

Make strong database performance stronger with Dell EMC PowerEdge and Samsung AutoCache

Dell EMC PowerEdge™ FC630 servers powered by Intel® Xeon® processors E5-2667 v4 with Dell EMC™ Storage SC9000 all-flash array, Qlogic® QLE2692 16G FC with StorFusion™ Technology, and Dell EMC PowerEdge Express Flash NVMe Performance PCIe SSDs



Using server-side caching with Samsung AutoCache and Dell EMC PowerEdge Express Flash NVMe Performance PCIe SSDs more than doubled the performance of the modern Dell EMC solution.

Using Dell EMC PowerEdge FC630 servers, powered by Intel Xeon processors E5-2667 v4, in a PowerEdge FX2 enclosure to run your database applications can be an excellent datacenter strategy. Along with QLogic® QLE2692 16Gb Fibre Channel (FC) adapter with StorFusion Technology, and the Dell EMC Storage SC9000 all-flash array, the modular architecture approach of the FX2 and FC630 servers packs a great deal of compute power into a small amount of space, which can boost the cost-effectiveness of your business.

In the Principled Technologies datacenter, we explored the potential of this modern Dell EMC solution to handle an intensive mixed database workload. We found that it achieved impressive performance in virtual machines running online transaction processing (OLTP) workloads simultaneously on SQL and Oracle databases. When we added Samsung AutoCache, a host-based I/O caching solution, and Dell EMC PowerEdge Express Flash NVMe Performance PCIe solid-state storage devices (SSDs), the Dell EMC hardware components could deliver twice the performance.



DELL EMC MODERN MODULAR ENVIRONMENT DELIVERS

For companies who demand strong SQL Server® 2016 performance, the Dell EMC PowerEdge FC630 is an excellent option. SQL Server 2016 features OS-maximum cores and memory as well as in-memory OLTP, meaning that it is well poised to take advantage of the vast resource pools new servers offer. The Dell EMC PowerEdge FC630 is a 1U, two-socket server that features Intel Xeon processors E5-2667 v4, provides up to 72 cores and 144 threads, and supports up to 1.5 TB of DDR4 RAM, making it a perfect candidate to provide large amounts of CPU and memory resources to SQL Server 2016 applications.

The all-flash Dell EMC Storage SC9000 array, geared toward large-scale storage, high-end workloads, and distributed enterprise environments, also helps speed up your SQL Server applications by offering 16Gb Fibre Channel, 12Gb SAS, and hardware redundancy to keep your data moving quickly and safely.

To quantify the SQL Server 2016 performance a company could experience with the modern PowerEdge FC630-SC9000 platform, we used six servers in three FX2 enclosures and created virtual machines with VMware vSphere. The servers simultaneously ran 36 VMs performing a SQL Server 2016 OLTP workload and 12 VMs performing an Oracle OLTP workload. We were primarily interested in the OLTP performance of the SQL VMs and included the Oracle workload to simulate a typical datacenter environment where many applications are competing for compute resources.

Figure 1 illustrates our test environment.

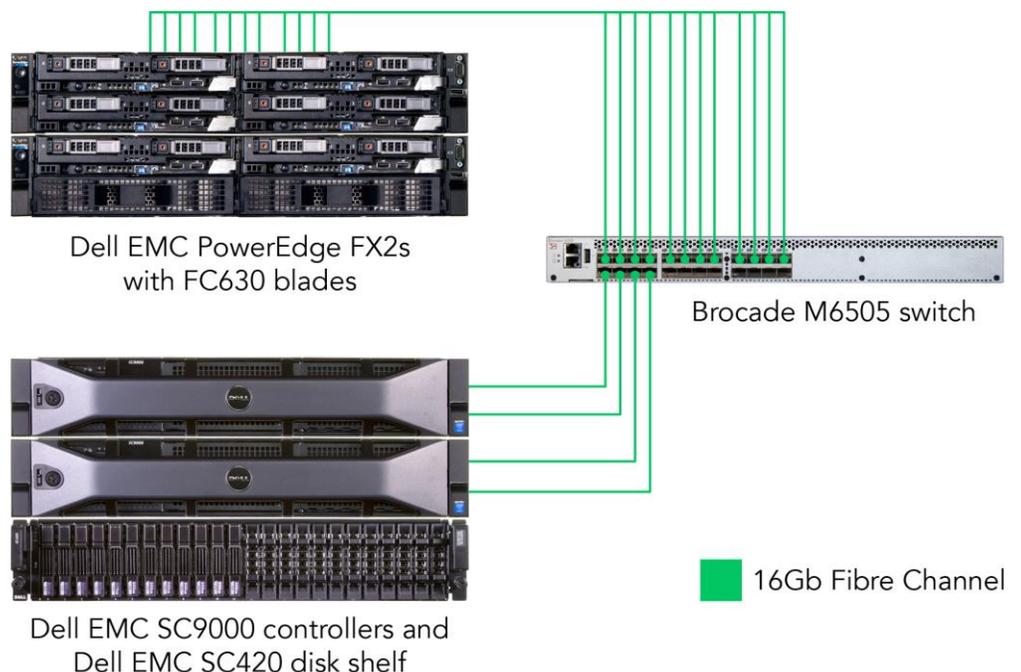


Figure 1: Our testbed.

Across the 36 SQL Server 2016 VMs, the Dell EMC modern environment could handle an impressive 431,839 total orders per minute (OPM), with each VM handling an average of 11,996 OPM.

Next, we added Samsung AutoCache v3.0, a host-based I/O caching solution, and installed a Dell EMC PowerEdge Express Flash NVMe Performance PCIe SSD¹ to each host for caching to see how performance would improve. With Dell Express Flash technology paired with a caching solution, the number of OPM the Dell EMC modern solution doubled to 871,580 and the per-VM average doubled to 24,211. This demonstrates the benefit of server-side caching in helping alleviate pressure on the storage and allowing you to get even more out of your SC9000 array.

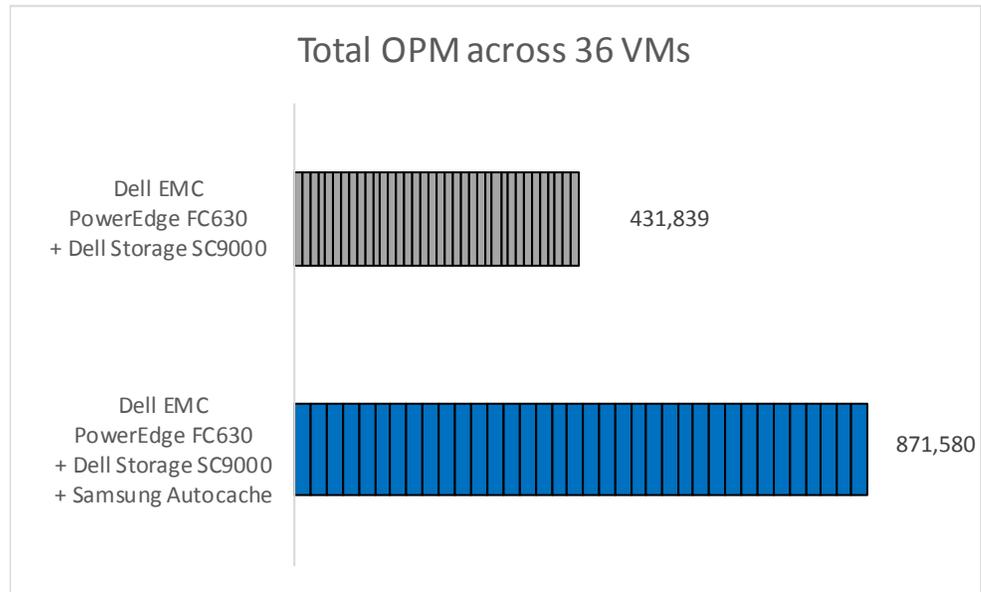


Figure 2: With the addition of the caching software, the total OPM the Dell EMC solution could handle increased.

For more information on components used in our testing, see [Appendix A](#). For detailed hardware configuration information, see [Appendix B](#). For details on our test procedure, see [Appendix C](#).

¹ As we specify in [Appendix B](#), the Dell EMC PowerEdge Express Flash NVMe Performance PCIe solid-state storage devices we used in our testing were model SM1715. On December 31, 2016, Dell discontinued this model and replaced it with the PM1725. According to Dell representatives, users can expect the performance of the PM1725 PCIe SSD to be comparable to or better than that of the SM1715 PCIe SSD.

OUR RESULTS IN DETAIL

We sized our VMs to utilize 60 percent of the RAM the server offered, leaving room for growth. Each of the 36 OLTP VMs had four vCPUs, 8 GB of RAM, and a 40GB SQL Server 2016 database. Each of the 12 VMs running the Oracle workload had two vCPUs, 16 GB of RAM, and a roughly 40GB Oracle database.

Figure 3 shows the median number of orders per minute that the solution could process in our testing, with and without host-based caching. As it shows, each of the 36 SQL VMs on the solution with caching achieved on average just over twice as many orders per minute as each of the SQL VMs without caching did.

	Dell EMC PowerEdge FC630 with Dell EMC Storage SC9000	Dell EMC PowerEdge FC630 with Dell EMC Storage SC9000 and Samsung AutoCache
VM 1	11,538	24,081
VM 2	11,751	25,067
VM 3	12,546	24,979
VM 4	11,632	24,429
VM 5	12,081	23,846
VM 6	12,355	23,830
VM 7	12,589	24,218
VM 8	11,435	23,545
VM 9	11,600	24,789
VM 10	11,437	25,280
VM 11	12,051	24,077
VM 12	11,775	25,174
VM 13	12,245	24,022
VM 14	11,747	25,276
VM 15	12,571	25,551
VM 16	11,762	23,422
VM 17	12,052	23,972
VM 18	12,584	23,912
VM 19	12,271	24,288
VM 20	12,040	24,594
VM 21	11,800	23,347
VM 22	12,516	23,506
VM 23	12,282	24,116
VM 24	12,345	23,583
VM 25	12,054	23,516
VM 26	12,866	24,178
VM 27	11,627	24,178
VM 28	11,572	25,262
VM 29	12,587	24,084
VM 30	11,446	24,776

	Dell EMC PowerEdge FC630 with Dell EMC Storage SC9000	Dell EMC PowerEdge FC630 with Dell EMC Storage SC9000 and Samsung AutoCache
VM 31	12,292	24,949
VM 32	11,542	24,670
VM 33	12,091	22,577
VM 34	11,464	22,982
VM 35	11,779	23,972
VM 36	11,514	23,532
Total	431,839	871,580

Figure 3: The SQL Server 2016 VMs running on the Dell EMC modern environment with the caching solution performed on average twice as many database transactions as the SQL Server 2016 VMs running on the environment without the caching solution did.

CONCLUSION

Upgrading the hardware running your SQL Server to a space-efficient modular Dell EMC modern environment can help your company achieve a great deal of database work in a small amount of space. With the Dell Express Flash technology, adding a caching solution such as Samsung AutoCache can make the environment even more efficient.

In the PT labs, we ran a mixed database workload on six Dell EMC PowerEdge FC630 servers, powered by Intel Xeon E5-2667 v4 processors, in three PowerEdge FX2 enclosures. The solution included the QLogic QLE2692 16Gb FC adapter with StorFusion Technology, Dell EMC Storage SC9000 all-flash storage, and Dell EMC PowerEdge Express Flash NVMe Performance PCIe SSDs.

With no caching solution, the 36 SQL Server 2016 VMs on the six servers achieved a total of 431,839 orders per minute while an Oracle workload ran on 12 VMs. When we added a caching solution to accelerate the SQL database volumes, the performance across the 36 SQL Server 2016 VMs doubled to 871,580. These numbers show the power of server-side caching to alleviate pressure on the storage array allowing you to get even more out of the Dell EMC modern environment.

APPENDIX A – ABOUT THE COMPONENTS

About the Dell EMC PowerEdge FX2s enclosure

The modular architecture approach of the Dell EMC PowerEdge FX2s enclosure increases flexibility and can help you make the most of your data center space while reducing the cables and switches needed to run your servers. The Dell EMC PowerEdge FX2s enclosure has a standard 2U footprint and features a modular design that can hold different combinations of compute and storage nodes to meet your specific goals. The PowerEdge FX2s fits four half-width or eight quarter-width compute nodes to increase the compute density in your rack and optimize the space in your data center. You can deploy the FX2s solution like a traditional rack-mounted server while gaining the benefits and features that more expensive dense blade solutions provide. Important features of the FX2s enclosure include:

- Up to eight low-profile PCIe expansion slots
- Two pass-through or optional networking FN I/O Aggregator modules
- Embedded network adapters within the server nodes
- Offers both chassis-based management through the Chassis Management Controller and rack-based management through Integrated Dell Remote Access (iDRAC) with Lifecycle Controller on each compute node

The Dell EMC PowerEdge FX2s enclosure fits a number of server and storage options, including the PowerEdge FC430, FC630, and FC830 servers, and PowerEdge FD332 storage – all Intel-powered. The Dell EMC PowerEdge FX2s solution we tested included two full-width Dell EMC PowerEdge FC630 server blades powered by Intel Xeon processors E5-2667 v4.

For more information about the Intel-powered Dell EMC PowerEdge FX2s solution, visit www.dell.com/us/business/p/poweredge-fx/pd.

About the Dell EMC PowerEdge FC630

Dell EMC calls the four-socket PowerEdge FC630 the ultimate dense scale-up server. Powered by the Intel Xeon processor E5-2600 v4 product family, this full-width server offers power, scalability, and flexibility. The FC630 offers up to four 18-core CPUs and up to 1.5 TB of memory. The FX2s enclosure can be configured with up to two FC630 servers or one FC630 server and two FD332 storage sleds.

About the Intel Xeon processor E5 family

The new Intel Xeon processor E5 family, which comes standard in new Dell EMC 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 the Dell EMC Storage SC9000 all-flash array

Dell EMC designed the Storage SC9000 as an ideal solution for large-scale storage, high-end workloads, and distributed enterprise environments. According to Dell EMC, this latest flagship array offers all the capabilities of the SC Series line in a fully upgraded, more scalable system leveraging the Dell EMC 13G server platform.

- 16Gb Fibre Channel capability provides a massive network pipe for achieving the throughput needed to take full advantage of the all-flash performance.
- Quick, modular expansion to over 3PB raw SAN and/or NAS storage capacity per array, and the ability to be interconnected with other SC Series arrays in larger federated systems under unified management.
- Superior flash and hybrid performance. Comprehensive SSD integration plus a wide range of HDDs and ultra-dense enclosures provide flexible performance.
- Always available storage with automated cost savings. Ideal for private cloud deployments, the SC Series Live Volume feature now offers seamless disaster recovery with transparent auto-failover to fully synchronized backup volumes on another SC series array.
- Live Volume with auto-failover keeps workloads running continuously during unplanned outages and repairs your high-availability environment automatically when an array comes back online. No extra hardware or software is required.
- Application Protection Manager Suite ensures server-side data integrity in Oracle, VMware and Microsoft database environments. Optional FIPS-certified self-encrypting SSDs and HDDs protect against data theft, loss or unauthorized access.
- Built-in efficiencies include new block-level compression on all-flash arrays and pervasive “thin” methods. Patented auto-tiering leverages the best attributes of diverse drive types to optimize your data throughout its lifecycle.
- Redundant, hot-swappable components make the SC9000 a resilient, easy-to-deploy and highly available solution. Add capacity quickly with any of five supported expansion enclosures. Customize I/O connections to multiprotocol SANs (FC, iSCSI and FCoE) and support file storage from the same pool via the optional FS8600 NAS appliance.

Learn more at www.dell.com/us/business/p/storage-sc9000/pd

About the QLogic QLE269X series of FC adapters

QLogic provides Dell EMC customers with future-ready I/O connectivity. According to QLogic, the QLE269x single and dual-port 16Gb Fibre Channel host bus adapters (HBAs) boast industry-leading native FC performance with extremely low CPU usage with full hardware offloads, and include the following advanced features:

- Enhanced reliability, diagnostics, and accelerated deployment powered by StorFusion technology
- Up to 1.3 million IOPS to fuel high performance in all-flash arrays and high-density virtualized environments
- Port isolation design that offers deterministic and scalable performance on each port

Learn more at www.qlogic.com/go/dell

About Samsung AutoCache v3.0

AutoCache is a host-based I/O caching solution designed to accelerate business-critical applications in physical and virtualized servers by using NVMe, PCIe, SAS or SATA SSDs as a local cache. It works with both virtual and physical operating systems and supports both write-back caching and read caching. AutoCache v3.0-V works with VMware ESXi 6.0U1 vSphere API for I/O Filtering (VAIO). AutoCache v3.0-V increases VM density and increases application performance while maximizing system resource usage and freeing up CPU cycles to support more business applications.

Learn more at www.samsung.com/semiconductor/support/tools-utilities/AutoCache/

About Dell EMC PowerEdge Express Flash NVMe Performance PCIe solid-state storage devices

Dell EMC PowerEdge Express Flash NVMe Performance PCIe solid-state storage devices aim to help companies break through I/O (input/output) bottlenecks for latency-sensitive applications. The technology is currently available for purchase on performance two-socket and four-socket PowerEdge server platforms, including the R630, R730xd, R920, R820, T630 and M820.

Learn more at www.dell.com/learn/us/en/04/campaigns/poweredge-express-flash

About Microsoft SQL Server 2016

According to Microsoft, “SQL Server 2016 is the biggest leap forward in Microsoft data platform history. Gain real time insights across your transactional and analytical data with a scalable database platform that has everything built in, from unparalleled in-memory performance, new security innovations and high availability, to advanced analytics that make mission-critical applications intelligent.”

Learn more at <https://www.microsoft.com/en-us/server-cloud/products/sql-server/>

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, to show what kind of performance you could expect for your customers. 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.

For more details about the DS2 tool, see www.delltechcenter.com/page/DVD+Store. To download DS2, go to <https://github.com/dvdstore>.

About SLOB 2.2

The Silly Little Oracle Benchmark (SLOB) can assess Oracle random physical I/O capability on a given platform in preparation for potential OLTP/ERP-style workloads by measuring IOPS capacity. The benchmark helps evaluate performance of server hardware and software, storage system hardware and firmware, and storage networking hardware and firmware.

SLOB contains simple PL/SQL and offers the ability to test the following:

- Oracle logical read (SGA buffer gets) scaling
- Physical random single-block reads (db file sequential read)
- Random single block writes (DBWR flushing capacity)

- Extreme REDO logging I/O

SLOB is free of application contention yet is an SGA-intensive benchmark. According to SLOB's creator Kevin Closson, SLOB can also offer more than testing IOPS capability such as studying host characteristics via NUMA and processor threading. For more information on SLOB, links to information on version 2.2, and links to download the benchmark, visit <https://kevinclosson.net/2012/02/06/introducing-slob-the-silly-little-oracle-benchmark/>

APPENDIX B – SYSTEM CONFIGURATION INFORMATION

Figure 4 provides detailed configuration information for the test systems. Figure 5 provides detailed configuration information for the storage array.

Server configuration information	Dell EMC PowerEdge FX2s FC630
BIOS name and version	Dell 2.2.5
Non-default BIOS settings	N/A
Operating system name and version/build number	VMware ESXi 6.0.0 build-4192238
Date of last OS updates/patches applied	11/23/16
Power management policy	Performance
Processor	
Number of processors	2
Vendor and model	Intel Xeon E5-2667 v4
Core count (per processor)	8
Core frequency (GHz)	3.20
Stepping	1
Memory module(s)	
Total memory in system (GB)	128
Number of memory modules	4
Vendor and model	Samsung M393A4K40BB1-CRC
Size (GB)	32
Type	PC4-19200
Speed (MHz)	2400
Speed running in the server (MHz)	2400
Storage controller	
Vendor and model	Dell EMC PERC H730 Mini
Cache size	1024MB
Firmware version	25.4.1.0004
Driver version	6.903.82.00
Local storage	
Number of drives	2
Drive vendor and model	Seagate® ST9300605SS
Drive size (GB)	300
Drive information (speed, interface, type)	10K, 6Gb SAS, HDD
Cache storage	
Number of drives	1
Drive vendor and model	Samsung SM1715
Drive size (GB)	3,200
Drive information (speed, interface, type)	NVMe PCIe SSD
Network adapter	
Vendor and model	QLogic QLE2692
Number and type of ports	2 x 16Gb FC

Server configuration information	Dell EMC PowerEdge FX2s FC630
Driver version	2.1.24.0
Enclosure	
Blade enclosure	PowerEdge FX2
Cooling fans	
Number of cooling fans	8
Power Supplies	
Vendor and model	Dell EMC 095HR5
Number of power supplies	2
Wattage of each (W)	1600

Figure 4: Detailed configuration information for the server under test.

	Dell EMC Storage SC9000
Vendor and model number	Dell EMC Storage SC9000
OS Version	Storage Center 6.7.5
Connection type	Fibre Channel 16Gb
Number of Fibre Channel cards	1 per controller (2 total)
Fibre Channel card model	QLogic QLE2662 16G Fibre Channel Adapter
Number of SAS cards	1 per controller (2 total)
SAS card model	SAS9300-8E 12G SAS Dual-Ext Port Adapter
Number of expansion enclosures	1
Expansion enclosure model number	SC420
Number of disks per shelf	24
Type of disk	SSD
Disk capacity	400 GB

Figure 5: Configuration information for the Dell EMC Storage SC9000 array.

APPENDIX C – HOW WE TESTED

Note: On November 23, 2016, 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 December 16, 2016.

Background

In our labs, we set up a mixed database workload environment, using a combination of Oracle Database 12c VMs and SQL Server 2016 VMs. We configured two Oracle Single Instance Database VMs per FC630 node, for a total of 12 VMs. We then ran SLOB locally on each VM against a 40GB database to produce a consistent I/O workload churn while we measured the impact on performance of the SQL VMs running DVD Store 2 both with and without caching enabled. See Appendix D for the SLOB configuration file we used to generate the background workload. The Slob VMs were sized as follows:

- 1 x 50GB VMDK for the OS
- 8 x 15GB VMDKs for Data
- 4 x 3GB VMDKs for Logs
- 2 x vCPUs
- 16GB of RAM

Installing VMware vSphere onto the servers

Before installing VMware vSphere, we set the System Profile to Performance on the servers. We installed the VMware vSphere 6.0 U2 hypervisor onto the servers' local hard drives, which we placed in a RAID1 pair.

1. Insert the VMware vSphere 6.0 U2 installation media into the optical drive.
2. Boot the server to the VMware vSphere installer.
3. Press F11 to begin the installation wizard.
4. Select the RAID1 pair as the installation location.
5. Select US English as the keyboard type and language.
6. Enter the root password for the host.
7. Press Enter to start the installation.
8. When the installation completes, press Enter to reboot the host.
9. At the home screen after the host reboots, press F2, and enter your credentials.
10. Select Configure Management Network.
11. Select IP Configuration.
12. Enter your static IP information, and press Enter.
13. Select DNS Configuration.
14. Enter a hostname, and press Enter.
15. Press Esc, and then type Y to restart the management network.

Deploying the VMware vCenter Server 6 Update 2

We used a client server running VMware ESXi to host our clients and virtualized management servers. For the VMware vCenter server VM, we installed Windows Server 2012 R2 and performed the following steps to install and configure vCenter.

1. Log into the vCenter VM.
2. From the VMware vCenter Server 6.0 install media, to start the install wizard, click Run.
3. Select vCenter Server, and click Install.
4. At the Install wizard welcome screen, click Next.
5. Agree to the License Agreement, and click Next.
6. Select the Embedded Deployment option, and click Next.
7. Enter the system IP address.
8. Enter and confirm the password you wish to use with the Administrator account for vCenter Single Sign On, and click Next.
9. Click Next.
10. Accept the default database settings, and click Next.
11. Accept the default https port, and click Next.
12. Accept the default installation path, and click Next.
13. Uncheck Join the VMware Customer Experience Improvement Program, and click Next.
14. Click Install.
15. To exit the wizard, click Finish.
16. On the installer, click Exit.
17. Restart the server.
18. Once completed, log into the first vCenter's web client at <https://vcenter-ip-address/vsphere-client/?csp>.
19. Add all the necessary ESXi and vCenter licenses to the vCenter.

Creating the cluster and adding the hosts to VMware vCenter

We used the following steps to create the FC630 cluster and add the desired servers and storage to the 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 a 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 PowerEdge FC630 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 8 through 15 for the remaining PowerEdge FC630 servers.
17. Once all the hosts are added to vCenter, use Update Manager to update the hosts.

Configuring the Fibre Channel networking

We used a Brocade 6505 16Gb Fibre Channel top-of-rack switch for the storage network. We left the switch ports at factory settings and created zones for traffic isolation.

Configuring zoning on the Brocade M6505 switch

1. In a web browser, connect to the Brocade M6505 switch, and log in as the admin user.
2. Click Configure→Zone Admin.
3. In the Zone tab, create the following zones:
 - a. All visible physical ports on the SC9000
 - b. All visible virtual ports on the SC9000
 - c. Server Port 1 and all four visible virtual ports
 - i. Repeat Step C for remaining server ports.
4. In the Zone Config tab, click New Zone Config, and give it a name.
5. Add the newly created Zones to the Zone Config.
6. Click Save Config.
7. Click Enable Config.
8. Repeat the zoning process for the legacy server, creating one zone for all Fibre Channel ports associated with the legacy environment.

Configuring the storage

After initial cabling and configuration of the Dell EMC Storage SC9000, we disabled the read and write cache and created a single large volume for the VMDKs. On the legacy storage, we created separate volumes for OS, Data, and Log VMDKs.

Creating a server cluster and connecting the volumes

1. In a web browser, connect to the Storage Center virtual IP address, and log in as the Admin user.
2. Click Storage Management→Servers→Create Server.
3. Select the four HBA WWNs that correspond to the Dell EMC PowerEdge FC630.
4. Give the server a name, and click Continue.
5. Click Storage Management→Servers→Create Server Cluster.
6. Click Add Existing Servers to Cluster.
7. Select all servers, and click Continue.
8. Click Storage Management→Volumes→Create Volume.
9. When prompted to specify a size for the volume, select Use All Space.
10. Click Storage Management→Volume→Map volume to server.
11. Select the volume, and click Continue.
12. Select the server cluster, and click Continue.

13. Using VMware vCenter, ensure that the volume is showing as connected to the server. Rebooting the servers and chassis may be necessary to propagate all changes.

Creating the VMs

We created one gold image VM for SQL using the following steps.

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 SC9000 LUN for the 70GB OS VMDK, and click Next.
7. Select the guest OS as Microsoft Windows Server 2016 (64-bit), and click Next.
8. In the Customize Hardware section, use the following settings:
 - Set the vCPU count to 4.
 - Set the Memory to 8GB, and check the Reserve all guest memory box.
 - Add 1 x 80GB VMDK for data and 1 x 25GB VMDKs for log. Set all VMDKs to thick provision eager zeroed.
 - Create two additional SCSI controllers, and assign the data VMDK to one and the log VMDK to the other.
 - Attach a Windows Server 2016 ISO to the CD/DVD drive.
9. Click Next.
10. Click Finish.
11. Power on the VMs, and follow the steps outlined in the next section to install and configure the workload.

Installing Windows Server 2016 onto the Dell EMC PowerEdge FC630 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.
12. Log in with the password you set up previously.

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. Click the checkbox to accept the license terms, and click Next.
6. Click Use Microsoft Update to check for updates, and click Next.
7. To install the setup support files, click Install.
8. If there are no failures displayed, click Next.
9. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
10. 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.
11. Click Next.
12. At the Instance configuration screen, leave the default selection of default instance, and click Next.
13. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
14. Enter and confirm a password for the system administrator account.
15. Click Add Current user. This may take several seconds.
16. Click Next.
17. At the Error and usage reporting screen, click Next.
18. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click
19. At the Ready to Install screen, click Install.
20. Close the installation window.

Installing Samsung AutoCache 3.0 for VMware

1. Unzip the release package (Autocache_VMware_3.0.0.zip) and place the files on a workstation capable of accessing the vSphere web client.
2. Place the AutoCache Web Client .zip archive (AC300VMW_autocachewebclient.zip) and the AutoCache Offline Bundle (AC300VMW_smgac-offline-bundle.zip) on a web server that the installation machine and the vCenter Server can both access. For our testing, we used a Windows virtual machine to host the .zip archive via HTTPS.
3. Unzip the Installer file (AC300VMW_WebClientInstaller.zip), and run AC300VMW_WebClientInstaller.exe.
4. From the Web Client Installer prompt, enter the IP address, username, and password for the vCenter Server. Click Next.
5. At the Download Selection screen, enter the URL for the AutoCache Web Client .zip archive (AC300VMW_autocachewebclient.zip). Click Next.
6. Review the installation settings, and click Next.

7. When setup completes, click Exit.
8. Log into the vCenter Web Client and the installation process will automatically complete. The status of the installation can be viewed from the vCenter event log. Verify that the AutoCache plugin appears on the vCenter home page under the Administration section.
9. From the vCenter Web Client home page, click AutoCache, and click on the Licensing tab.
10. Click the + icon to add a new license. Enter the activation key, click OK, and then close the dialog.
11. Next, the AutoCache filter must be installed on the cluster. Before the AutoCache filter is installed, the vCenter Host Acceptance Level must be configured at VMware Accepted or lower. To change the Host Acceptance Level:
 - a. Select each host, and navigate to the Settings subtab under Manage.
 - b. Under System, click Security Profile.
 - c. Select Host Image Profile Acceptance Level, and click Edit.
 - d. Click the pull-down menu, and change the Acceptance Level to VMware Accepted.
 - e. Repeat for each host in the cluster.
12. From the vCenter Web Client, click the Hosts and Clusters tab. Click the Manage tab, and navigate to the AutoCache subtab.
13. Enter the URL for the AutoCache Offline Bundle (AC300VMW_smgac-offline-bundle.zip) and click Install. The process of the installation will be shown in the screen. AutoCache installation is complete once the filter is successfully installed.

Configuring Samsung AutoCache 3.0 for VMware

1. For each host in the cluster, you must configure a cache partition. From the vCenter Web Client, select the first host, and place it in Maintenance Mode.
2. From the Manage tab, click the AutoCache subtab.
3. From the Cache Partition Configuration screen, select the PCIe device that will be used as a cache partition.
4. Set the cache partition size to the maximum value, and click Create Partition.
5. When partition creation completes, click Edit Configuration.
6. Select Main next to the device ID, and change the write cache percentage to 25.
7. Repeat for each host.
8. After the cache partitions are configured, a storage policy must be set for AutoCache. Navigate to the vCenter Web Client home page, and click VM Storage Policies under Monitoring.
9. Click the Create New Storage Policy Based Management icon, and enter a name for the policy (AutoCache read & write). Click Next.
10. Read the Rule-Sets description, and click Next.
11. Check Use common rules in the VM storage policy.
The <Add rule> pull-down menu appears.
12. Click <Add rule> and select Cache.
13. From the Cache pull-down, select AutoCache 3.0 for VMware.

14. Ensure Read caching and Write caching are enabled. For our testing, we changed the Write cache size in MB to the maximum value (40,960), and left the default values for DRAM read cache size, and Fast warm.
15. When the Common rules definitions are complete, click OK.
16. From the Rule-Set 1 screen, uncheck Use rule-sets in the storage policy. Click Next.
17. The Storage compatibility screen will automatically check compatibility. When the check is complete, click Next.
18. Review the information on the Ready to complete screen, and click Finish.
19. Once the storage policy is created, the policy must be applied to the VMDKs under test. From the vCenter Web Client home page, navigate to Hosts and Clusters, select the cluster, and select Related Objects to see a list of virtual machines on the cluster.
20. For each virtual machine to use AutoCache, right click the virtual machine, and click Edit Settings. Expand the drop-down for the Hard disk to be cached, and change the VM storage policy to the newly created AutoCache policy. Click OK to save the settings, and repeat for each virtual machine.

Configuring 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 40GB database size and the Microsoft SQL Server 2016 platform. We ran the Install.pl script on a utility system running Linux®. The Install.pl script also 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 2016. We built the 40GB database in SQL Server 2016, 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. 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. Generate the data and create the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our 40GB database and 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 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. Create 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 (T-SQL) 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 mapped 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 relatively quickly between tests.

Figure 6 shows our initial file size modifications.

Logical name	Filegroup	Initial size (MB)
Database files		
primary	PRIMARY	5
cust1	DS_CUST_FG	6,000
cust2	DS_CUST_FG	6,000
cust3	DS_CUST_FG	6,000
cust4	DS_CUST_FG	6,000
ind1	DS_IND_FG	5,665
ind2	DS_IND_FG	5,665
ind3	DS_IND_FG	5,665
ind4	DS_IND_FG	5,665
ds_misc	DS_MISC_FG	200
orders1	DS_ORDERS	3,000
orders2	DS_ORDERS	3,000
orders3	DS_ORDERS	3,000
orders4	DS_ORDERS	3,000
Log files		
ds_log	Not applicable	24,781

Figure 6: Our initial file size modifications.

Configuring the database workload client

For our testing, we used a virtual client for the Microsoft SQL Server client. To create this client, we installed Windows Server 2008 R2, assigned a static IP address, and installed .NET 3.5.

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 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 and the client system.
7. Let the test server idle for 10 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=90  
--n_threads=32 --db_size=40GB --think_time=0 --detailed_view=Y --  
warmup_time=30 --report_rate=1 --csv_output=<drive path>
```

APPENDIX D – SLOB CONFIGURATION FILE

```
UPDATE_PCT=25
RUN_TIME=10800
WORK_LOOP=0
SCALE=300M
WORK_UNIT=16
REDO_STRESS=LITE
LOAD_PARALLEL_DEGREE=16
THREADS_PER_SCHEMA=1

# Settings for SQL*Net connectivity:
#ADMIN_SQLNET_SERVICE=slob
#SQLNET_SERVICE_BASE=slob
#SQLNET_SERVICE_MAX=2
#SYSDBA_PASSWD=change_on_install

#####
#### Advanced settings:
#
# The following are Hot Spot related parameters.
# By default Hot Spot functionality is disabled (DO_HOTSPOT=FALSE).
#
DO_HOTSPOT=FALSE
HOTSPOT_MB=8
HOTSPOT_OFFSET_MB=16
HOTSPOT_FREQUENCY=3

#
# The following controls operations on Hot Schema
# Default Value: 0. Default setting disables Hot Schema
#
HOT_SCHEMA_FREQUENCY=0

# The following parameters control think time between SLOB
# operations (SQL Executions).
# Setting the frequency to 0 disables think time.
#
THINK_TM_FREQUENCY=1
THINK_TM_MIN=0.25
THINK_TM_MAX=0.25
#####

export UPDATE_PCT RUN_TIME WORK_LOOP SCALE WORK_UNIT LOAD_PARALLEL_DEGREE
REDO_STRESS
export DO_HOTSPOT HOTSPOT_MB HOTSPOT_OFFSET_MB HOTSPOT_FREQUENCY
HOT_SCHEMA_FREQUENCY THINK_TM_FREQUENCY THINK_TM_MIN THINK_TM_MAX
```

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