2. Mount the image, navigate to the vcsa folder, and launch VMware-ClientIntegrationPlugin.exe.
3. In the wizard that appears, click Next.
4. Accept the terms of the license agreement, and click Next.
5. Leave the default installation directory, and click Next.
6. Click Install.
7. Click Finish.
8. In the mounted image's top directory, open vcsa-setup.html.
9. When prompted, click Allow.
10. Click Install.
11. Accept the terms of the license agreement, and click Next.
12. Enter the FQDN or IP address of the host onto which the vCenter Server Appliance will be deployed.
13. Provide a username and password for the system in question, and click Next.
14. Accept the certificate of the host you chose to connect to by clicking Yes.
15. Select the appropriate datacenter, and click Next.
16. Select the appropriate resource, and click Next.
17. Provide a name and password for the virtual machine, and click Next.
18. Select Install vCenter Server with an Embedded Platform Services Controller, and click Next.
19. Select Create a new SSO domain.
20. Provide a password, and confirm it.
21. Provide an SSO Domain name and SSO Site name, and click Next.
22. Set an appropriate Appliance Size, and click Next.
23. Select an appropriate datastore, and click Next.
24. Select Use an embedded database (PostgreSQL), and click Next.
25. At the Network Settings page, configure the network settings as appropriate for your environment, and click Next.
26. Review your settings, and click Finish.
27. When installation completes, click Close.
28. Using the vSphere web client, log into the vCenter server using the credentials previously provided.

Creating a cluster and adding the hosts to VMware vCenter

1. Once logged into the vCenter, navigate to Hosts and Clusters.
2. Select the primary site management vCenter.
3. Right-click the vCenter object, and select New Datacenter...
4. Enter a name for the new datacenter, and click OK.
5. Right-click the new datacenter, and click New Cluster...
6. Enter vSAN as the name for the new cluster.
7. Click OK.
8. Once the cluster has been created, right-click the cluster, and click Add Host.
9. Enter the IP address for the first server, and click Next.
10. Enter the root credentials for the server, and click Next.
11. To accept the server's certificate, click Yes.
12. Review the server details, and click Next.
13. Assign the desired license, and click Next.
14. Disable Lockdown mode, and click Next.
15. Click Finish.
16. Repeat steps 10 through 16 for the remaining servers.



Configuring the VMware vSphere Distributed Switch for the cluster

1. Navigate to the Networking tab.
2. Expand the vCenter for the cluster.
3. Right-click the datacenter, and click Distributed Switch→Distributed Switch.
4. Enter a name for the vDS, and click Next.
5. Select Distributed switch: 6.5.0, and click Next.
6. Set the number of uplinks to two, and enter a vSAN as the new default port group.
7. Click Next.
8. Review the settings, and click Finish.
9. Select the new vDS, and click the configure tab.
10. Under Properties, click Edit...
11. Click Advanced, and for the MTU setting, type 9000.
12. Click OK.
13. On the left-hand side, right-click the new vSAN port group that was created along with the new vDS.
14. Click Edit Settings.
15. Click VLAN, and enter the VLAN for vSAN traffic.
16. Click OK.
17. Right-click the vDS, and click Distributed Port Group→New Distributed Port Group.
18. Enter vMotion as the name of the new port group and click Next.
19. Under VLAN, set a VLAN to for vMotion. Click Next.
20. Review the port group settings, and click Finish.
21. Right-click the vDS, and click Distributed Port Group→New Distributed Port Group.
22. Enter VM_NET as the name of the new port group and click Next.
23. Under VLAN, set a VLAN to for VM_NET. Click Next.
24. Review the port group settings, and click Finish.
25. Right-click the vDS, and click Add and Manage Hosts...
26. Select Add hosts, and click Next.
27. Click + New hosts...
28. Select all the compatible hosts in vCenter cluster, and click OK.
29. Click Next.
30. Select Manage physical adapters and Manage VMkernel adapters, and click Next.
31. For each host, select each of the two 10Gb ports, click Assign uplink, and assign them to the two uplink ports.
32. Click Next.
33. Select the first host, and click +New adapter.
34. Click an existing network, and click Browse.
35. Select the vMotion port group, and click OK.
36. Click Next.
37. Check the vMotion service to enable it, and click Next.
38. Enter the desired network information for the new VMKernel, and click Next.
39. Click OK.
40. Select the first host, and click +New adapter.
41. Click select an existing network, and click Browse.
42. Select the vSAN port group, and click OK. Click Next.
43. Check the Virtual SAN service to enable it, and click Next.
44. Enter the desired network information for the new VMKernel, and click Next. Click OK.
45. Select each of the remaining hosts individually, and repeat steps 33 through 44 for each server. Click Next.
46. Analyze the impact, and click Next.
47. Review the settings, and click Next.



Enabling Virtual SAN on server cluster

1. Log into the vCenter web client, and navigate to Hosts and Clusters.
2. Expand the primary site management vCenter, and select the vSAN cluster.
3. Select the Configure tab, and under Virtual SAN, click General→Configure
4. Click Next on the vSAN capabilities screen.
5. Click Next on the Network validation screen.
6. Select which disks should be claimed for cache and which for capacity in the vSAN cluster, and click Next.
7. Click Finish on the Ready to complete screen.

Creating the SQL Server VMs

We used the following steps to create 6 SQL Server VMs per cluster.

1. In VMware vCenter, navigate to Virtual Machines.
2. To create a new VM, click the icon.
3. Leave Create a new virtual machine selected, and click Next.
4. Enter a name for the virtual machine, and click Next.
5. Place the VM on the desired host with available CPUs, and click Next.
6. Select the appropriate datastore to host the VM, and click Next.
7. Select the appropriate guest OS, and click Next.
8. In the Customize Hardware section, use the following settings:
 - Set the vCPU count to 4.
 - Set the Memory to 8GB.
 - Add 1 x 80GB VMDK for OS, 1 x 50GB VMDKs for database files and 1 x30GB VMDK for database logs. Set all VMDKs to thick provision eager zeroed.
 - Create three additional VMware Paravirtual SCSI controllers, and assign the VMDKs to the new controllers.
 - Attach the OS ISO to the CD/DVD drive.
9. Click Next.
10. Click Finish.

Installing and configuring SQL Server VMs

Installing Windows Server 2016

We used the following steps to install and configure SQL Server VMs:

1. Attach the Windows Server 2016 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When prompted to boot from DVD, press any key.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2016 Datacenter Edition (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password. Log in with the password you set up previously.
12. Install VMware Tools in the VMs hosted on the ESXi servers.

Installing SQL Server 2016

1. Attach the installation media ISO for SQL Server 2016 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2016 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Specify Evaluation as the edition you are installing, and click Next.
6. To accept the license terms, click the checkbox, and click Next.



7. Click Use Microsoft Update to check for updates, and click Next.
8. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
9. Click Next.
10. At the Instance configuration screen, leave the default selection of default instance, and click Next.
11. At the Server Configuration screen, accept defaults, and click Next.
12. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
13. Enter and confirm a password for the system administrator account.
14. Click Add Current user. This may take several seconds.
15. Click Next.
16. At the Ready to Install screen, click Install.
17. Close the installation window.
18. In the SQL Server Installation Center, click on Install SQL Server Management Tools.
19. Click Download SQL Server Management Studio.
20. Click Run.
21. When the Microsoft SQL Server Management Studio screen appears, click Install.
22. When the installation completes, click Close.

Installing Windows Server 2012 R2

1. Attach the Windows Server 2012 R2 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When prompted to boot from DVD, press any key.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. Enter the product key, and click Next.
7. Select Windows Server 2012 R2 Datacenter (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password.
12. Log in with the password you set up previously and install VMware Tools.

Installing SQL Server 2012

1. Mount the installation media for SQL Server 2012
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2012 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Select Enter the product key, and enter the product key. Click Next.
6. Click to accept the license terms, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.
8. To install the setup support files, click Install.
9. If there are no failures displayed, click Next.
10. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
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, after the check completes, click Next.
13. At the Instance configuration screen, leave the default selection of default instance, and click Next.
14. At the Server Configuration screen, choose NT Service\SQLSERVERAGENT for SQL Server Agent, and choose NT Service\MSSQLSERVER for SQL Server Database Engine. Change the Startup Type to Automatic. Click Next.
15. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
16. Enter and confirm a password for the system administrator account.
17. Click Add Current user. This may take several seconds.
18. Click Next.



19. At the Error and usage reporting screen, click Next.
20. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
21. At the Ready to Install screen, click Install.
22. After installation completes, click Close.
23. Run through the installation again, creating a new installation of SQL with the same settings.
24. Close the installation window.

Configuring and running the DVD Store 2 benchmark

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 we used. We ran the Install.pl script on a utility system running Linux® to generate 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 2016. We built the 20GB database in SQL Server, then performed a full backup, storing the backup file remotely for quick access. We used that backup file to restore the database when necessary.

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. Generate the data, and create the database and file structure using database creation scripts in the DS2 download. Make size modifications specific to our 20GB database, and make the appropriate changes to drive letters.
2. Transfer the files from our Linux data generation system to a Windows system running SQL Server.
3. Create database tables, stored procedures, and objects using the provided DVD Store scripts.
4. Set the database recovery model to bulk-logged to prevent excess logging.
5. Load the data we generated into the database. For data loading, use the import wizard in SQL Server Management Studio. Where necessary, retain options from the original scripts, such as Enable Identity Insert.
6. Create indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, create 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. Set the database recovery model back to full.
10. Create the necessary full text index using SQL Server Management Studio.
11. Create a database user, and map this user to the SQL Server login.
12. Perform a full backup of the database. This backup allows you to restore the databases to a pristine state.

Running the DVD Store tests

We created a series of batch les, 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 that each target reported.

Each complete test cycle consisted of general steps:

1. Clean up prior outputs from the target system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the target host.
6. Wait for a ping response from the server under test and the client system.
7. Let the test server idle for 10 minutes.
8. Start the DVD Store driver on the four clients.



We used the following DVD Store 2 parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=60 --n_threads=32 --db_size=20GB --think_time=0.00 --detailed_view=Y --warmup_time=15 --report_rate=1 --pct_newcustomers=20 --csv_output=<drivepath>
```

This project was commissioned by Dell Technologies.



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