



25% more IOPS
on an OLTP-type
workload*

Strong performance



44% less storage
required after migrating
compressible data*

Store data more efficiently



45% fewer steps and
51% less admin time
to provision new storage*

Faster and simpler



The Dell EMC PowerMax 8000 outperformed another vendor's array on an OLTP-like workload

It also stored data more efficiently,
leaving room for growth

When selecting enterprise-class storage, companies seek a platform that delivers strong application performance while using capacity efficiently. They also look for an underlying architecture that offers flexibility as their needs evolve, and a graphical user interface (GUI) that simplifies routine tasks.

At Principled Technologies, we conducted hands-on testing of two storage platforms for the enterprise data center, the Dell EMC™ PowerMax 8000 and a storage array from a competitor that we will refer to as Vendor A. Like the PowerMax 8000, the Vendor A competitor array is an All-Flash offering in the high-end storage market that uses Non-Volatile Memory Express (NVMe) storage. Our test tool simulated input/output operations of an online transaction processing (OLTP) workload, and we then used the same tool to simulate a migration of a compressible data set to a new array. We also explored the architectural differences of the two platforms and used each one's GUI to perform an administrative task.

In all of the areas we investigated, the Dell EMC PowerMax 8000 platform had strong advantages over the platform from Vendor A.

*compared to the array of Vendor A

A photograph of a Dell EMC PowerMax storage array. The top part of the image shows a black panel with the 'DELLEMC' logo in white. Below the logo, the word 'PowerMax' is printed in white. The bottom part of the image shows a perforated metal mesh, likely part of the cooling system or a protective enclosure.

DELLEMC

PowerMax

About the Dell EMC PowerMax array

Dell EMC PowerMax storage arrays utilize NVMe for customer data. According to Dell EMC, "The NVMe-based PowerMax was specifically created to fully unlock the bandwidth, IOPS, and latency performance benefits that NVM media offers to host-based applications which are unattainable using the current generation all-flash storage arrays."¹ To learn more about Dell EMC PowerMax, visit DellEMC.com/PowerMax.

How well does All-Flash Dell EMC PowerMax 8000 meet enterprise storage requirements?

If you're in the market for enterprise storage, you're probably weighing a number of different factors. Your platform must deliver strong application performance, use storage capacity efficiently to keep ownership costs down and have room for growth, and minimize headaches and hassle for your storage admins so they can focus on more important projects and initiatives. Each storage platform has its own unique architecture that affects how well it addresses these needs. The platforms vary widely, so it's essential to do your homework.

We compared the Dell EMC PowerMax 8000 and the Vendor A array on a number of fronts. First, we used the Vdbench storage benchmarking tool to conduct simulations that shed light on the performance and storage efficiency capabilities of the two platforms:

- We executed an online transaction processing (OLTP)-type workload and measured input/output operations per second (IOPS) and latency while maintaining a 2.3:1 compression ratio
- We simulated the migration of a previously compressible data set from an old array to a new one to see how well each platform maintained the compression ratio.

Next, we looked into the design of the two platforms to assess how they could help or hinder planning and everyday administration. Finally, we tested each platform's GUI by using them to perform the routine task of provisioning a new LUN.

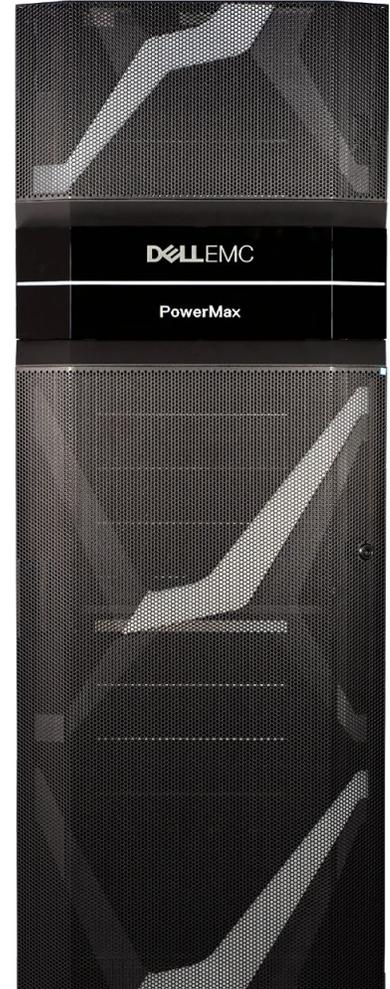
Read on for the details of the advantages the Dell EMC PowerMax 8000 demonstrated over the Vendor A array in all of these areas.

The Dell EMC PowerMax array delivered greater performance on an OLTP-like workload

Keeping critical business applications running at a fast clip is often the most important job for a storage platform. To compare the performance of the Dell EMC PowerMax platform and the Vendor A platform, we used Vdbench to measure input/output on a workload similar to online transaction processing.

Companies rely on OLTP systems for business-critical activities in a variety of areas including finance, ecommerce, and customer relationship management (CRM). They can't afford to deliver a sluggish experience to their users. To get a glimpse into how each storage platform would perform on such applications, we used the OLTP-like workload in Vdbench. (See Appendix E for the configuration files we used.)

As the chart below shows, the Dell EMC PowerMax 8000 array achieved 25 percent more IOPS than the Vendor A array. The Dell EMC PowerMax solution achieved this win while maintaining a 2.3:1 data compression ratio after a simulated migration, while the Vendor A array was unable to compress all the migrated data.



25% more IOPS
on an OLTP-type
workload

OLTP-like IOPS

Higher is better

Dell EMC PowerMax 8000

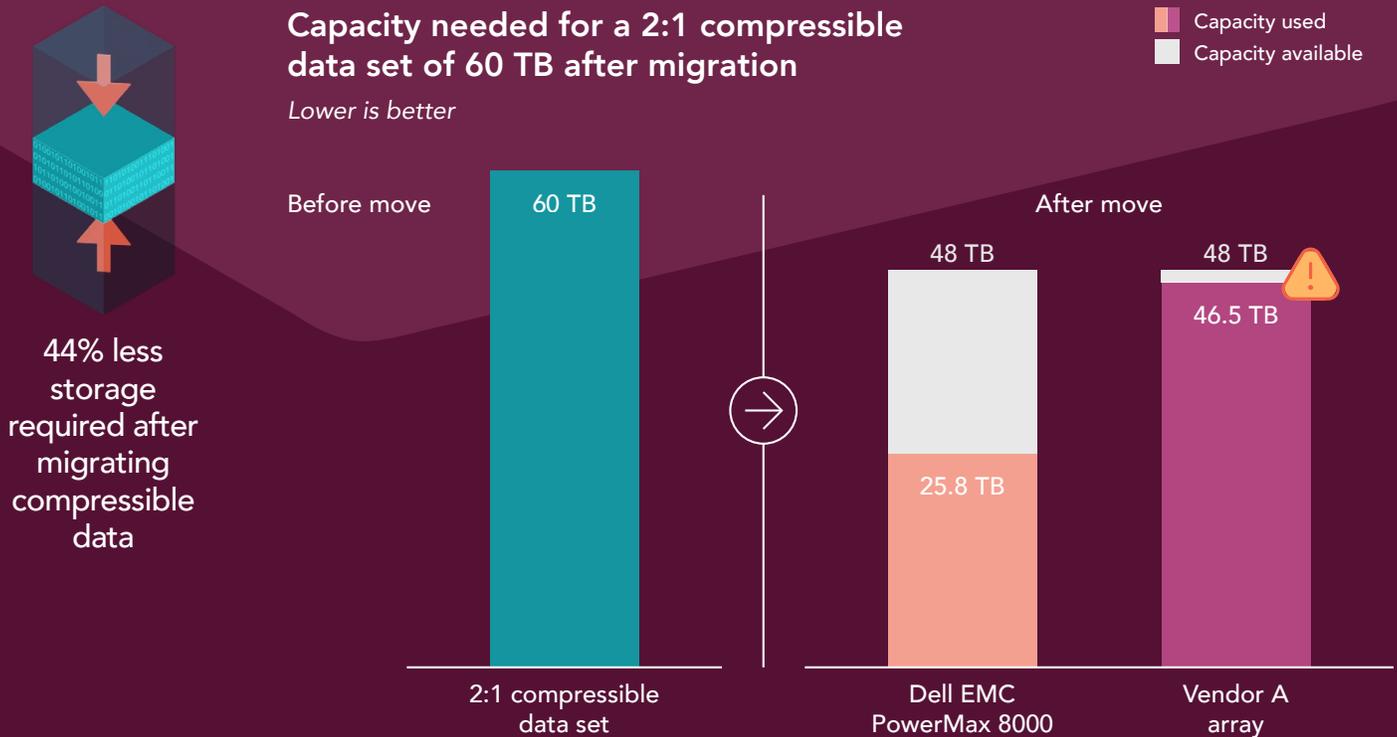
275,301

Vendor A array

219,571

What do IOPS have to do with it?

When a storage array can handle more IOPS, that indicates its ability to support periods of heavy activity. To measure the number of IOPS a solution is capable of sustaining, Vdbench generates an I/O workload.



The Vendor A array fell short of the expected compression ratio, but the Dell EMC PowerMax 8000 exceeded it

Because NVMe storage space is expensive, storage platforms typically employ strategies to compress data so that less space is required. Compression ratios vary depending on the type of data, but consider a data set that totaled 60 TB and was 2:1 compressible. In this case, the compressible data would require roughly 30 TB of physical disk capacity. The advantages for the company's bottom line are obvious—their precious resources could go twice as far.

What happens when the time comes to refresh an older storage array and the company must migrate a compressible data set to new hardware? Ideally, the new platform would maintain the compression ratio and the data would take up roughly the same amount of space as it did prior to migration. However, this doesn't always happen. Even if the company's storage administrators allowed for a certain amount of expansion in their capacity planning, the resource consumption of the new platform could be an unpleasant surprise. The company could find themselves on the hook for investments in storage capacity and could even have their data go completely offline if the new platform's usage hit 100 percent.

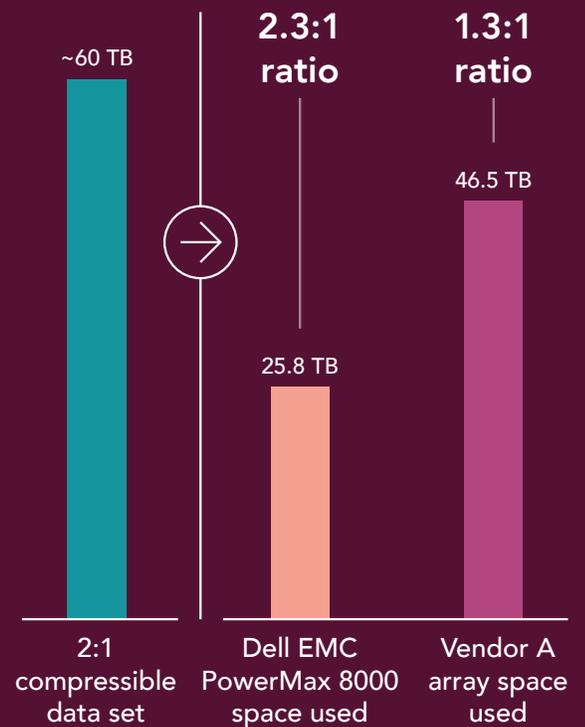
To gain insight into how our enterprise storage platforms would behave when migrating compressible data, we simulated a migration using Vdbench. This simulation wrote 60 TB of 2:1 compressible data to the Dell EMC PowerMax 8000 array and the Vendor A array, both of which had a capacity of about 48 TB. The chart above presents the results.

The leftmost bar shows the volume of the compressible data set prior to the simulated migration. As the middle bar shows, the Dell EMC PowerMax platform achieved a compression ratio of 2.3:1, which is better than the expected 2:1 ratio (see the sidebar on the next page for an explanation). Because the migrated data set uses less than 26 TB, more than 22 TB remains available in the array. As the rightmost bar shows, we saw a dramatically different outcome in our simulated migration to the Vendor A platform. The data set used 46.48 TB, leaving less than 2 TB free on the array and jeopardizing the integrity of the data.

The Dell EMC PowerMax platform was able to write the data in the simulated migration up to its peak rate and still achieve the 2.3:1 compression ratio. On the Vendor A array, we initially ran the simulated migration at 100 percent of its peak rate but found that it reached its maximum capacity and all storage LUNs went offline, effectively hanging the test before completion. We subsequently throttled the array to reduce speed by 75 percent. When operating at 25 percent of maximum I/O rate, Vendor A was still unable to archive the expected 2:1 data compression ratio using adaptive compression. This is because when the system gets busy, the Vendor A array turns off data reduction to speed up access, whereas the PowerMax platform uses intelligent data reduction to maintain data performance and efficiency.

Another limitation of Vendor A's inline adaptive compression is its inability to do background compression during maintenance or when idle. Once it performs a migration, even if there is compressible data on the array, the user or admin is stuck with the data as is and can't perform additional compression.

Compression ratios



The chart above presents the compression ratios for the data we showed on the previous page in terms of physical and logical space used. As it shows, the Dell EMC PowerMax 8000 array achieved a ratio of 2.3:1 while the Vendor A array achieved a ratio of 1.3:1.

What these results could mean for your company

By achieving a 2.3:1 data compression ratio, the Dell EMC PowerMax platform would reduce the amount of space needed to store the data after the migration by 44 percent compared to the Vendor A platform, and would leave a comfortable amount of space on the new array. If a company were anticipating a 15 percent annual growth rate in storage capacity needs, the PowerMax array could easily meet their needs for years, but the Vendor A array would be out of space in year one.

How the Dell EMC PowerMax 8000 exceeded the expected compression ratio

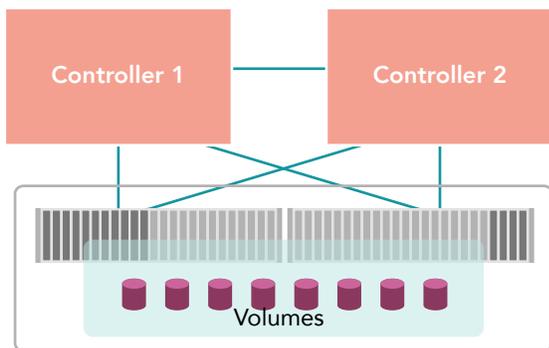
In our testing, we used a Vdbench 2:1 compressible data set of 60 TB, which you would expect to take up 30 TB of physical capacity after compression. However, as we note above, the Dell EMC PowerMax 8000 needed only 25.8 TB of physical capacity. This was possible due to the different compression algorithms involved in the testing. Vdbench uses one algorithm (LZJB) to create compressible data and the Dell EMC PowerMax 8000 uses a different algorithm (DEFLATE). Because DEFLATE has a higher compression ratio than LZJB, the Dell EMC PowerMax 8000 achieved a compression ratio of 2.3:1.

How the shared architecture of the Dell EMC PowerMax platform can reduce upfront planning time and let your company respond to fluctuating needs in real time

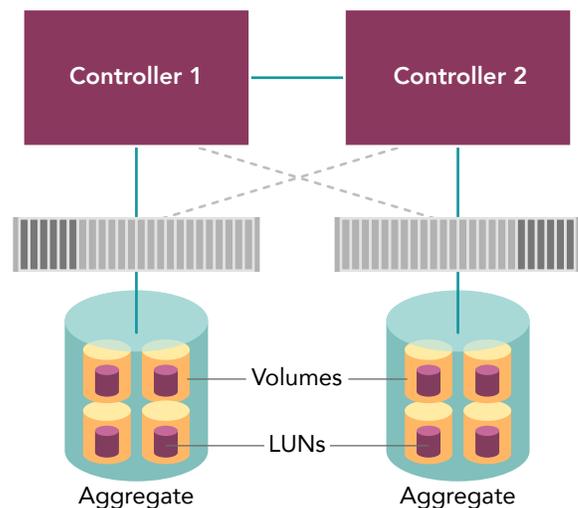
While the storage platforms we tested both have two controllers and approximately the same number of disks and raw storage capacity, they differ dramatically in terms of how these resources interact. Simply put, the Dell EMC PowerMax platform treats all of the disks as a single pool, which means both of the controllers can access any of the disks at any time. This eliminates the need for upfront estimating and planning, and offers a great deal of flexibility as storage needs fluctuate.

To ensure load balancing of controller resources, the Vendor A platform divides the disks into two or more primary pools, each of which is linked exclusively to one of the controllers. It subdivides each pool into volumes, then creates one or more LUNs within each volume. This federated approach could require more effort in both planning and ongoing maintenance. In contrast, the PowerMax architecture is truly active active, allowing full load balancing of drives across both controllers.

Dell EMC PowerMax 8000 disk ownership architecture



Vendor A array disk ownership architecture



For example, say a storage admin needed to migrate a workload to balance I/O resources across disks or controllers using the Vendor A platform. They would have to identify the LUNs the workload was running on, identify the parent volumes of the LUNs, and then execute one or more volume copies from one pool/controller to another. This manual process would require real-time alerting, planning, available capacity, and administrator time. On the Dell EMC PowerMax platform, none of this would be necessary. Anecdotally, after Vdbench simulated our migration, both of the pools on the Vendor A array were at greater than 95 percent capacity utilization because of the compression loss. This indicates that in a real-world situation, there would be insufficient space on either pool to perform the kind of volume move we describe above. This could introduce the risk of an outage or data loss as a result.

About Unisphere for PowerMax

Dell EMC positions Unisphere for PowerMax as an intuitive management interface that lets IT managers spend less time provisioning, managing, and monitoring PowerMax storage assets. According to Dell EMC, "Unisphere delivers the simplification, flexibility, and automation that are key requirements to accelerate the transformation to the modern data center. For customers who frequently build up and tear down storage configurations, Unisphere® for PowerMax makes reconfiguring the array even easier by reducing the number of steps required to delete and repurpose volumes."²

With the Unisphere for PowerMax management tool, the routine task of provisioning a new LUN took half the time it did on the Vendor A platform

If you're a storage administrator, spending some of your time at work performing routine tasks is unavoidable. However, the right tools can simplify and shorten these tasks, freeing time for you to focus on higher-value activities. To learn about the GUI management tools of the two storage platforms we investigated, we provisioned a single LUN on each and measured the time and steps required.

As the charts below illustrate, executing this task with the Unisphere for PowerMax tool took six steps and 30 seconds. That's roughly half of the eleven steps and 62 seconds the same task required using the management tool of the Vendor A array. If your administrators could cut the time they devote to routine tasks in half, think of what they could accomplish.



45% fewer steps
51% less admin time

Steps to provision new LUN

Lower is better

Dell EMC PowerMax 8000



Vendor A array



Time to provision new LUN

Min:sec | Lower is better

Dell EMC PowerMax 8000



Vendor A array



Conclusion

Our testing indicated several areas where the Dell EMC PowerMax 8000 platform offered advantages over the Vendor A array. The Dell EMC PowerMax array delivered 25 percent more IOPS on an OLTP-like workload. In a simulated migration of a compressible data set, the Dell EMC PowerMax exceeded the expected compression ratio while the Vendor A array failed to meet it. In contrast to the federated architecture of Vendor A, the Dell EMC PowerMax architecture lets both controllers access every disk, which could increase flexibility and reduce upfront planning and ongoing maintenance. Finally, the Unisphere for PowerMax management tool let us execute a routine task in half the time we needed on the Vendor A array. Each of these individual advantages can directly benefit your enterprise. Together, they make a very strong case for the Dell EMC PowerMax 8000.



To learn more about
Dell EMC PowerMax, visit
DellEMC.com/PowerMax.

- 1 Dell EMC, "The Dell EMC PowerMax Family Overview," accessed January 2, 2019, https://www.dell EMC.com/resources/en-us/asset/white-papers/products/storage/h17118_dell_emc_powermax_family_overview.pdf.
- 2 Dell EMC, "Dell EMC PowerMax Family," accessed January 2, 2019, <https://www.dell EMC.com/resources/en-us/asset/data-sheets/products/storage/h16891-powermax-family-ds.pdf>.

We concluded our hands-on testing on December 6, 2018. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on September 27, 2018 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Appendix A: Our results

The table below presents our findings in detail.

	Dell EMC™ PowerMax 8000	Vendor A array	Percentage difference
Space savings			
Space needed for 2:1 compressible data set of 60 TB after migration	25.8 TB	46.5 TB	44% less space needed
Performance			
IOPS on OLTP-like workload	275,301	219,571	25% more IOPS
Management task			
Admin steps to provision one new host (see page 14 for steps)	6	11	45% fewer steps
Admin time to provision one new host (min:sec)	0:30	1:02	51% less time

Appendix B: System configuration information

The table below presents detailed information on the systems we tested.

Storage

Storage configuration information	Dell EMC PowerMax 8000	Vendor A array
Operating system	5978.221.221	9.4
Number of storage shelves	2	2
Total drives	33	36
Drive vendor and model number	HGST Ultrastar SN200	Samsung® PM1723a 1.92TB SSD
Drive size (TB)	1.92	1.92
Usable capacity	48 TB	48 TB

Servers

Server configuration information	12 x Dell EMC PowerEdge R740 servers
BIOS name and version	Dell EMC PowerEdge™ R740 1.4.9
Non-default BIOS settings	Virtualization enabled
Operating system name and version/build number	VMware ESXi™ 6.5.0 build-10175896
Date of last OS updates/patches applied	10/1/2018
Power management policy	Performance
Processor	
Number of processors	2
Vendor and model	Intel® Xeon® Platinum 8168
Core count (per processor)	24
Core frequency (GHz)	2.70
Memory module(s)	
Total memory in system (GB)	256
Number of memory modules	8
Vendor and model	Samsung M393A4k40CB2-CTD
Size (GB)	32
Type	DDR4
Speed (MHz)	2,666
Speed running in the server (MHz)	2,666

Server configuration information	12 x Dell EMC PowerEdge R740 servers
Storage controller	
Vendor and model	Dell EMC PERC H740p
Cache size (GB)	8
Firmware version	50.3.0-1512
Driver version	7.7.03.18.00
Local storage	
Number of drives	2
Drive vendor and model	Dell/Toshiba PGNV6
Drive size (GB)	120
Drive information (speed, interface, type)	6Gb SATA, SSD
Network adapter	
Vendor and model	Intel Ethernet Converged Network Adapter X520-2
Number and type of ports	2 x 10GbE
Driver version	4.1.1.1-iov
Storage adapter	
Vendor and model	QLogic QLE2742 32Gb FC Adapter
Number and type of ports	2 x 32Gb
Firmware version	8.07.80
Power supplies	
Vendor and model	Dell EMC DD1100E-S0
Number of power supplies	2
Wattage of each (W)	1,100

Appendix C: Testbed diagrams

Dell EMC PowerMax platform

Dell EMC PowerMax 8000

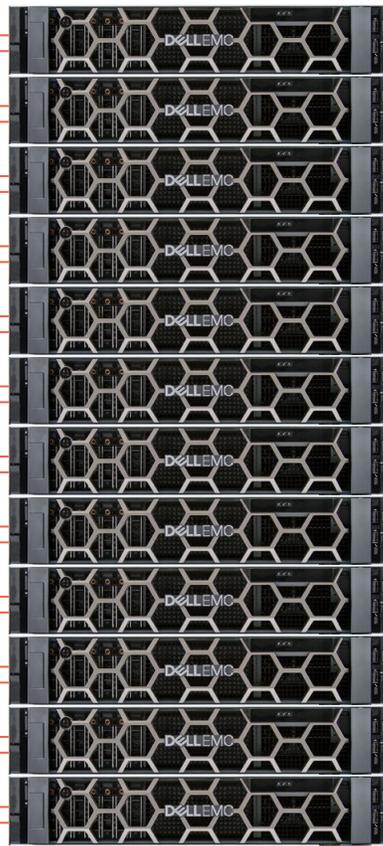
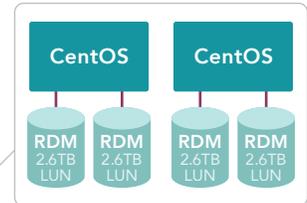


■ 1 Gbps Ethernet ■ 16 Gbps Fibre Channel



Top-of-rack 1Gbps Ethernet switch

12 x Dell EMC PowerEdge R740 servers each with:



Dell EMC Connectrix DS-6620B switch

24x 16 Gbps FC

Vendor A platform

Vendor A array



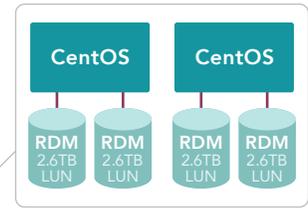
- 1 Gbps Ethernet
- 16 Gbps Fibre Channel
- 32 Gbps Fibre Channel



Top-of-rack 1Gbps Ethernet switch



12 x Dell EMC PowerEdge R740 servers each with:



Dell EMC Connectrix DS-6620B switch

16x 32 Gbps FC

Appendix D: How we tested

We created 48, thin provisioned, 2.6TB LUNs for the Dell EMC PowerMax 8000. We installed 12 Dell EMC PowerEdge R740 servers with vSphere 6.5. Each server had the following:

- Four LUNs mapped and zoned for exclusive use
- One dual-port 32Gb QLogic adapter
- Two VMs, with each VM having exclusive control of its two respective LUNs as RDMs (Raw Device Mapping). Each VM was installed with CentOS, Java, and Vdbench version 50407

We ran coordinated Vdbench jobs across all servers and storage on the Dell EMC PowerMax and then repeated the process on the Vendor A array using the same servers and infrastructure. We used publicly available best practices from [Dell EMC](#) and Vendor A for pathing, queue depth, and other storage-specific settings.

The remainder of this section provides the steps we followed to configure the environment.

Configuring and provisioning storage

We zoned and optimized server paths as per vendor instructions to maximize HBA throughput. For PowerMax and the similarly configured AF (All-Flash Array), we created 12 storage groups and included their respective HBA WWNNs. For the Vendor A array, which had 16 x 32 Gbps ports on the array to connect to 24 server HBA ports, we zoned three server HBAs for every two initiator ports to balance the paths. For the PowerMax 8000, we had 24 16Gbps ports, so we zoned one server HBA to each of the array initiator ports.

Creating a single volume and mapping on the Vendor A array

1. Log onto the administrative portal as admin.
2. Click Storage→Volumes→Create.
3. Select the appropriate SVM, and click Select.
4. At the Create LUN wizard screen, click Next.
5. Name the LUN "Select VMware," and click Next.
6. Select Create a new flexible volume, and select the appropriate aggregate. Click Next.
7. Name the volume. For size, type 2.6 TB, and click Create.
8. Select the server you wish to attach, and click Next.
9. Leave Manage Storage Quality of Service unselected, and click Next.
10. Review the summary, and click Next.
11. Click Finish.

Repeat steps 2 through 11 as necessary to create and map 48 LUNs and 48 volumes.

Creating volumes and mapping on the Dell EMC PowerMax array

1. Open Unisphere, and log in as smc.
2. Click hosts. Select host1, and click Provision storage.
3. For the storage group name, type host 1. For the number of volumes, type 4. For size, type 2.6 TB. Click Next.
4. Select the appropriate port group, and click Next.
5. Click Run Now.
6. Click Close.

Repeat steps 2 through 6 as necessary to create and map 48 LUNs and 48 volumes.

Installing VMware vSphere Hypervisor (ESXi) 6.5

We installed and configured 12 servers under test and a single server for infrastructure. For each of the 13 hosts, we installed VMware vSphere® Hypervisor (ESXi) 6.5, accepting defaults and naming each server appropriately. We used the following steps for installation:

1. Attach the installation media to the server.
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 disk, and press Enter.
6. Select US as the keyboard layout, and press Enter.
7. Enter a root password twice, and press Enter.
8. To start the installation, press F11.
9. To reboot the server, remove the installation media, and press Enter.
10. After the server reboots, press F2, and enter root credentials.
11. Select Configure Management Network, and press Enter.
12. Select IPv4 Configuration, and enter the desired configuration details. Press Enter.
13. Select DNS Configuration, and enter the Primary DNS Server. Press Enter.
14. Press Esc, and type Y to accept changes.

Deploying the VMware vCenter Server 6.5 Appliance

Once we installed ESXi on the 13 hosts, we created a vCenter Server Appliance on our infrastructure server and added the 12 hosts under test to the vCenter.

1. On a Windows client, open the installation media folder.
2. Select vcsa-ui-installer, and right-click the installer application.
3. Click Run as Administrator.
4. Click Yes.
5. In the Appliance 6.5 Installer window, click Install.
6. At the Introduction, click Next.
7. Accept the terms of the license agreement, and click Next.
8. Select vCenter Server with an Embedded Platform Services Controller, and click Next.
9. Enter the IP address for the ESXi target server. Enter the username, the password, and click Next.
10. To accept the certificate, click Yes.
11. Enter and confirm a root password for the appliance, and click Next.
12. Select the deployment size (we selected Tiny and the default storage size), and click Next.
13. Check the box to enable thin disk mode, and click Next.
14. Enter the appropriate network information (including IP address of the application, subnet, gateway, and DNS), and click Next.
15. Review all information, and click Finish.
16. To move on to stage two of deployment, click Continue.
17. At the introduction, click Next.
18. Enter the name of the NTP servers for synchronization, enable SSH, and click Next.
19. Enter a domain name, password, and site name, and click Next.
20. Click Next for CEIP.
21. Review the stage two settings, and click Finish.
22. After setup completes, click Close.
23. Using the credentials you created in step 19, log onto <http://vcenterip:8443>.
24. On the left-hand pane, right-click the vCenter server, and select New Datacenter.
25. Right-click Datacenter, and select New Cluster.
26. Enter a Cluster name, and Click OK.
27. To create the additional cluster, repeat steps 25 and 26.
28. Right-click the newly created cluster, and add all six ESXi servers to each cluster.

Creating the client (Vdbench slave) VMs

We created a single master image and cloned it to make additional 24 client VMs. We installed the master VM on our infrastructure server. The master VM orchestrated Vdbench testing and collected data from the 24 client (slave) VMs.

1. Navigate to the vSphere web client.
2. Log in as administrator@vsphere.local.
3. Select Create a new virtual machine.
4. Choose Custom, and click Next.
5. Name the virtual machine master, and click Next.
6. Select the host, and click Next.
7. Select the appropriate storage, and click Next.
8. Select Compatibility ESXi 6.5 and later, and click Next.
9. Select Linux for the Guest OS family, and choose Linux Centos7 for the OS version.
10. For customized hardware, edit the following values:
 - CPU: Four virtual processor sockets, and one core per virtual socket
 - Memory: 16GB RAM (click Reserve all guest memory)
 - New Hard disk: 30 GB
 - New Network: Select VMXNET 3, connect to the VM network, and click Next
 - Leave all other options as default
11. Click Finish.
12. Connect the VM virtual CD-ROM to the CentOS installation disk.
13. Start the VM.
14. Right-click the VM, and select Open Console.
15. At the splash screen, select Install CentOS 7, and press Enter.
16. Choose your desired language, and click Continue. We chose English (United States).
17. At the Installation Summary screen, configure the date and time to match your time zone.
18. Set the Software Selection to Minimal Install.
19. Set the Installation Destination to Automatic partitioning.
20. Configure the network and host name for your testing network.
21. Click Begin Installation.
22. During the installation process, set the root password. We elected not to create another user for this setup.
23. Once the installation completes, disconnect the installation media, and click Reboot.

Configuring the master VM

1. Log into CentOS as root.
2. Download and unpack JAVA ver 1.8.0_181 to /opt.
3. Download and unpack vdbench50407 to the root directory.
4. Edit the /etc/hosts file as indicated in [The files we used in our testing](#). You should edit the IP addresses to reflect your own scheme.
5. Type `ssh-keygen`
6. At the prompt that reads "Enter file in which to save the key (/root/.ssh/id_rsa):" press Enter.
7. At the prompt that reads "Enter passphrase (empty for no passphrase):" press Enter.
8. Confirm the empty passphrase.
9. Type `ssh-copy-id -f -i /root/.ssh/id_rsa.pub root@master`
10. Type `yes` to accept, and confirm with the root password.
11. To disable the firewall, type `systemctl disable firewalld`
12. To stop the firewall, type `systemctl stop firewalld`

Cloning the master VM to create 24 client VMs

1. Log into the vSphere client as administrator@vsphere.local.
2. Navigate to Home→Customization Specification Manager.
3. Click the icon for Create a new Specification.
4. Select Linux for target OS, and name the specification client. Click Next.
5. Select the radio button next to Use the virtual machine name. For domain name, type test.local and click Next.
6. Select the appropriate time zone, and click Next.
7. Select the appropriate network configuration, and click Next.
8. Enter the appropriate DNS, and click Next. (Note: The /etc/hosts file will override this.)
9. To create the custom specification, click Finish.
10. Select the VM named master, right-click, and select Clone→Clone to virtual machine.
11. Name the new VM client01, and click Next.
12. Select host1, and click Next.
13. For storage, for Format, select Thin Provisioned. For Datastore, select the server's local datastore, and click Next.
14. Check the boxes next to the following:
 - Customize the operating system
 - Power on the virtual machine after creation
15. Click Next.
16. For customized specification, select Client, and click Next.
17. To deploy, click Finish.
18. Repeat steps 10 through 16 to create two VMs per host for a total of 24 clients.

Installing the PowerPath virtual appliance

To ensure optimization for the PowerMax 8000 and licensing for PowerPath, we installed the PowerPath virtual appliance on our infrastructure server.

1. Download EMCPower.PPMA-2.3.0.00.00-43.ova from DellEMC.com.
2. Log into the vSphere client, and select the infrastructure server.
3. Right-click the infrastructure server, and select Deploy OVF template.
4. Browse to where you saved the EMCPower.PPMA-2.3.0.00.00-43.ova file in step 1.
5. Click Next.
6. Select the appropriate location, and click Next.
7. Select the appropriate server, and click Next.
8. Accept the license agreement, and click Next.
9. Select a storage location, and click Next.
10. Select a network, and click Next.
11. Enter TCP/IP information, and click Next.
12. To deploy, click Finish.
13. When deployment has completed, power on the VM.
14. Open a browser and navigate to https://<ipaddress from step 10>
15. Log in as root.
16. Navigate to Inventory→vCenter Servers.
17. Click Add vCenter, enter the appropriate address and credentials, and click Register Plugin.
18. Log out.

Deploying Virtual Storage Console (VSC) 7.2 for VMware vSphere

To ensure optimization for the Vendor A array, we installed the VSC virtual appliance on our infrastructure server.

1. Download unified-virtual-appliance-for-vsc-vp-sra-7.2.ova from Vendor A.
2. Log into vCenter Server.
3. Right-click Datacenter.
4. Click Deploy OVF Template.
5. Select Local file, and click Browse.
6. Select unified-virtual-appliance-for-vsc-vp-sra-7.2.ova, and click Open.
7. Click Next.
8. At the Select name and location screen, click Next.
9. Select the infrastructure host, and click Next.
10. At the Review details screen, click Next.
11. At the Accept license agreement screen, click Accept, and click Next.
12. At the Select storage screen, choose a datastore to host the appliance, and click Next.
13. At the Select network screen, select the destination network, and click Next.
14. At the Customize template screen, enter the administrator password, the NTP server, the vCenter IP, and the vCenter credential and network settings, and click Next.
15. At the Ready to complete screen, click Finish.
16. Power on the VSC appliance.
17. Right-click the appliance, and click Install VMware tools.
18. To confirm vCenter plugin registration details, navigate to https://<appliance_ip>:8143/Register.html.

Configuring the Virtual Storage Console for VMware vSphere

1. Log into the vCenter server.
2. Click Home→Virtual Storage Console.
3. On the left-hand pane, select Storage Systems.
4. Click Add, and enter the storage array IP and credentials.

Optimizing ESXi hosts using the Virtual Storage Console

1. Log into the vCenter server.
2. Click Home→Virtual Storage Console.
3. Under Host Systems, click Edit Settings.
4. Select all the appropriate hosts.
5. Select the HBA/CAN, MPIIO, and NFS settings checkboxes.
6. Click OK.

Attaching storage LUNs to VMs via Raw Device Mapping (RDM)

Each host has access to four 2.6TB LUNs per vendor. We toggled access to each vendor based on the active zone setting on the Fiber Channel switch. We attached two LUNs directly to each VM via RDMs. Each time we switched vendors, we removed the old RDMs and attached new ones.

1. Log onto the vSphere client.
2. Select client01, and right-click Edit settings.
3. Click New device→RDM disk, and click Add.
4. Select a fiber-attached LUN, and click OK.
5. Repeat steps 3 and 4 so the VM has two 2.6TB RDMs, and click OK.
6. Repeat steps 2 through 5 on all 24 client VMs.

How we used the Vdbench workloads

We ran Vdbench across all clients. We used several Vdbench workloads:

- **Migrate.** Running this workload simulates moving from an old array to a new one. We used it to create 60 TB of data with a 2.3:1 compression ratio. After running the migrate workload, we confirmed the compression ratios on the storage dashboard before continuing.
- **Online transaction processing (OLTP).** This workload puts stress on storage with different read and write patterns. Realistically, there will be some variance from enterprise to enterprise. However, this workload has I/O patterns that are similar to those in a typical enterprise running real-world OLTP.
- **Clear cache.** We ran clear cache between runs to eliminate leftover cache hits and to ensure reproducible results.

Note: Before we began testing, we created three configuration files: migrate.cfg, OLTP.cfg, and clearcache.cfg. See the next page for our specific code.

Running the tests

1. Log onto master as root.
2. Run the Migrate job using the following code:

```
- ./vdbench -f migrate.cfg -o migrate_out
```
3. Run the clearcache job using the following code:

```
- ./vdbench -f clearcache.cfg
```
4. Run the OLTP job using the following code:

```
- ./vdbench -f oltp2a.cfg -o OLTP_out
```

Detaching storage RDMs from VMs

To switch storage vendors, we re-cabled our storage platform and changed zone sets. We rebooted all 12 hosts to ensure the correct paths. We then removed the old RDMs on each VM and attached new LUNs as RDMs.

1. Log onto the vSphere client.
2. Select all 12 hosts, and right-click Power→Reboot.
 - a. Wait until the 12 servers reboot.
3. On Host 1, select the first client VM, and right-click Edit settings.
4. Click Manage other disks.
5. Click the delete icon next to disk 3, and click Close.
6. Click the delete icon next to disk 2.
7. Click New device→RDM disk, and click Add.
8. Select the first new fibre-attached LUN and click OK.
9. Click New device→RDM disk, and click Add.
10. Select the second new fiber-attached LUN.
11. Click OK, and click Finish.
12. Repeat steps 3 and 10 on the second VM so the ESXi host has two VMs, both with the old RDMs deleted and the new RDMs added.
13. Repeat steps 3 through 11 on hosts 2 through 12, ensuring that you have reconfigured all 24 client VMs with new RDMs.

Appendix E: The configuration files we used in our testing

Hosts file

```
127.0.0.1    localhost localhost.localdomain localhost4 localhost4.localdomain4
::1        localhost localhost.localdomain localhost6 localhost6.localdomain6
192.168.0.200    master
192.168.0.201    client01
192.168.0.202    client02
//continue to 24 clients
```

Vdbench configuration files

Each of the four configuration files had the same hd and sd variables:

```
messagescan=no
compratio=2
hd=default,vdbench=/vdbench-kit03.PT/vd,user=root,shell=ssh,jvms=1
hd=client01,system=192.##.201
hd=client02,system=192.##.202
//continue to 24 clients

sd=sd_0,host=client01,lun=/dev/sdb,openflags=o_direct
sd=sd_1,host=client01,lun=/dev/sdc,openflags=o_direct
sd=sd_2,host=client02,lun=/dev/sdc,openflags=o_direct
sd=sd_3,host=client02,lun=/dev/sdb,openflags=o_direct
// continue to 48 LUNs and 24 clients
```

flushcache.cfg

```
wd=wd_CACHEFLUSH_RRM,sd=*,rdpct=100,xfersize=128k,range=(0,2)
rd=rd_CACHEFLUSH,wd=wd_CACHEFLUSH_RRM,iorate=max,elapsed=14400,interval=60,maxdata=1024g
```

migrate.cfg

```
wd=wd_MIGRATE_SW,sd=*,seekpct=eof
rd=rd_MIGRATE,wd=wd_MIGRATE_SW,elapsed=144000,interval=30,forxfersize=(128k),forrdpct=(0),
forthreads=(1),iorate=10000,maxdata=60000g
```

OLTP.cfg

```
wd=wd_OLTP2A_RRH,sd=*,rdpct=100,xfersize=8K,skew=20,range=(1728m,1760m)
wd=wd_OLTP2A_RM,sd=*,rdpct=100,xfersize=8k,skew=45,range=(2,6)
wd=wd_OLTP2A_RW,sd=*,rdpct=0,xfersize=8K,skew=15,range=(2,6)
wd=wd_OLTP2A_SR,sd=*,rdpct=100,seekpct=seqnz,range=(2,6),xfersize=128K,skew=10
wd=wd_OLTP2A_SW,sd=*,rdpct=0,seekpct=seqnz,range=(2,6),xfersize=128K,skew=10

rd=rd_OLTP2A,wd=wd_OLTP2A_*,iorate=curve,curve=(10-100,10),elapsed=300,interval=30,warmup=120,forhita
rea=(20m),threads=16
```

This project was commissioned by Dell EMC.



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