Dell EMC™ PowerEdge™ MX platform
powered by Intel® Xeon® Scalable processors*

up to **625,000** more orders per minute**

up to **40%** more virtual machines**

up to **55.9%** lower storage latency**

Ensure greater uptime and boost VMware vSAN cluster performance with the Dell EMC PowerEdge MX platform

The Dell EMC PowerEdge MX with VMware vSAN Ready Nodes delivered a 55.9% faster response time than a Cisco UCS solution and a 41.3% faster response time than an HPE Synergy solution

Improving the performance of traditional applications with emerging technologies can help your organization achieve many goals, from growing your revenue to expanding your customer base. The new Dell EMC PowerEdge MX modular solution powered by Intel Xeon Scalable processors offers an innovative, flexible architecture that allows your organization to create sizable VMware vSAN™ software-defined storage (SDS) environments that can boost performance of traditional applications. These environments can also dynamically scale and respond to your changing operational needs now and in the future.

The Dell EMC PowerEdge MX loosens the bounds of traditional infrastructure by leveraging shared pools of compute, storage, and networking assets to create consumable resources on demand, which can allow organizations to adapt to changing workload demands and get better performance from applications.

Our Dell EMC PowerEdge MX solution was a vSAN Ready Node configuration with all NVMe drives for both cache and capacity tiers.[1] The unique all-NVMe design and greater drive count of the platform contributed to the advantages we saw in our testing. Due to this unique storage layout, the powerful, robust Dell EMC PowerEdge MX solution with vSAN in our data center at Principled Technologies supported more virtual environments and offered better database application performance than HPE Synergy and Cisco UCS® vSAN ReadyNode™ solutions.

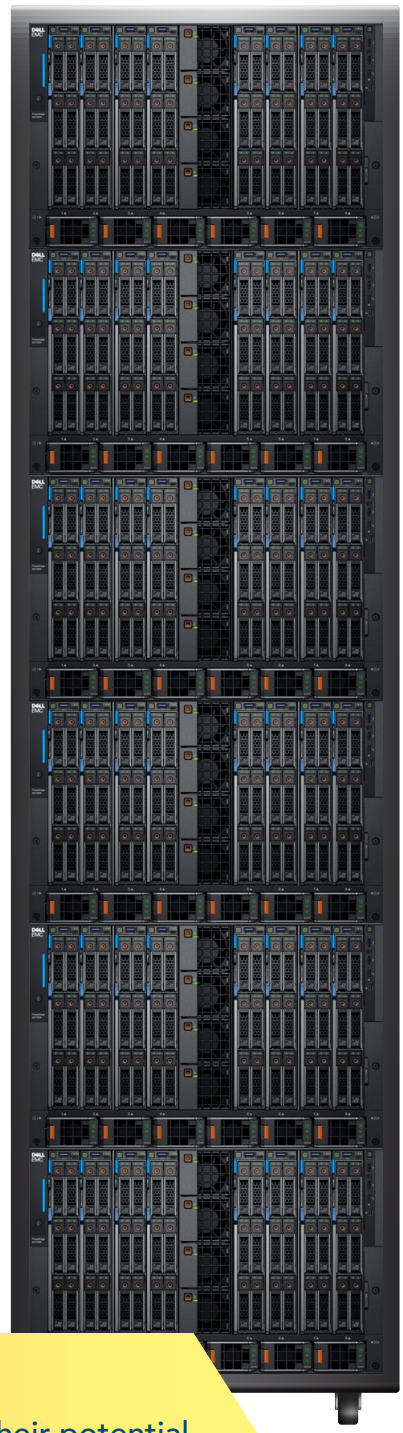
*Image provided by Dell EMC.
**vs. two competing hyper-converged solutions.

Exploring the unique design of the Dell EMC PowerEdge MX

Organizations deploying vSAN can bring storage and compute resources closer together to simplify hardware management and storage provisioning. The Dell EMC PowerEdge MX does this with the two-socket, single-width, six-drive Dell EMC PowerEdge MX740c compute sled. Using the Dell EMC PowerEdge MX, we were able to build a higher performing vSAN cluster because it supports more high-performing modular infrastructure components than the HPE Synergy and Cisco UCS solutions.

Many organizations can take advantage of the innovative Dell PowerEdge MX platform to create vSAN environments large enough to host all their applications and workloads. To illustrate the potential resource availability of a kinetic solution, a standard 19-inch, 42U rack of MX7000 chassis can support any of the following configurations:

- Up to 48 two-socket Dell EMC PowerEdge MX740c compute sleds with up to 96 Intel Xeon Scalable processors and 2,688 cores; options for storage include up to 288 2.5-inch SAS, SATA, or Non-Volatile Memory Express (NVMe) drives
- Up to 24 four-socket Dell EMC PowerEdge MX840c compute sleds with up to 96 Intel Xeon Scalable processors and 2,688 cores; options for storage include up to 192 2.5-inch SAS, SATA, or NVMe drives
- Up to 42 single-width Dell EMC PowerEdge MX5016s storage sleds with up to 672 2.5-inch, dual-port 12Gb SAS hot-pluggable drives and hot serviceable expanders for availability; IT administrators can map the drives individually to one or more servers and can choose PERC or HBA storage controller options to best fit workloads; each Dell EMC PowerEdge MX7000 full of Dell EMC PowerEdge MX5016s sleds requires one single-width compute sled



Kinetic infrastructure: Helping organizations realize their potential

According to Dell EMC, kinetic infrastructure delivers the benefits of a modular data center solution while leveraging configuration flexibility at the storage-drive level. In the future, this flexibility could extend to memory-centric devices. Kinetic infrastructure can put the power to assign the right resources for the right workload in the hands of IT administrators and decision-makers.[2] The PowerEdge MX can contribute to a data center's kinetic infrastructure and help achieve the goal of full data center resource composability.

Get more infrastructure flexibility with the Dell EMC PowerEdge MX

The Dell EMC PowerEdge MX solution offers two ways for your organization to more effectively protect data and maintain better uptime than HPE Synergy and Cisco UCS:

- First, the Dell EMC PowerEdge MX solution we tested offered **greater flexibility** than the competition. We loaded our MX7000 with Dell EMC PowerEdge MX740c compute sleds, but you can configure the compute, storage, and networking components of your Dell EMC PowerEdge MX7000 based on your own current infrastructure needs and change components when necessary. More flexibility for compute and storage components could, for example, allow your IT administrators to build more resilient all-NVMe-based vSAN clusters with multiple disk groups per server. More vSAN disk groups means **greater redundancy for improved data protection and better performance**.
- Second, each Dell EMC PowerEdge MX740c compute sled can **support up to six NVMe drives** while each HPE and Cisco compute node can support only two. Considering each solution ran a four-sled or node vSAN cluster, the Dell EMC PowerEdge MX solution could have larger storage capacity in the same amount of rack space. With the competing solutions, IT administrators would need to attach more compute nodes or a storage node (as we did in our Synergy tests) to match the number of drives in the Dell EMC PowerEdge MX solution. Increased complexity means more IT administrator labor that your company could better spend elsewhere.

Another benefit of the Dell EMC PowerEdge MX solution is that it allows the use of NVMe SSDs, while the HPE Synergy solution can use only SAS drives when using a Synergy storage node. NVMe SSDs offer design advantages that can speed database operations and reduce input/output (I/O) overhead compared to hard disk drives as well as SAS and SATA SSDs.

Dell EMC PowerEdge MX platform powered by
Intel Xeon Scalable processors*

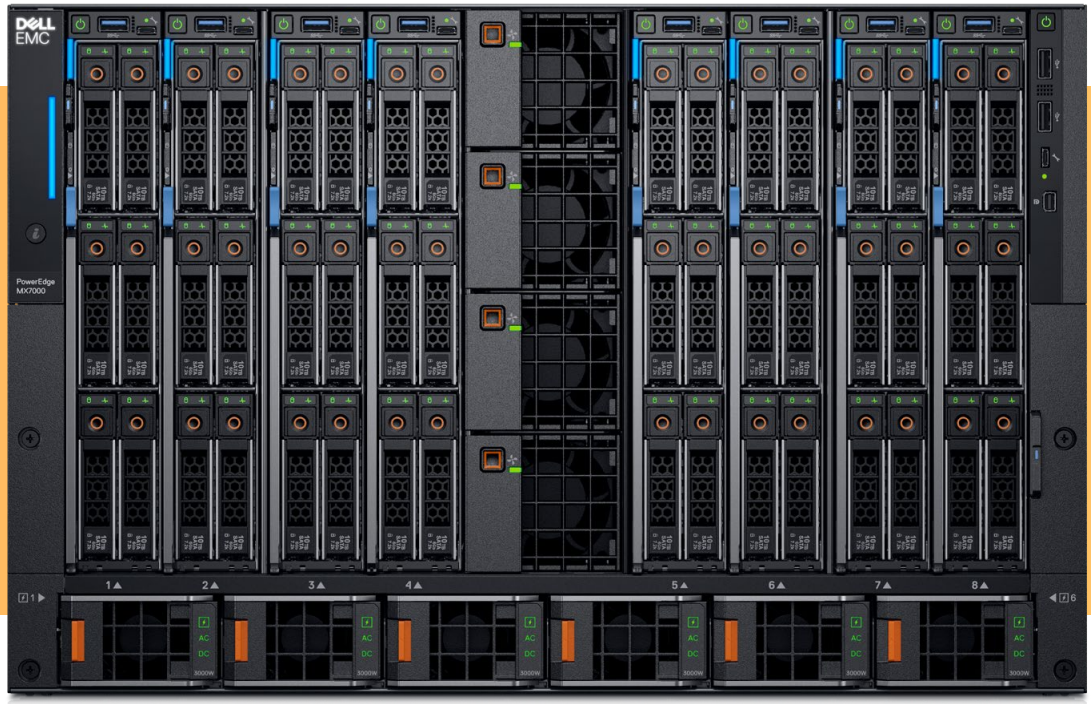


*Image provided by Dell EMC.

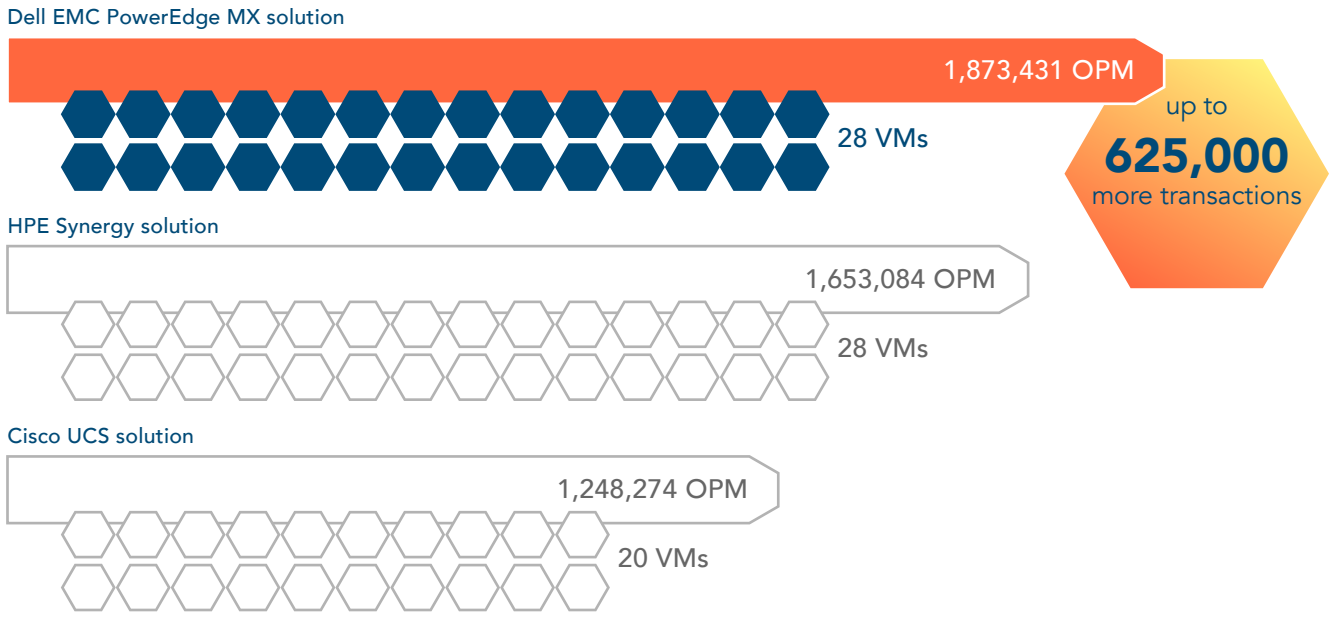
Maximize vSAN environments with more VMs

The modular Dell EMC PowerEdge MX allows organizations to assign the right resources for the right workload and to change dynamically with business needs. This means maximizing vSAN environments that can scale and support better database performance.

The Dell EMC PowerEdge MX solution supported 28 VMs running online transaction processing (OLTP) workloads, while the competing HPE Synergy and Cisco UCS ReadyNode solutions supported 28 and 20 VMs, respectively. Scaling to more than 28 VMs on the Synergy solution and 20 VMs on the Cisco UCS solution caused storage latency levels to further exceed the critical storage latency vSAN threshold of 30 milliseconds under heavy workloads.

As each workload instance contributes to the total orders per minute (OPM) a solution can handle, being able to support more workloads can lead to better productivity and more application usage. The chart below shows the number of VMs each solution supported in addition to total OPM.

SQL Server transactions and VM count (higher is better)



Handle more transactions for Microsoft SQL Server 2016 databases

Retail, finance, and insurance organizations, among others, can all benefit from choosing a solution that handles more database transactions. An increase in database transactions indicates that a higher number of users can place orders, browse your catalog, and more, which can ultimately increase your revenue. The new Dell EMC PowerEdge MX solution achieved over 1.8 million OPM and outperformed the HPE Synergy and Cisco UCS solutions by 220,347 and 625,157 OPM respectively. With the Dell EMC PowerEdge MX solution, more users can search, view, or update data faster. If your organization runs e-commerce and other transactional database applications, better performance can lead to more sales and more happy customers.

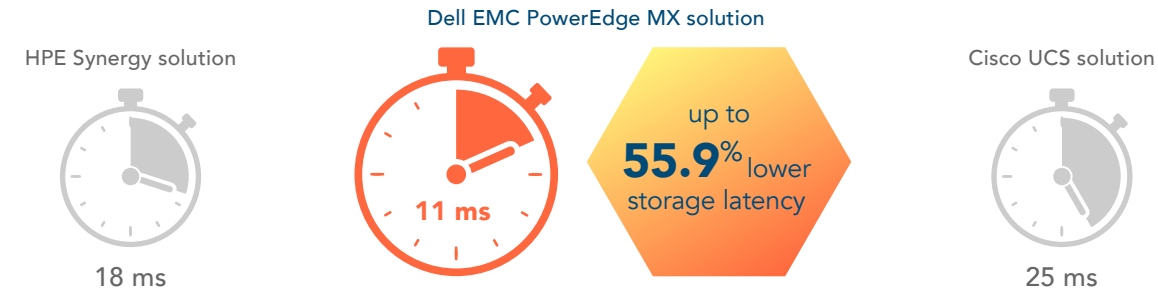
Fast computing with Intel Xeon Scalable processors

Intel Xeon Scalable processors are the latest generation of server processors from Intel, which comprises four feature configurations designed for various workloads: Platinum, Gold, Silver, and Bronze. In our tests with the PowerEdge MX solution, the Dell EMC PowerEdge MX740c nodes used Intel Xeon Platinum 8164 processors. The Intel Xeon Platinum 8164 processor contains 26 cores running at 2.00 GHz frequency, with a Max Turbo frequency of 3.70 GHz. To learn more about Intel Xeon Scalable processors, visit the Intel website.

Boost application response times

When webpages and applications take too long to load, you can lose customers—and revenue. The Dell EMC PowerEdge MX solution offered 41.3 percent shorter average response times than the HPE solution and 55.9 percent shorter average response times than the Cisco solution. Saving even fractions of a second on large-scale operations can help increase the volume of e-commerce orders and generate more revenue.

Average latency in milliseconds (lower is better)



What is vSAN?

VMware vSAN makes storage a virtual resource for your applications, reducing the need for external storage arrays. Embedded in the hypervisor of VMware Hyper-Converged Software solutions, vSAN clusters server-attached flash devices and hard disks to create a shared datastore. For more information, visit the VMware vSAN website.

According to Dell EMC, "Dell EMC vSAN Ready Nodes [like the ones we used in testing] have been pre-configured, tested, and certified to run VMware vSAN."[3] Learn more about Dell EMC vSAN Ready Nodes here.

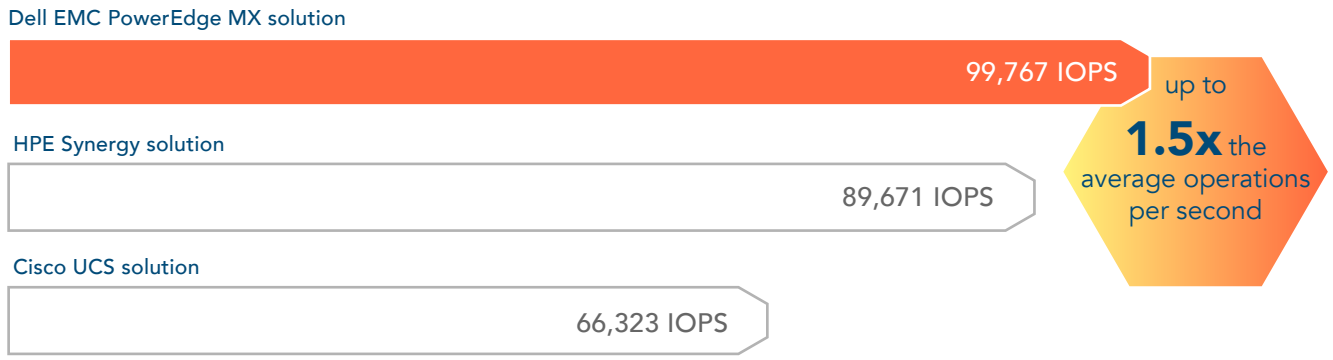
Help protect vSAN clusters with fault domains

For vSAN clusters than span multiple Dell EMC PowerEdge MX7000 chassis or racks of chassis, you can create fault domains to help protect against rack or chassis failure. Such failures can cause vSAN clusters to lose necessary data center resources. According to VMware, "A fault domain consists of one or more vSAN hosts grouped according to their physical location in the data center. When configured, fault domains enable vSAN to tolerate failures of entire physical racks as well as failures of a single host, capacity device, network link, or a network switch dedicated to a fault domain." To learn more about fault domains for vSAN, visit this VMware page in the documentation for VMware vSphere® 6.5.

Manage larger workloads

While running our OLTP workload, we gathered input/output operations per second (IOPS) data for each solution. IOPS show the number of interactions the storage can support when users access its databases, so more IOPS can indicate the ability to handle larger and heavier workloads. Solutions that support more IOPS can, for example, help users make purchases more quickly, view more items from a catalog, or receive more order confirmations in a given period. The Dell EMC PowerEdge MX solution supported 1.1 times the IOPS of the HPE solution and 1.5 times the IOPS of the Cisco solution. This not only demonstrates that the system can move more data, it also indicates a higher threshold of activity without storage bottlenecks, which slow applications and cause users to wait.

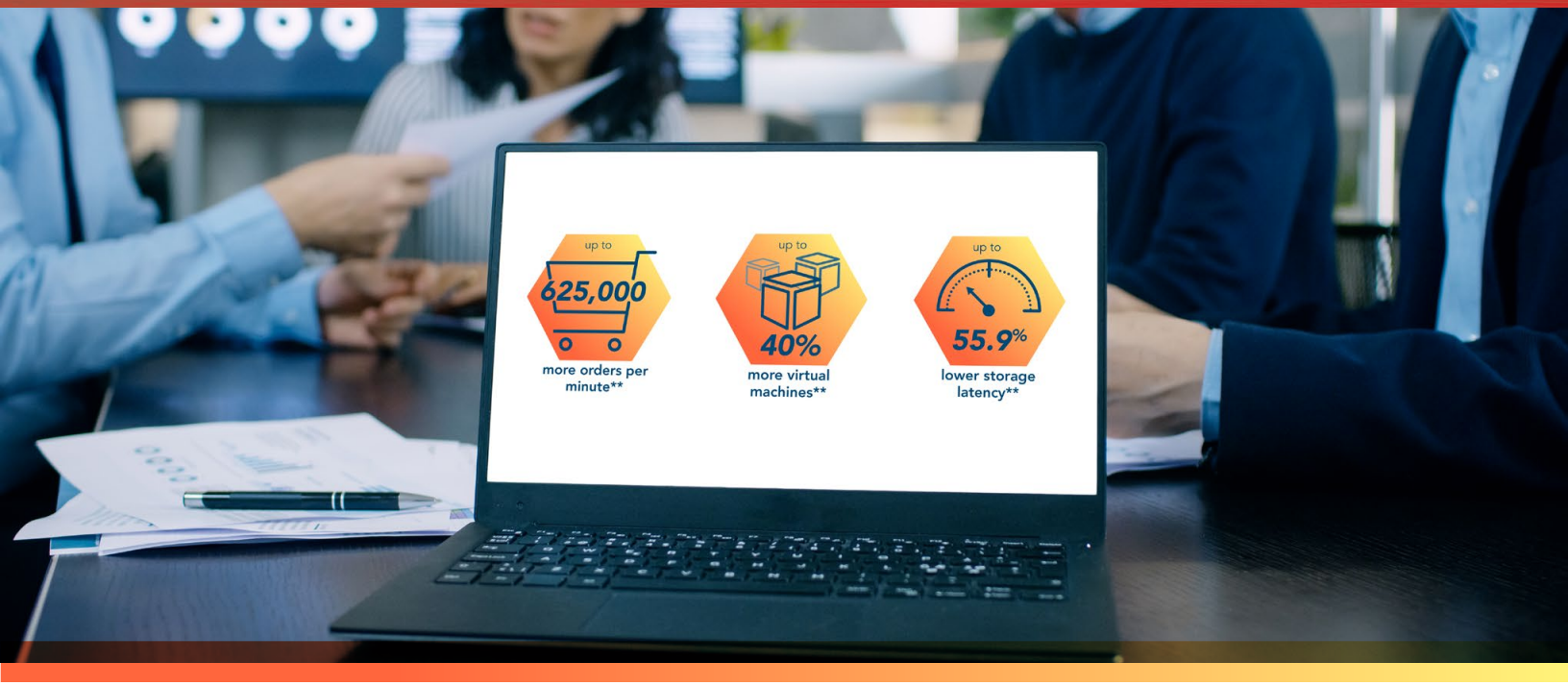
Average IOPS (higher is better)



Our test tool: DVD Store 2

To create a real-world database workload, we used DVD Store Version 2.1 (DS2). DS2 models an online store where customers log in, search for products, and make purchases. It reports these actions by showing how many orders per minute the system can handle, which in turn demonstrates the kind of performance you could expect for your customers. DS2 also performs other actions, such as adding new customers, to exercise the wide range of database functions you might need.

To download DS2, see https://github.com/dvdstore.



Conclusion

If you want better database performance and data center flexibility to meet future demand, the new, innovative Dell EMC PowerEdge MX powered by Intel Xeon Scalable processors offers distinct architectural advantages that can allow your organization to build high-performing, robust VMware vSAN environments. In our tests, the Dell EMC PowerEdge MX solution with Dell EMC vSAN Ready Nodes beat HPE Synergy and Cisco UCS ReadyNode solutions by supporting more VMs and handling more database transactions. In addition, the Dell EMC PowerEdge MX solution accelerated response times for workloads and supported more IOPS, demonstrating that the solution can better handle high-volume workloads. The Dell EMC PowerEdge MX solution gained this performance advantage because it used only NVMe drives and supported more drives overall than the competition. By doing more work, the flexible Dell EMC PowerEdge MX modular platform for vSAN environments can help you grow your user base and ultimately help your organization's bottom line.

1 The configuration we used differed in CPU, NIC, and storage from the vSAN ReadyNode configuration on the VMware vSAN compatibility guide as of 10/30/2018. We used Intel Xeon 8164 processors, Intel Ethernet 25G 2P XXV710, and 1.6TB and 3.2TB PM1725a SSDs. The vSAN ReadyNode configuration for the PowerEdge MX740C specifies Intel Xeon 5118 processors, QLogic 41232 Dual Port 25GbE, and PM1725a SSDs (800GB capacity). We upgraded as allowed based on this article: Bhattacharjee, Biswapati, "What You Can (and Cannot) Change in a vSAN ReadyNode™," accessed October 29, 2018, https://blogs.vmware.com/virtualblocks/2017/03/14/can-cannot-change-vsan-readynode/

2 Hormuth, Robert, "Kinetic Infrastructure is the Path to Full Composability," accessed July 27, 2018, https://blog.dellemc.com/en-us/making-composability-kinetic/

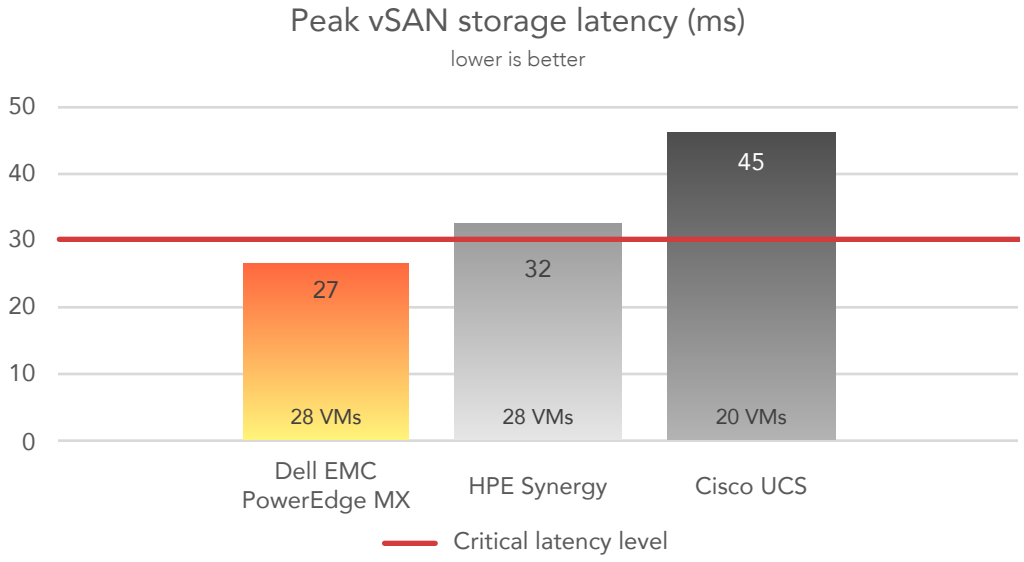
3 "Dell EMC vSAN Ready Nodes," accessed October 26, 2018, https://www.dell.com/en-us/work/shop/povw/virtual-san-ready-nodes?dgc=SRVR&cid=emcprd&lid=PowerEdge

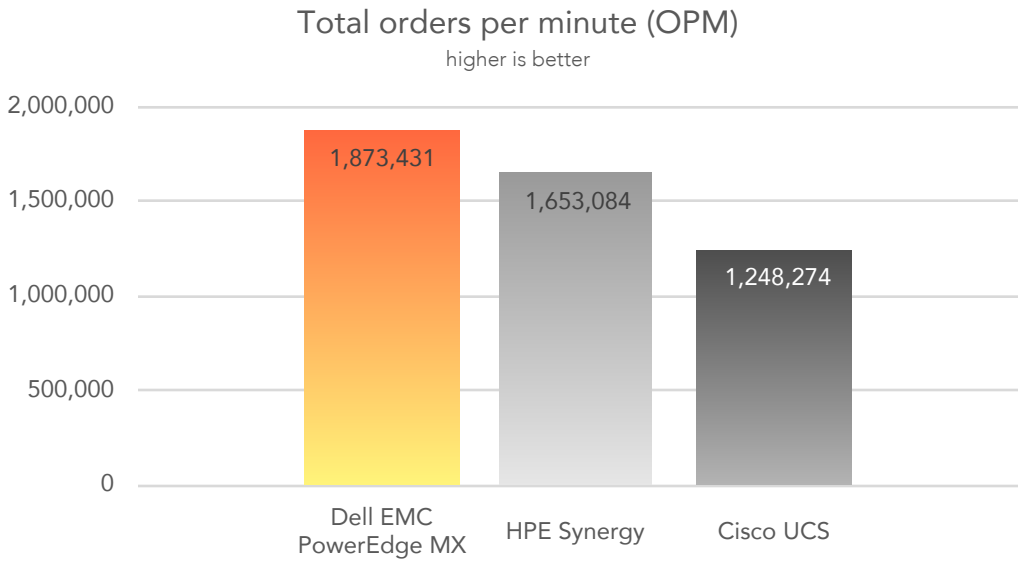
To find out more about Dell EMC PowerEdge MX, visit https://www.dellemc.com/en-us/servers/modular-infrastructure.htm

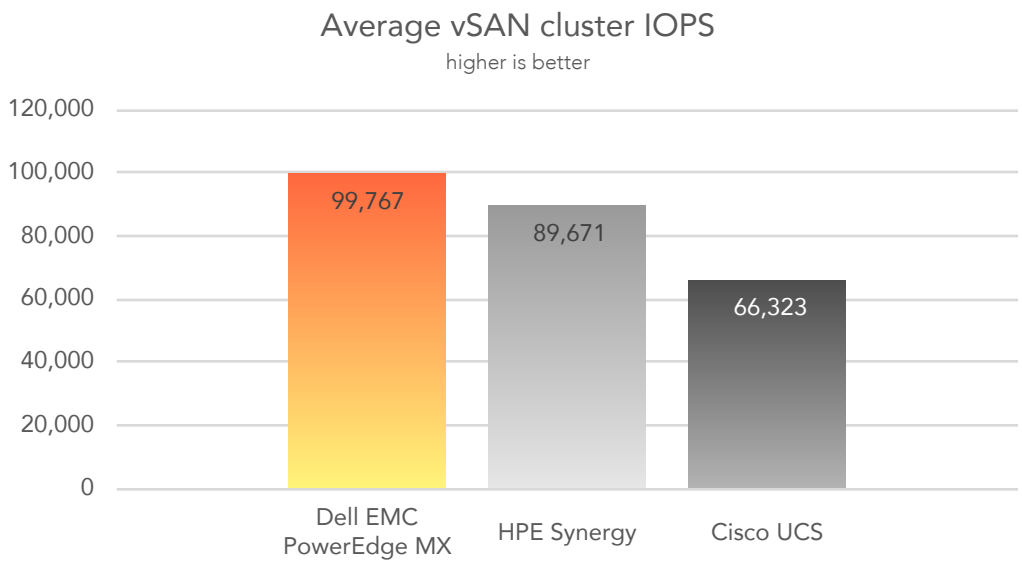
On August 20, 2018, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on September 10, 2018.

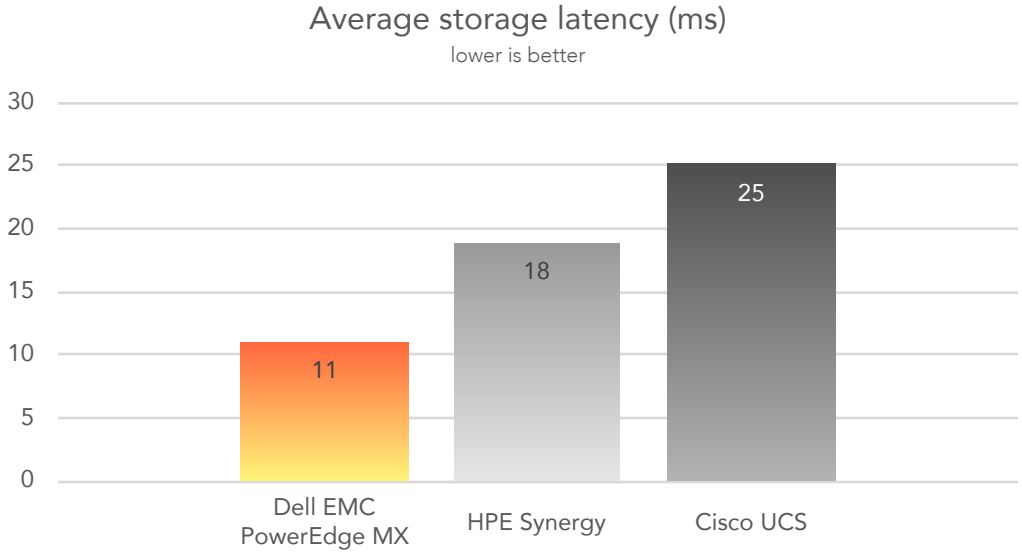
Our results

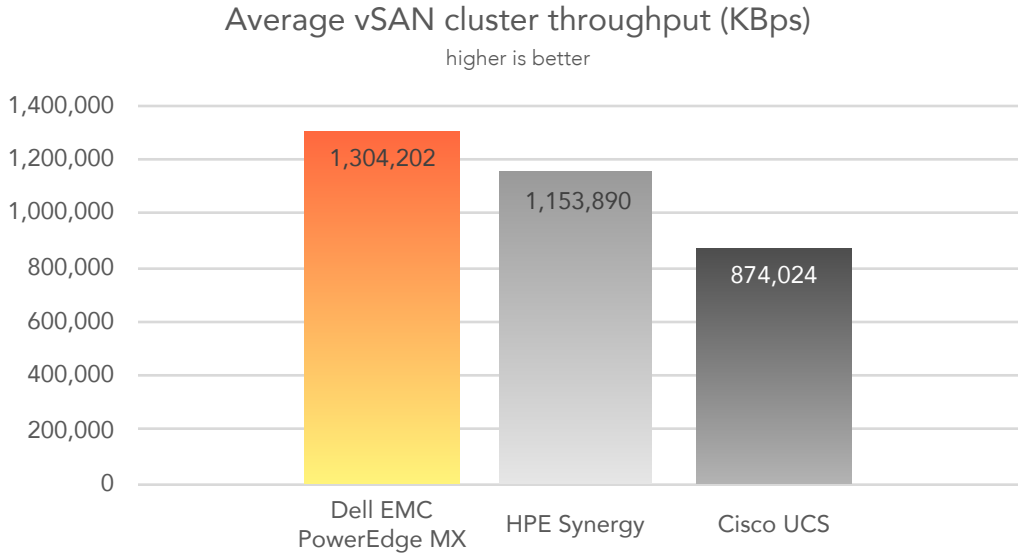
The graphs below present our findings in detail.






Average vSAN cluster IOPS
higher is better
120,000
100,000
80,000
60,000
40,000
20,000
0
99,767
89,671
66,323
Dell EMC PowerEdge MX
HPE Synergy
Cisco UCS


Average storage latency (ms)
lower is better
30
25
20
15
10
5
0
11
18
25
Dell EMC PowerEdge MX
HPE Synergy
Cisco UCS


Average vSAN cluster throughput (KBps)
higher is better
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1,304,202
1,153,890
874,024
Dell EMC PowerEdge MX
HPE Synergy
Cisco UCS

System configuration information

The tables below present detailed information on the systems we tested.

Server enclosure configuration information	Dell EMC PowerEdge MX7000	Cisco UCS 5108	HPE Synergy Chassis
Power supplies			
Number of power supplies	6	4	6
Vendor and model number	Dell EMC	Cisco Systems Inc N20-PAC5-2500W	HPE 2650W AC Titanium Hot Plug Power Supply
Wattage of each (W)	3,000	2,500	2,650
Cooling fans			
Total number of fan modules	9	8	10
Vendor and model number	Dell EMC	Cisco Systems Inc N20-FAN5	HPE Synergy Fan Module
I/O modules			
Model	Dell EMC MX7116n Fabric Expander Module, MX9116n Fabric Engine	Cisco UCS 2304	HPE Synergy Frame Link Module
Occupied bays	1, 2	1, 2	1, 2

Server configuration information	Dell EMC PowerEdge MX740c	Cisco UCS B200 M5	HPE Synergy 480c Gen10
BIOS name and version	Dell 0.4.3	Cisco B200M5.3.2.3c.0.0307181316	HPE I42 v1.36
Operating system name and version/build number	VMware ESXi™ 6.7.0 (build 9484548)	VMware ESXi 6.7.0 (build 9484548)	VMware ESXi 6.7.0 (build 9484548)
Date of last OS updates/patches applied	8/20/18	8/20/18	8/20/18
Power management policy	Performance	Performance	Performance
Processor			
Number of processors	2	2	2
Vendor and model	Intel Xeon Platinum 8164	Intel Xeon Platinum 8164	Intel Xeon Platinum 8164
Core count (per processor)	26	26	26
Core frequency (GHz)	2.0	2.0	2.0
Stepping	H0	H0	H0
Memory module(s)			
Total memory in system (GB)	384	384	384
Number of memory modules	12	12	24
Vendor and model	Hynix HMA84GR7AFR4N-VK	UCS-MR-X32G2RS-H	HPE SmartMemory 840757-091
Size (GB)	32	32	16
Type	DDR4-2666V 2Rx4	DDR4-2666	DDR4-2666
Speed (MHz)	2,666	2,666	2,666

Server configuration information	Dell EMC PowerEdge MX740c	Cisco UCS B200 M5	HPE Synergy 480c Gen10
Speed running in the server (MHz)	2,666	2,666	2,666
Storage controller			
Vendor and model	Dell PERC H730P MX	Cisco UCSB-LSTOR-PT	HPE Smart Array P416ie-m SR G10
Network adapter			
Vendor and model	Intel Ethernet 25G 2P XXV710 Mezz	Cisco UCS VIC 1340	Synergy 3820C 10/20 Gb CNA

The table below provides information about our vSAN clusters.

VMware vSAN cluster information	Dell EMC vSAN cluster	Cisco UCS ReadyNode	HPE Synergy 480c Gen10
Number of servers in the cluster	4	4	4
Number of vSAN disk groups per cluster	8	4	8
Cache drives			
Number of drives per cluster	8	4	8
Drive vendor and model	Dell P/N 0JDMHM (MZWLL3T2HMJP)	HGST HUSMR7680BDP301	HGST HUSMM3280ASS20
Drive size (GB)	3,200	800	800
Drive information (interface, type)	NVMe SSD	NVMe SSD	SAS 12Gb/s
Capacity drives			
Number of drives per cluster	16	4	16
Drive vendor and model	Dell P/N JD6CH (MZWLL1T6HEHP)	HGST HUSMR76832BDP301	HGST HUSMR3280ASS20
Drive size (GB)	1,600	3,200	800
Drive information (interface, type)	NVMe SSD	NVMe SSD	SAS 12Gb/s
vSAN configuration details			
vSAN storage policy	Default vSAN policy	Default vSAN policy	Default vSAN policy

How we tested

Setting up the testbeds

The following sections detail the hardware configurations of each solution. For all solutions, we configured BIOS for maximum performance and ensured that the following settings were identical (if available) on all the servers under test:

BIOS attribute	Status
Node Interleaving	Disabled
Virtualization Technology	Enabled
Sub NUMA Cluster	Enabled
Hardware Prefetcher	Enabled
DCU Streamer Prefetcher	Enabled
DCU IP Prefetcher	Enabled
CPU Power Management	Maximum Performance
Memory Frequency	Maximum Performance
C1E	Disabled
C States	Disabled
Memory Patrol Scrub	Disabled
Adjacent Cache Line Prefetch	Enabled
Memory Refresh Rate	1x
Uncore Frequency	Maximum
Energy Efficient Policy	Performance
x2APIC Mode	Enabled
Intel NIC DMA Channels (IOAT) / IOAT DMA Engine	Enabled
SR-IOV	Enabled

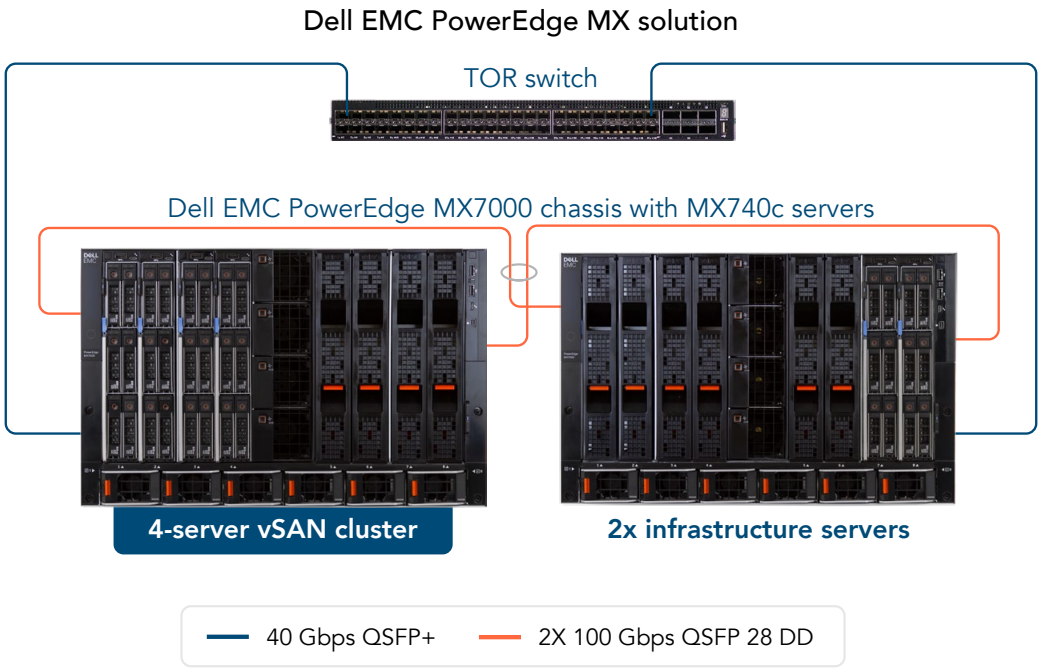
We also installed VMware ESXI 6.7 on compute nodes and configured two NICs for management as well as private VM, VMware vMotion, and VMware vSAN traffic. We enabled MTU 9000 and ensured functionality by running the vmkping command between all hosts.

Setting up the Dell EMC PowerEdge MX solution testbed

We set up two Dell EMC PowerEdge MX7000 chassis as follows:

- For one, we installed a Dell EMC MX9116n Fabric Engine in slot A1 and a Dell EMC MX7116n Fabric Expander Module in slot A2. We also installed four Dell EMC PowerEdge MX740c compute nodes to be used as servers under test that host Microsoft SQL Server VMs.
- For the other, we installed a MX7116n Fabric Expander Module in slot A1 and a MX9116n Fabric Engine in slot A2. We also installed two MX740c compute nodes to be used as infrastructure servers that host a VMware vCenter® server and DVD Store load-generating VMs.

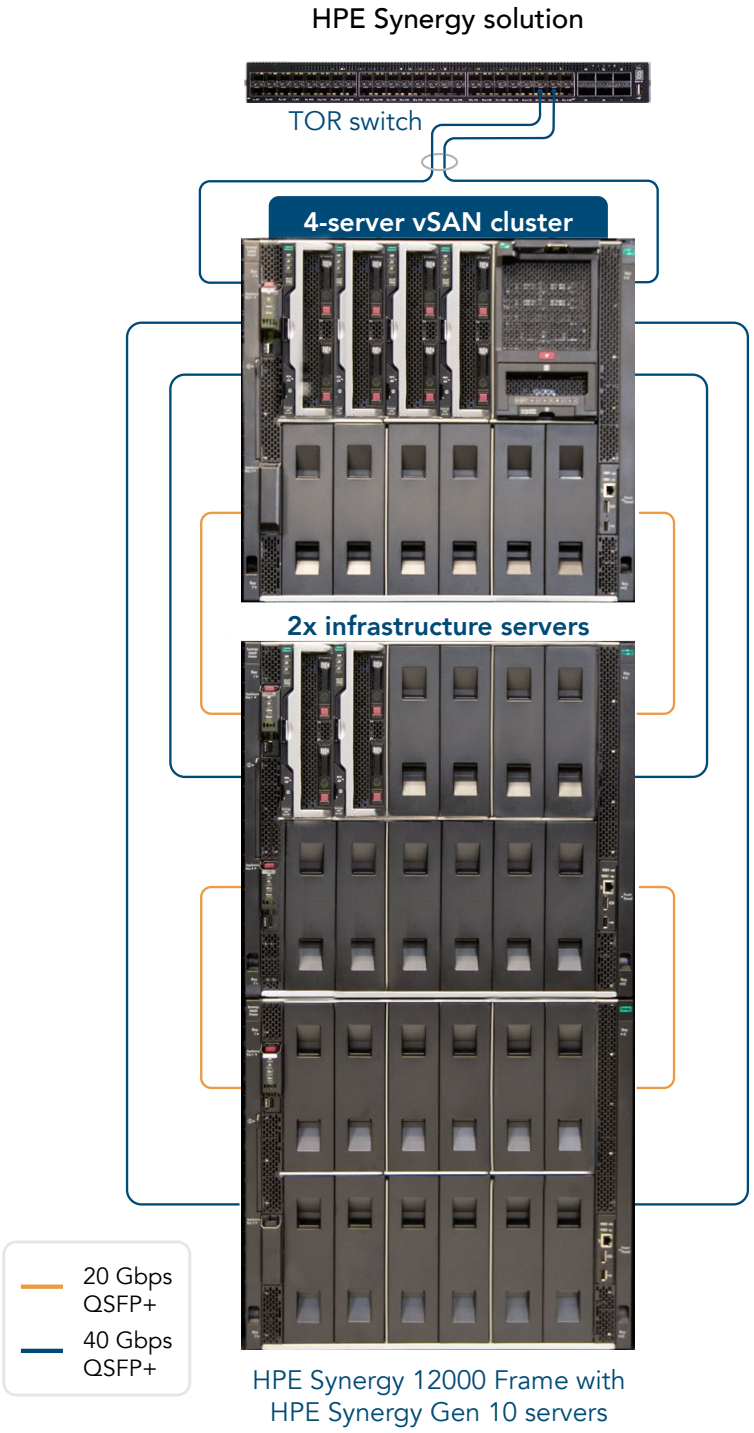
We connected the two chassis via QSFP28DD cables and connected a top-of-rack (ToR) switch to each chassis via two 40 Gbps QSPF+ connections. The diagram below shows the Dell EMC solution configuration.



Setting up the HPE Synergy solution testbed

We contacted HPE professional services to install our three-frame HPE Synergy solution. We used only two of the HPE Synergy 12000 frames in testing. After HPE professional services set up and cabled the solution, we installed the nodes and virtual infrastructure as follows:

- For one frame, we installed four HPE Synergy 480 Gen10 compute nodes to be used as servers under test that host SQL VMs.
- For the other frame, we installed two Synergy 480 Gen10 compute nodes to be used as infrastructure servers that host a vCenter server and DVD Store load-generating VMs. The diagram below shows the HPE solution configuration.

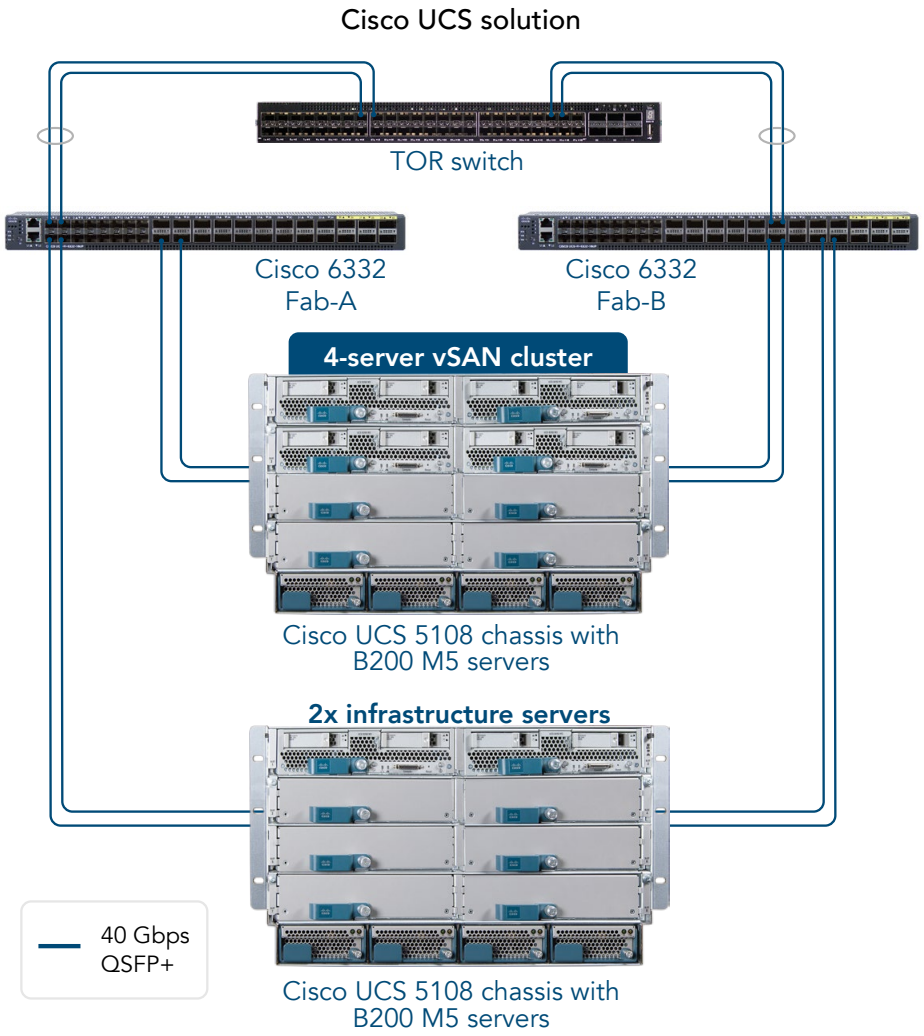


HPE Synergy 12000 Frame with HPE Synergy Gen 10 servers

Setting up the Cisco UCS solution testbed

We set up two Cisco UCS 6332 16UP Fabric interconnects into a standard UCS cluster. For each Fabric Interconnect, we connected two 40 Gbps QSFP+ cables to a Cisco UCS 5108 chassis via a pair of Cisco UCS 2304 IO modules. We also connected each Cisco UCS 6332 16UP Fabric Interconnect to a network top-of-rack (ToR) switch via two 40 Gbps QSFP+ modules and configured an LACP port channel.

We installed four Cisco UCS B200 M5 blades in the first Cisco UCS 5108 chassis to be used as servers under test that hosted SQL VMs. We also installed two Cisco UCS B200 M5 blades in the second Cisco UCS 5108 chassis to be used as infrastructure servers that hosted a vCenter server and DVD Store load-generating VMs. The diagram below shows the Cisco solution configuration.



Installing VMware ESXi 6.7

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. For the keyboard layout, select US, and press Enter.
7. Enter the root password twice, and press Enter.
8. To start the 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 VMware vCenter Server 6.7

1. On a Windows server or VM, locate the VMware-VCSA installer image.
2. Mount the image, and navigate to the vcsa-ui-installer folder.
3. Double-click installer.exe.
4. Click Install.
5. Click Next.
6. Accept the terms of the license agreement, and click Next.
7. Leave "vCenter Server with an Embedded Platform Services Controller" selected, and click Next.
8. Enter the FQDN or IP address of the vCenter Server Appliance host.
9. Provide the server's username and password, and click Next.
10. Accept the certificate of the host you chose to connect to by clicking Yes.
11. Provide a name and password for the vCenter Appliance, and click Next.
12. Set an appropriate Appliance Size, and click Next.
13. Select the appropriate datastore, and click Next.
14. At the Configure Network Settings page, configure the network settings as appropriate for your environment, and click Next.
15. Review your settings, and click Finish.
16. When the deployment completes, click Next.
17. At the Introduction page, click Next.
18. At the Appliance configuration page, select the time synchronization mode and SSH access settings, 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. At the CEIP page, click Next.
23. At the Ready to complete page, click Finish.
24. When installation completes, click Close.
25. 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. After vCenter creates the cluster, right-click the cluster, and click Add Host.
9. Enter the FQDN 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. For the remaining servers in the cluster, complete steps 10 through 15.

Configuring VMware vSphere Distributed Switch

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: 6.7.0, and click Next.
6. Set the number of uplinks to two, and enter 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 side of the screen, right-click the new vSAN port group that you 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. Type `vMotion` as the name of the new port group, and click Next.
19. Under VLAN, set a VLAN 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. Type `VM_NET` for the name of the new port group, and click Next.
23. Under VLAN, set a VLAN 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 networking 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. On the vSAN capabilities screen, click Next.
5. On the Network validation screen, click Next.
6. Select which disks to claim for cache and which disks to claim for capacity in the vSAN cluster, and click Next.
7. On the Ready to complete screen, click Finish.

Creating the SQL Server Master VM

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 four.
   - Set the Memory to 8 GB.
   - Add one 80GB VMDK for OS, one 50GB VMDK for database les, and one 30GB VMDK for database logs. Set OS VMDK to thin provisioning, and set all other VMDKs to thick provisioning, 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 Windows Server® 2016

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, enter a password and confirm it. Log in with the password you set up previously.
12. Install VMware Tools in the VMs hosted on the ESXi servers.
13. From Server Manager, disable Windows Firewall.
14. Run Windows Updates.

Installing Microsoft SQL Server 2017

1. Attach the installation media ISO for SQL Server 2017 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2017 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, select 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.

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 2014. 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.

In regards to schema creation scripts modifications, we only 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.

Cloning additional SQL Server VMs

After generating the database, creating the ds2user login, and storing the backup on the Master SQL VM, we cloned the rest of our VMs from the Master. For our testing, we created 32 SQL VMs.

1. From a web browser, log into vCenter.
2. Right-click the Master SQL VM, and select Clone→Clone to Virtual Machine.
3. Select a name for the VM and a datastore location to store it, and click Next.
4. Select the compute resource which the VM will reside on, and click Next.
5. Set "Select virtual disk format" to "Same format as source."
6. Set "VM Storage Policy" to "Keep existing VM storage policies."
7. Select the appropriate datastore, and click Next.
8. Deselect all clone options, and click Next.
9. Review your settings, and click Next.

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=45 --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>
```

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