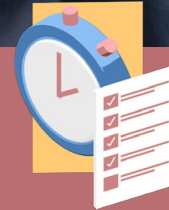**Up to 93% more IOPS*†**
Support data-intensive workloads

129% greater data reduction*
Use storage more efficiently

94% faster bulk storage provisioning*
Save IT admin time and steps

Get the most out of your storage with the Dell EMC Unity XT 880F All-Flash array

This Dell EMC solution processed more IOPS and reduced data more efficiently than a competitor array

Businesses of all sizes struggle with aging gear and lack of storage. In fact, in a 2018 Enterprise Storage Forum survey, IT and business leaders cited these concerns as their two biggest storage infrastructure challenges.[1] But in mid- to enterprise-sized businesses, where every dollar counts, fixing these problems can feel like a tall order. If you're going to upgrade your storage, you need to make sure you're getting an efficient array that will help you maximize the value of your storage and your data.

We tested two storage arrays to see which could best help organizations meet these goals: the Dell EMC™ Unity™ XT 880F, and a comparable model from a competitor ("Vendor A"). In our hands-on testing, the Dell EMC Unity XT array processed up to 93 percent more input/output operations per second (IOPS) in an 8KB 100% random read test and reduced 129 percent more data. It also carried out common management tasks faster, cutting the number of deployment steps in half and allowing us to complete bulk storage provisioning in 94 percent less time than the Vendor A array.

The Dell EMC Unity XT can help you maximize storage capacity, enabling you to serve more customers and potentially drive a higher return on your infrastructure investment.

*compared to the array from Vendor A
† in an 8KB 100% random read test

Dell EMC Unity XT 880F All-Flash array

According to Dell EMC, the Dell EMC Unity XT 880F array "delivers modern unified storage for the midmarket to the enterprise."[2] Powered by Intel® Xeon® Scalable processors, this all-flash platform is designed to "deliver high-speed access to business data with the ability to simultaneously run mixed application workloads, process inline data reduction, and provide data services with no performance overhead."[3] Learn more about the Dell EMC Unity XT 880F array: DellEMC.com/Unity.

# A storage array designed for resource-constrained environments

Dell EMC designed the Unity XT Series for IT professionals without enough time or resources.[4] These professionals could be working in a medium-sized business, or for a larger enterprise in a department that operates its own storage. Dell EMC says the Unity XT 800F array delivers "high-speed access to business data with the ability to simultaneously run mixed application workloads, process inline data reduction, and provide data services with no performance overhead."[5] Features include:[6]

- Support for block, file, and VMware® Virtual Volumes (VVols) in a single array
- Up to 16 PB of max raw capacity
- Dell EMC Unisphere™, a single HTML5 graphical user interface (GUI) for management, monitoring, and analysis
- An NVMe™-ready design

Read on to learn how the Dell EMC Unity XT processed up to 93 percent more IOPs, reduced 129 percent more data, and provisioned bulk storage in 94 percent less time compared to the array of Vendor A.

Maximizing your data center space with the Dell EMC Unity XT

Businesses are constantly looking for data center solutions that maximize performance while minimizing sprawl. The Dell EMC Unity XT packs its capacity and performance into just 2U of rack space. By contrast, the array from Vendor A takes up twice this amount of space (4U), despite its poorer performance on the tests we outline in the following pages. The Dell EMC Unity XT array can support more storage performance in a smaller footprint, helping organizations get the most out of their existing data center space.

2U

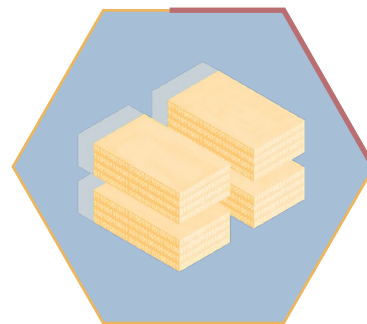Dell EMC Unity XT 880F

vs

4U
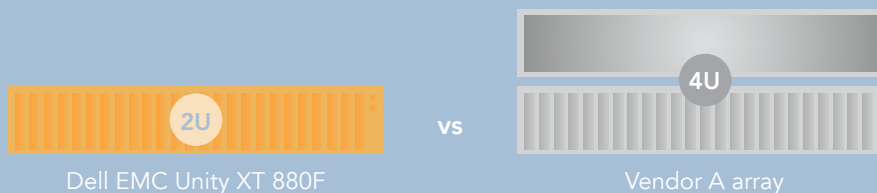
Vendor A array

How we tested

We configured two identical testbeds, one each for the Dell EMC Unity XT 880F and the Vendor A array. For each testbed, we grouped six Dell EMC PowerEdge™ R740 servers into a single VMware vCenter™ 6.7 server cluster. We deployed an additional Dell EMC PowerEdge R740 server with VMware ESXi™ 6.7 as an infrastructure server. Following each vendor's best practices, we used default configuration settings on both storage solutions.

For storage provisioning, management, and monitoring on the Dell EMC Unity solution, we used Dell EMC Unisphere. For the solution from Vendor A, we used their recommended management GUI software. We measured each solution's input/output operations per second (IOPS) and usable storage capacity using Vdbench, which executes disk I/O workloads onto an array's SSDs to validate storage performance. We tested the peak performance of both arrays with data reduction off and on and then measured how each system handled data reduction based on the same performance loads. We also measured how well each solution performed on management tasks including array deployment and storage provisioning. As we outline below, the Dell EMC Unity XT 880F beat out the Vendor A array on every one of these tasks. For a more detailed review of our testing process, see Appendix C.

Test 1: Storage performance with data reduction off

We first tested both solutions with data reduction turned off. (For an explanation of data reduction, see page 5.) Using Vdbench, we measured how many IOPS each solution could handle. We used a read-heavy test (which indicated how quickly the solutions could retrieve information from their disks) running 8KB and 32KB workloads. In the course of its daily data center work, a storage array will have to process many types of data. Seeing each solution's performance with these two different data-intensive workloads helps us understand how the solutions could handle workloads of different block sizes.

Support data-intensive workloads with up to

93% more

IOPS in an 8KB 100% random read test

In an 8KB 100% random read test, the Dell EMC Unity XT array supported 93 percent more IOPS than the solution from Vendor A. Here, IOPS serves as a useful storage performance measurement because it indicates the ability of the Dell EMC Unity XT solution to process a high volume of data. With a solution that can process more transactions, your data center could support more users, enabling your business to expand its customer base and potentially generate more revenue.

Storage IOPS performance with Vdbench (Data reduction off)
8KB 100% random read workload | Higher is better

Dell EMC Unity XT 880F

702,628

Vendor A array

363,829

93%
more IOPS
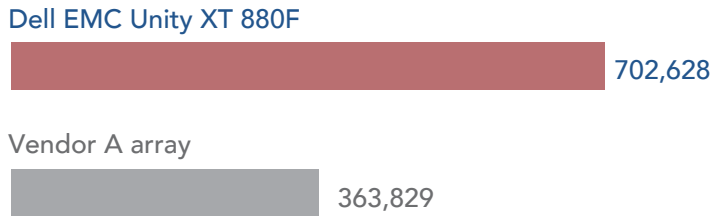
With a bigger, 32KB workload, the Dell EMC Unity XT solution processed 47 percent more IOPS compared to the other solution.

Storage IOPS performance with Vdbench (Data reduction off)
32KB 100% random read workload | Higher is better

Dell EMC Unity XT 880F

306,329

Vendor A array

207,808

47%
more IOPS
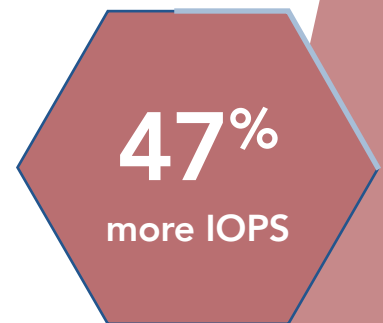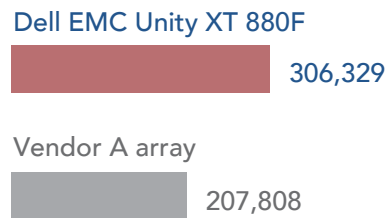
Data reduction on the Dell EMC Unity XT array

During a prolonged period of heavy storage utilization, storage on the Vendor A array would bypass data reduction and continue to take up valuable storage space. This could force an organization to purchase more storage to gain additional capacity, potentially increasing costs, infrastructure complexity, and management time. The Dell EMC Unity XT array reduces data in real time, all the time. The solution from Vendor A, by contrast, is more beholden to CPU utilization: in order to maintain performance, its array must wait to reduce incoming data until the storage CPU has available cycles.

## Test 2: Storage performance with data reduction on

Users wanting to maximize storage efficiency and space will often enable data reduction. This is because, with an array with better data reduction capabilities, an organization can increase the amount of data it can store on its existing array without having to expand to an entirely new system. With data reduction enabled, we ran three different tests on the arrays of Dell EMC and Vendor A:

- 8KB 100% random read
- 32KB 100% random read
- 32KB 70%/30% random read/write

The Dell EMC Unity XT solution outperformed the Vendor A array in all three tests, providing up to 67 percent more IOPS even with data reduction enabled. On a 70%/30% read/write workload, which represents the mixed I/O a storage array often processes, the Dell EMC Unity XT handled 22,782 more IOPS than the Vendor A array.

Storage IOPS performance with Vdbench (Data reduction on)
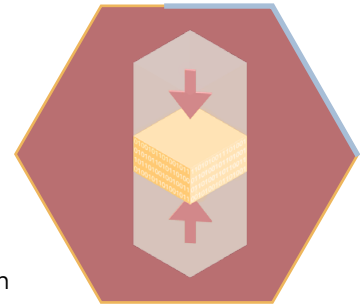*Higher is better*
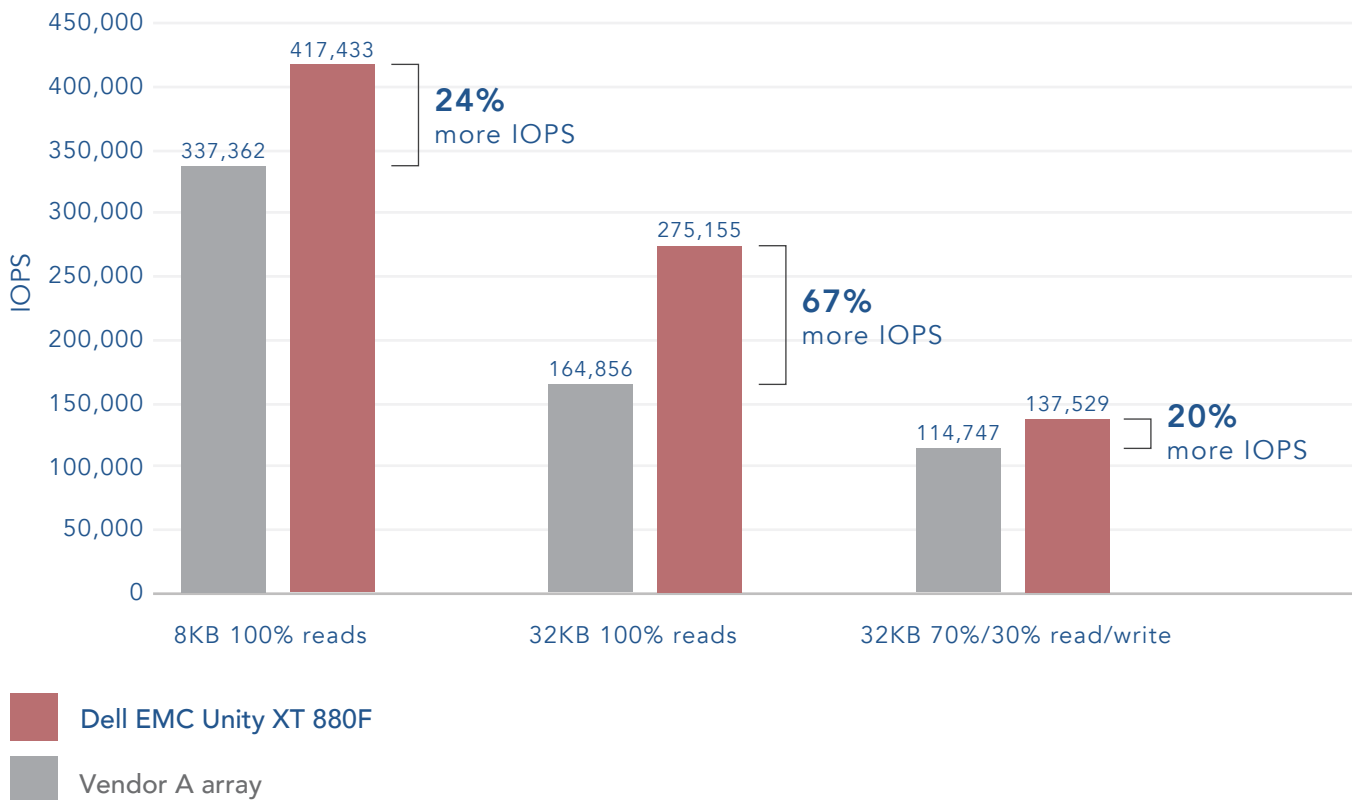
Test 3: Data reduction

To gauge the data reduction ability of the two arrays, we provisioned storage LUNs and filled them with 29.2 TB of data. We used 60 LUNs, each of which contained a data set with a 4:1 compressible and 3:1 dedupable data reduction ratio. Next, we measured how well each solution deduplicated and compressed the data; that is, how much duplicate data it recognized that didn't need to consume physical space, and how much data it compressed, reducing storage utilization. We ran an 8KB 100% random write test at 70,000 total IOPS. We cut the maximum IOPS workloads in half to ensure that each array was performing at the same level, allowing us to more accurately determine storage efficiency. In this test, the Dell EMC Unity XT solution reduced 129 percent more data than the Vendor A array.

If your organization is heavily utilizing storage, you need a solution that can keep up with your demands while maintaining storage efficiency. As our testing demonstrated, the Dell EMC Unity XT array reduced data more efficiently, potentially providing more usable storage capacity.

Maximize storage capacity with

129% greater
data reduction

Storage consumption
Lower consumption and higher data reduction is better

Dell EMC Unity XT 880F

| 4.20 TB | | 29.2 TB |

[data reduction ratio 7.00:1]

Vendor A array

| 9.76 TB | | 29.2 TB |

[data reduction ratio 3.05:1]

Test 4: Usable storage

When you're considering a new storage array, storage capacity should be top of mind. How much raw storage does a solution contain? And, more importantly, how much of this storage is usable? Any unusable storage is simply overhead—something that your company is paying for without being able to use.

To test the usable storage on both solutions, we configured both arrays with disks of the same capacity until they reached their maximum storage capacity. While usable storage of the Vendor A array maxed out at just over 65 TB, the Dell EMC Unity XT solution provided 73.4 TB of usable storage, or 82 percent of the raw storage capacity—a usable storage capacity improvement of 12 percent over the array from Vendor A. With more usable storage at your disposal, your organization will be able to maximize your current storage capacity for longer. This could lead to cost savings for your company, especially across multiple arrays, by allowing your organization to delay or forgo costly storage expansion.

Usable storage

89.40 TB

73.40 TB

85.82 TB

65.02 TB

Dell EMC
Unity XT 880F

Vendor A array

Raw storage capacity

Usable storage capacity
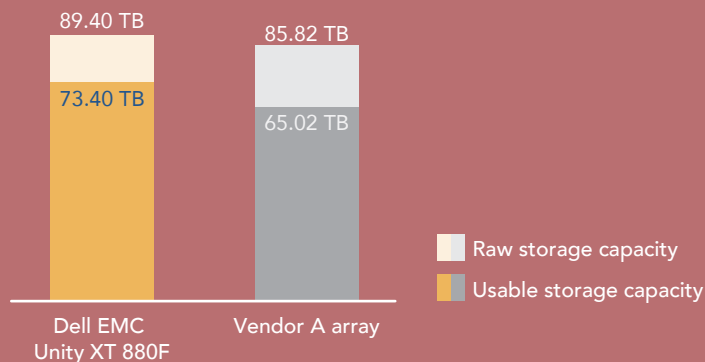
Get the most out of your storage with

12% greater usable storage capacity

We released a test report on a previous version of the Dell EMC Unity, the Dell EMC Unity 550F, in February 2019. We tested that solution against the same Vendor A array as in this study. The following section provides results from that February 2019 report. To read the report, visit https://facts.pt/1mmyay4.

Platform resiliency

For our February 2019 report, Maximize your storage capacity with the Dell EMC Unity 550F All-Flash array, we tested the platform resiliency of the Dell EMC Unity 550F against that of the array from Vendor A. We simulated a storage controller failure by pulling one controller from each system and measuring how quickly the remaining controller took over the failed controller's workload. We then plugged the controller back in and timed how long this controller took to restore to its full operations. Although the Vendor A array completed the initial takeover in less time than the Dell EMC Unity array, the Dell EMC solution performed better on the takeback test, resuming normal operations in under two minutes. The array from Vendor A, by contrast, took almost three minutes. With faster takeback times, your storage arrays could return to their full power sooner, ensuring that users could continue their business as usual.

Crucially, the Dell EMC Unity array also maintained drastically faster VM disk response times (78 percent) throughout the failover and recovery process. By contrast, latency on the array from Vendor A spiked throughout the test, meaning it took longer to respond. (For a visual representation of this process, see the graph in the report link below.) On the Dell EMC Unity solution, users would be unlikely to experience high wait times, even in the event of a storage controller failure. The benefits of having a robust and responsive system are numerous. In a 24-hour workplace like a hospital or call center, time spent waiting is time in which core operations slow down, possibly missing completion windows or service-level agreements. Any downtime could cost your organization in lost labor, revenue, or both. By contrast, faster response and recovery times allow users to quickly access important information.

For more information on the testing process, platform resiliency, and latency on the Dell EMC Unity 550F, read the February 2019 report: https://facts.pt/1mmyay4.

Scaling on the Dell EMC Unity XT 880F

The Dell EMC Unity XT groups its disks into a single unified storage pool, while the Vendor A array splits its disks into multiple smaller pools. Admins managing the Vendor A array would need to manage these pools individually. By contrast, on the Dell EMC Unity XT solution, admins would need only manage one storage pool. For organizations scaling up their arrays to meet growing storage needs, the architecture of the Dell EMC Unity XT solution could translate to less time and hassle for IT admins.

Time to return to normal operations
min:sec | Lower is better | Results from February 2019 report

Dell EMC Unity 550F

01:47

Vendor A array

02:49

Test 5: Everyday management tasks

Deploying and provisioning hardware is a common management task—one that smaller IT departments with limited resources want to make as quick and painless as possible. We tested two everyday management tasks: deploying a storage array and provisioning storage. While admins would generally only deploy a storage array once, they might provision storage on a daily basis; together, these tasks give us important insight into the efficiencies the Dell EMC Unity XT solution can offer to IT departments. To test these tasks, we used the Dell EMC Unity XT solution's graphical user interface (GUI), Unisphere. Non-technical or new customers are more likely to use GUIs, so it's important to have a GUI that is easy to use and manage. Dell EMC Unisphere is a single GUI that does not require specialized knowledge, making it a good choice for overstretched IT generalists in the midmarket space.

In our testing, we found that the Dell EMC Unity XT 880F could allow IT staff to spend 26 percent less time and half as many steps on deployment versus the Vendor A array (using the Vendor A GUI). While we needed only 9 minutes and 18 steps to deploy the Dell EMC Unity XT solution, deploying the array from Vendor A required 36 steps and over 12 and a half minutes.

Additionally, we measured how long it took to provision a single storage LUN. We used the Unisphere GUI on the Dell EMC Unity XT, while on the Vendor A array we used their GUI solution. The Dell EMC Unity XT beat the array from Vendor A, enabling us to provision a single LUN 41 percent faster, in just 30 seconds.
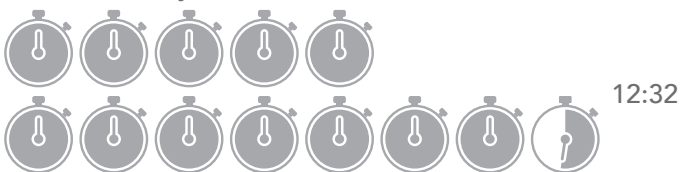
Time to deploy storage array
min:sec | Lower is better

Dell EMC Unity XT 880F

09:15

Vendor A array

12:32
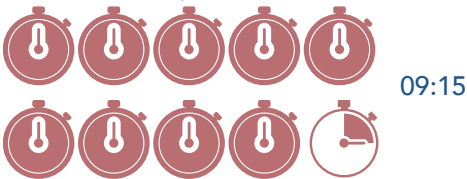
Steps to deploy storage array
Lower is better

Dell EMC Unity XT 880F

18

Vendor A array

36
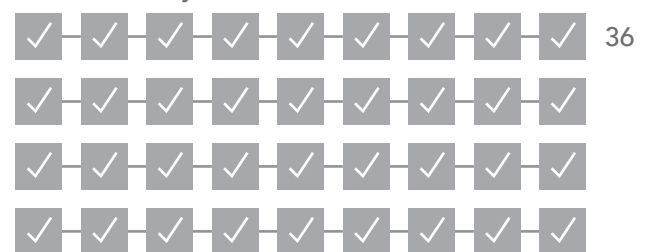
About Unisphere for Dell EMC Unity

With its simple HTML5 interface, Unisphere helps users provision, manage, and monitor storage on their Dell EMC Unity XT arrays. Unisphere allows users to configure and schedule protection for stored data, and includes advanced features like replication, Quality of Service, and performance analysis.

When we expanded our testing to bulk LUN provisioning, the Dell EMC Unity XT outstripped its competitor dramatically. To provision 60 LUNs at once, we used a Dell EMC feature called consistency groups, which allowed us to deploy multiple LUNs with minimal steps. This feature helped yield substantial time savings: The Dell EMC

Time to provision a single LUN
min:sec | Lower is better

Dell EMC Unity XT 880F

0:30

Vendor A array

0:51

Steps to provision a single LUN
Lower is better

Dell EMC Unity XT 880F

8

Vendor A array

13

Unity XT array enabled our admins to complete the task in under three minutes, compared to over 50 minutes on the array from Vendor A, making the Dell EMC Unity XT solution 94 percent faster. This greater efficiency also held true for the number of steps involved. The Dell EMC solution required only 12 steps compared to 780 on the Vendor A array, a difference of 768 steps.

With the Dell EMC Unity XT solution's time savings mounting each time your admins perform routine tasks, such as deploying storage arrays and provisioning LUNs, your admins can turn to the work that matters—like implementing strategic measures that make your data center run more efficiently. And, with fewer steps involved in both processes, your IT staff will encounter fewer opportunities for error and inefficiency.
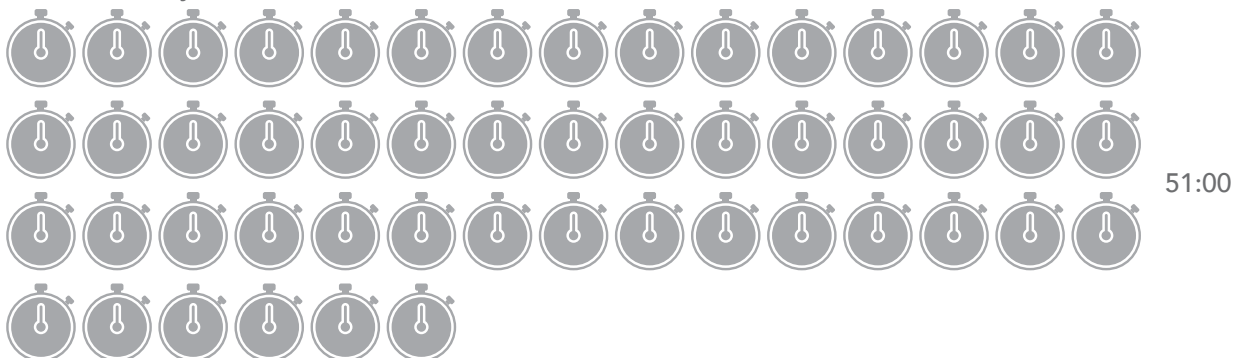
Time to provision 60 LUNs
min:sec | Lower is better

Dell EMC Unity XT 880F

02:45

Vendor A array

51:00

A modern interface for the modern IT department

We administered and managed the Dell EMC Unity XT solution using a single GUI (Unisphere), although users could also carry out management tasks via command line interface or REST API. Unisphere allows users to securely manage Dell EMC Unity XT storage systems using a web browser that supports HTML5 technology.
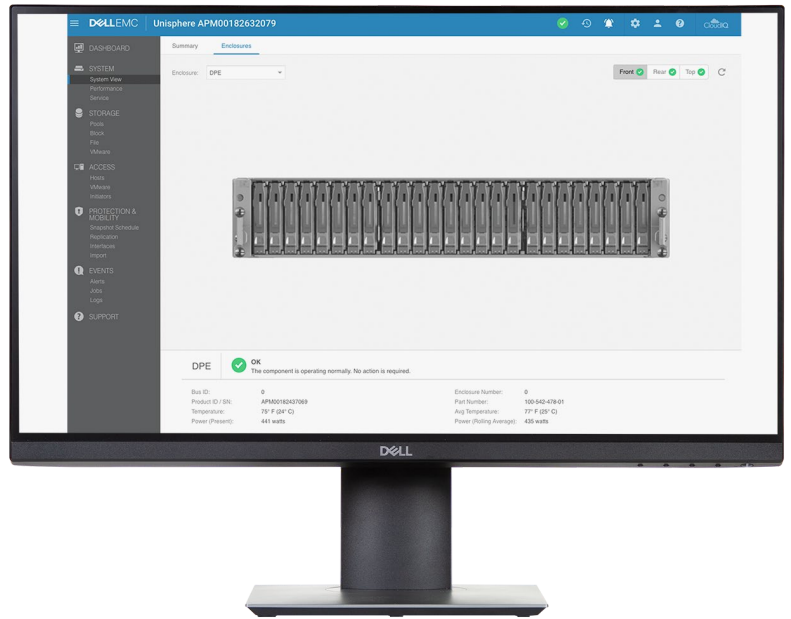
Unisphere presents a complete view of all relevant information needed to assess storage health and performance. The intuitive navigation pane allowed us to visualize content, while the sub-menus let us quickly access multiple storage features and configuration options. With Unisphere, we could efficiently view the storage system status, retrieve system notifications, and display alarm details from the main dashboard.
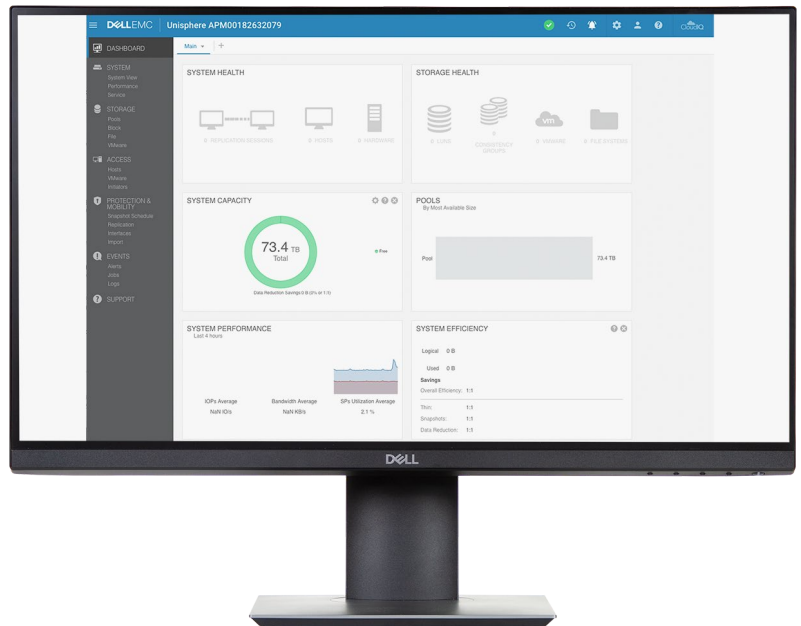
The main dashboard is fully customizable, allowing users to organize the display into blocks of information that let them easily view what they care most about. These blocks can include storage usage statistics, the health of the storage system and resources, system alerts, and overall performance.
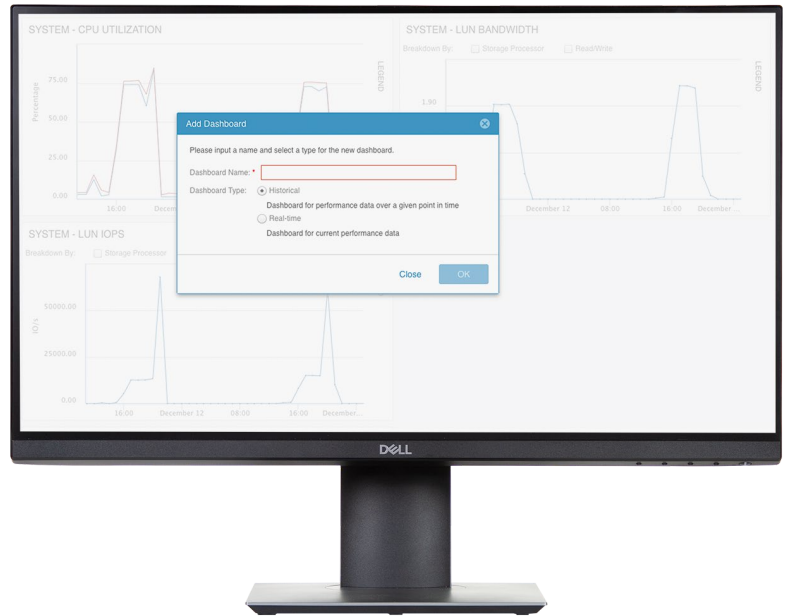
Admins can further analyze storage performance in the Unisphere GUI by interacting with dynamic charts that display historical and real-time performance metrics. The charts, which show detailed network traffic, bandwidth, and throughput data, can display data at various granular levels. While the Vendor A array requires admins to install additional software and use multiple panes to view performance statistics, the Dell EMC Unity XT solution allows admins to view performance statistics in one place. Admins can also export data to a .csv file for analysis or customize the performance dashboards to efficiently assess storage performance.

Conclusion

In our testing of the Dell EMC Unity XT 880F against the Vendor A array, the Dell EMC Unity solution supported more IOPS and reduced data more efficiently. Dell EMC Unity Unisphere management software also enabled us to deploy the Dell EMC solution in half the steps of the Vendor A array. For mid- to enterprise-sized businesses seeking to address the day-to-day challenges of storage provisioning, supporting multiple workloads, and scalability, the Dell EMC Unity XT offers a solution that can help maximize performance and efficiency.

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

1   Enterprise Storage Forum, "Survey Reveals Tech Trends Reshaping Data Storage," accessed June 12, 2019, https://www.enterprisestorageforum.com/storage-management/survey-reveals-tech-trends-reshaping-data-storage.html.

2   Dell EMC, "Dell EMC Unity XT 880F All-Flash Storage," accessed June 12, 2019, https://shop.dellemc.com/en-us/Prod-uct-Family/Dell-EMC-Products/Dell-EMC-Unity-XT-880F-All-Flash-Storage/p/DellEMC-Unity-XT-880F-Storage.

3   Dell EMC, "Dell EMC Unity XT 880F All-Flash Storage."

4   Dell EMC, "Dell EMC Unity XT All-Flash Unified Storage," accessed June 12, 2019, https://www.dellemc.com/en-us/storage/unity.htm.

5   Dell EMC, "Dell EMC Unity XT 800F All-Flash Storage."

6   Dell EMC, "Dell EMC Unity XT 880F All-Flash Storage," accessed June 12, 2019, https://shop.dellemc.com/en-us/Prod-uct-Family/Dell-EMC-Products/Dell-EMC-Unity-XT-880F-All-Flash-Storage/p/DellEMC-Unity-XT-880F-Storage.

We concluded our hands-on testing on May 23, 2019. 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 May 13, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Appendix A: Our results

Storage performance with Vdbench (data reduction off)

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
8KB 100% random read			
IOPS	702,628	363,829	93%
32KB 100% random read			
IOPS	306,329	207,808	47%

Storage performance with Vdbench (data reduction on)

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
8KB 100% random read			
IOPS	417,433	337,362	24%
32KB 100% random read			
IOPS	275,155	164,856	67%
32KB 70/30 random read/write			
IOPS	137,529	114,747	20%

Data reduction

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
4:1 compressible and 3:1 dedupable data			
Data reduction rate	7.0:1	3.05:1	129%

Usable capacity

The Dell EMC Unity solution offered 96.00 TB of raw storage, while the Vendor A array offered 92.16 TB.

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
Usable storage capacity (TB)	73.40	65.02	12%

Initial deployment

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
Total steps	18	36	50% fewer steps
Total time (min:sec)	09:15	12:32	26% faster

LUN provisioning

	Dell EMC Unity XT 880F	Vendor A array	Percentage win
Time			
Provisioning a single LUN (min:sec)	00:30	00:51	41% faster
Provisioning 60 LUNs (min:sec)	02:45	51:00	94% faster
Steps			
Provisioning a single LUN	8 steps	13 steps	38% fewer steps
Provisioning multiple LUNs	12 steps	780 steps	98% fewer steps

Appendix B: System configuration information

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

Storage configuration information	Dell EMC Unity XT 880F	Vendor A array
Operating system	5.0.0	9.5P2
Number of storage shelves	1 (Integrated disk processor enclosure)	1
Number of drives per shelf	25	24
Drive vendor and model number	Toshiba PX05SRB384	Samsung® PM1643
Drive size	3.84 TB	3.84 TB

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	VMware ESXi™ 6.7.0 build-13006603
Date of last OS updates/patches applied	04/15/2019
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 server (MHz)	2,666
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

Server configuration information	12 x Dell EMC PowerEdge R740 servers
Local storage	
Number of drives	2
Drive vendor and model	Dell/Toshiba PGNY6
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 supply	
Vendor and model	Dell EMC DD1100E-S0
Number of power supplies	2
Wattage of each (W)	1,100

Appendix C: How we tested

Detailed testing procedure

We configured two separate testbeds, one for each storage array under test. Each testbed had a total of six Dell EMC PowerEdge R740 servers with VMware ESXi 6.7 and dual-port 32Gb QLogic fibre channel adapters. We grouped all six servers on each testbed into a single VMware vCenter 6.7 server-cluster. We also deployed an additional Dell EMC PowerEdge R740 server with VMware ESXi 6.7 to serve as an infrastructure server.

We created 60 thinly provisioned LUNs on each storage array, then added those LUNs to ESXi servers as VMFS6 datastores.

We used the open-source benchmarking tool Vdbench v5.04.07 as a disk I/O workload generator and employed VMware HCIBench v2.0 to deploy VMs, coordinate workloads, and aggregate test results.

We deployed 60 VMs per server cluster, with each VM having access to a single LUN. For the Dell EMC Unity XT 880F, we used publicly available best practices from Dell EMC to optimize ESXi servers. As recommended by the Vendor A published best practices for VMware vSphere in document TR-4597, we used the Vendor A Virtual Storage Controller to optimize ESXi multipathing and HBA timeout settings.

We configured the storage arrays using out-of-box defaults. On the Dell EMC Unity XT 880F, we deployed all LUNs under a single storage pool on the extreme performance tier, using all 25 disks on a RAID-5 configuration. All LUNs were part of the same pool and automatically distributed across the controllers. On the Vendor A array, we used the OnCommand System Manager storage recommendation to create two all-flash-optimized RAID-DP data aggregates with two spare disks out of the 24 available disks. For the Vendor A array, we also created one LUN per volume. We distributed the volumes evenly across both data aggregates, a task that we had to do manually.

We used the Dell EMC Unisphere™ GUI for storage provisioning, management, and monitoring on the Dell EMC Unity XT 880F. On the Vendor A array, we used the Vendor A Virtual Storage Console (VSC) to optimize ESXi hosts and OnCommand System Manager for storage provisioning, management, and monitoring.

Configuring Fibre Channel

We zoned and optimized server paths following vendor best practices to maximize HBA throughput. For both solutions, we used 12 x 16 Gbps ports and 12 server-HBA ports per testbed. We created multiple single-initiator zones, zoning a single host initiator to a single port on each storage controller. To spread workloads evenly, we used all 12 ports on both storage arrays.

Installing VMware ESXi 6.7

We installed and configured 13 servers in total: 12 servers as servers under test, and an additional server as an infrastructure server. We installed ESXi 6.7 on all 13 hosts, accepting defaults and naming each server appropriately. We used the following installation steps:

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. To accept changes, press Y.

Deploying VMware vCenter Server 6.7 Appliance

Once we installed ESXi on the 13 hosts, we deployed VMware vCenter Server® Appliance™ on our infrastructure server, created two separate server clusters, and added six ESXi hosts to each vCenter server cluster.

1. 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 6.7 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 and 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, and click Next.
13. Check the box to enable thin disk mode, and click Next.
14. Enter the desired network information (including IP address of the application, subnet, gateway, and DNS), and click Next.
15. Review the stage one information, and click Finish.
16. To move to stage two of deployment, click Continue.
17. At the introduction, click Next.
18. Enter the NTP servers for synchronization, enable SSH, and click Next.
19. Enter a domain name, password, and site name, and click Next.
20. For CEIP, click Next.
21. Review the stage two settings, and click Finish.
22. After setup completes, click Close.
23. Log onto http://vcenterip:8443, using the credentials previously provided.
24. On 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. Repeat the previous two steps to create the additional cluster.
28. Right-click the newly created cluster and add all 6 ESXi servers to each cluster.

Configuring and provisioning storage on the Dell EMC Unity XT 880F

Downloading and installing the Dell EMC Unity Connection Utility
1. Visit https://community.emc.com/docs/DOC-51785, and download the Dell EMC Unity Connection Utility.
2. When the download has finished, click Run.
3. At the Select Setup Language screen, select English, and click OK.
4. At the Welcome screen, click Next.
5. At the Choose Install Folder screen, accept defaults, and click Next.
6. At the Pre-Installation Summary screen, click Install.
7. Check Run Connection Utility, and click Finish.

Connecting to the storage and configuring the management IP address
1. In the connection utility, select Auto Discover, and click Next.
2. Select the system, and click Next.
3. Enter the management IP information, and click Next.
4. Review the information provided, and click Next.
5. Click Deploy.

Running the initial configuration wizard

1. At the Introduction screen, click Next.
2. Enter the DNS server address, and click Next.
3. At the NTP server screen, click Add.
4. Enter the NTP server IP, and click Next.
5. Apply the Unisphere license, and click Next.
6. Click Next until the initial configuration has completed.

Creating a storage pool

1. On the left-hand Unisphere pane, under Storage, click Pools.
2. Click the "+" sign.
3. Enter a Pool name and description.
4. Select Extreme Performance Tier, and click Next.
5. Select all available drives, and click Next.
6. At the Capability Profile Name, click Next.
7. At the Summary screen, click Finish.

Discovering and adding multiple ESXi hosts

1. On the left-hand Unisphere pane, under Access, click VMware.
2. To connect to the vCenter server, click the "+" sign.
3. At the Find ESXi Hosts screen, enter vCenter credentials, and click Find.
4. Select the appropriate ESXi hosts, and click Next.
5. At the VSA Provider screen, click Next.
6. At the Summary screen, click Finish.

Provisioning a single storage LUN

1. On the left-hand Unisphere pane, under Storage, click Block.
2. To launch the create LUN wizard, click the "+" sign.
3. Enter a LUN name, select a Pool, and enter LUN Size. Select Thin, Data Reduction, and Host I/O Limits if necessary. Click Next.
4. At the Access screen, to select the host that can access resources, click the "+" sign.
5. Select the appropriate hosts, and click OK. Click Next.
6. At the Snapshot screen, enable snapshots if necessary. Click Next.
7. At the Replication screen, enable snapshots if necessary. Click Next.
8. At the Summary screen, click Finish.

Provisioning multiple storage LUNs using consistency groups

1. On the left-hand Unisphere pane, under Storage, click Block.
2. Click Consistency Groups.
3. To launch the consistency groups wizard, click the "+" sign.
4. Enter a name for the group.
5. At the storage screen, click the "+" sign, and select Create new LUNs.
6. Enter the appropriate number of LUNs, Name, Description, Pool, and Size. Select Thin, Data Reduction, and Host I/O Limits if necessary. Click OK.
7. Select the appropriate consistency group, and click Next.
8. At the Access screen, to select the host that can access resources, click the "+" sign.
9. Select the appropriate hosts, and click OK. Click Next.
10. At the Snapshot screen, enable snapshots if necessary. Click Next.
11. At the Replication screen, enable replication if necessary. Click Next.
12. At the summary screen, click Finish.

Configuring and provisioning storage on the Vendor A array

Connecting to storage and configuring management IP addresses

1. Connect the serial cable to node-1.
2. To enable AutoSupport, type `Yes`
3. Enter the node management interface port.
4. Enter the node management interface IP address.
5. Enter the node management interface netmask.
6. Enter the node management interface default gateway.
7. Connect the serial cable to node-2.
8. To enable AutoSupport, type `Yes`
9. Enter the node management interface port.
10. Enter the node management interface IP address.
11. Enter the node management interface netmask.
12. Enter the node management interface default gateway.
13. To open OnCommand System Manager and complete storage setup, open the web browser session.

OnCommand System Manager guided setup

1. At the welcome screen, click Guided Setup.
2. At the cluster screen, enter a storage cluster name.
3. Enter the password.
4. Confirm the password.
5. Click Submit and Continue.
6. At the Network screen, select the IP address range.
7. Enter the starting address, ending address, netmask and gateway, clicking Apply after each.
8. Click Browse, and select a port for cluster management.
9. Enter the DNS domain name.
10. Enter the DNS IP address.
11. Enter the IP of the primary NTP server.
12. At the support screen, under Event Notifications, select Email.
13. Enter the SMTP mail host details.
14. Enter the email addresses.
15. Click Submit and Continue.
16. At the Storage screen, to accept the OnCommand System Manager storage recommendation, click Submit and Continue.
17. At the Aggregates Created screen, click Close.
18. At the SVM screen, select FC/FCoE data protocol.
19. Enter licenses.
20. Under FC, click Browse and, select FC ports for each node.
21. Click Submit and Continue.
22. At the Summary screen, to log into OnCommand System Manager, click Manage Your Cluster.

Deploying Virtual Storage Console (VSC) 7.2.1 for VMware vSphere

We downloaded Virtual Storage Console 7.2 from the Vendor A support site and deployed it onto our infrastructure server.

1. Log into the vCenter server.
2. Right-click Datacenter.
3. Click Deploy OVF Template.
4. Select Local file, and click Browse.
5. Select unified-virtual-appliance-for-vsc-vp-sra-7.2.1.ova, and click Open.
6. Click Next.
7. At the Select name and location screen, click Next.
8. Select the infrastructure host, and click Next.
9. At the Review details screen, click Next.
10. At the Accept license agreement screen, click Accept, and click Next.

11. At the Select storage screen, choose a datastore to host the appliance, and click Next.
12. At the Select network screen, select the destination network, and click Next.
13. At the Customize template screen, enter administrator password, NTP server, vCenter IP, vCenter credential, and network settings, and click Next.
14. At the Ready to complete screen, click Finish.
15. Power on the VSC appliance.
16. Right-click the appliance, and click Install VMware Tools.
17. To confirm your vCenter plugin registration details, go to https://<appliance_ip>:8143/Register.html.

Configuring Virtual Storage Console for VMware vSphere

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

Optimizing ESXi hosts using Virtual Storage Console

1. Log into 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, MPIO, and NFS settings checkboxes.
6. Click OK.

Provisioning storage LUNs using OnCommand System Manager

1. On the left-hand side of OnCommand System Manager, click Storage.
2. Under Storage, click LUNs.
3. Click the Create icon, and select FlexVol.
4. Under the LUN Management tab, click the Create icon.
5. Select the appropriate SVM, and click Select.
6. At the Welcome to Create LUN Wizard screen, click Next.
7. At the General Properties screen, enter a LUN name, select the OS type, and enter a LUN size. Click Next.
8. At the LUN Container screen, select Create a new flexible volume in..., and click Choose.
9. Select the appropriate aggregate, click OK, and click Next.
10. At the Initiators Mapping screen, select the appropriate Initiator group name, and click Next.
11. At the Storage Quality of Service Screen, select Next.
12. At the LUN Summary screen, click Next.
13. Click Finish.
14. Repeat steps 1 through 13 as necessary to create 60 volumes and LUNs.

Deploying the HCIBench controller VM

We downloaded HCIBench v2.0 from https://labs.vmware.com/flings/hcibench and deployed it onto our infrastructure server. We also downloaded Vdbench 5.04.07 from https://www.oracle.com/technetwork/server-storage/vdbench-downloads-1901681.html.

1. Log into vCenter server.
2. Right-click Datacenter.
3. Click Deploy OVF Template.
4. Select Local file, and click Browse.
5. Select HCIBench_2.0.ova, and click Open.
6. Click Next.
7. At the Select name and location screen, click Next.
8. Select the infrastructure host, and click Next.
9. At the Review details screen, click Next.
10. At the Accept license agreement screen, click Accept twice, and click Next.

11. At the Select storage screen, choose a datastore to host the appliance, and click Next.
12. At the Select network screen, select the VM and Management networks, and click Next.
13. At the Customize template screen, enter Network Settings and Root credentials, and click Next.
14. At the Ready to complete screen, click Finish.

Configuring HCIBench

1. Navigate to http://HCIBench_IP:8443/ and log in using root credentials.
2. Provide the following vSphere environment information:

- vCenter hostname or IP
- vCenter username and password
- Datacenter name
- Cluster name
- Network name
- Datastore name
- Hosts
- Host username and password

3. Under Upload the Vdbench File, click Choose File, and select the vdbench50407.zip file.
4. Select Open, and click Upload Vdbench.
5. Click Save Configuration.

Deploying Vdbench guest VMs and running the test

We deployed 60 VMs with one data disk each. The size of the data disk varied; see below for detailed Vdbench parameter files.

1. Navigate to http://HCIBench_IP:8443/ and log in using root credentials.
2. Provide the following guest VM specifications:

- VM name prefix
- Number of VMs
- Number of data disks
- Size of data disks

3. Under Upload a Vdbench parameter file, click Choose File.
4. Select the appropriate parameter file, and click Open.
5. Click Upload Parameter File.
6. Under Select a Vdbench parameter file, click Refresh.
7. Select the appropriate parameter file, and click Save Configuration.
8. Click Test.

We performed SSD preconditioning and aging cycles to ensure that we properly seasoned both storage arrays before any performance testing. We used the same test procedures, sequences, and configuration files for both storage arrays. We prefilled LUNs with data prior to any performance testing.

Preconditioning the SSDs

To eliminate temporary elevated fresh out of the box (FOB) performance, we deployed 60 LUNs to consume all available storage and ran a sequential mixed I/O size (50% each of 128KB and 256KB) through the whole SSD space twice.

```
sd=sd1,lun=/dev/sda,openflags=o_direct
wd=wd_precondition,sd=(sd1),xfersize=(128k,50,256k,50),rdpct=0,seekpct=eof
rd=fill_1,wd=wd_precondition,iorate=max,interval=100h,elapsed=100h,forthreads=4
rd=fill_2,wd=wd_precondition,iorate=max,interval=100h,elapsed=100h,forthreads=4
```

Prefilling LUN data

We used 256KB sequential writes with single thread to fill the LUNs with data.

```
sd=sd1,lun=/dev/sda,openflags=o_direct
wd=wd_prefill,sd=(sd1),xfersize=256k,rdpct=0,seekpct=eof
rd=prefill_1,wd=wd_prefill,iorate=max,interval=30,elapsed=100h,threads=1
```

Testing 8KB and 32KB Vdbench maximum performance

For these tests, we deployed 60 x 1TB LUNs, and we ran 8KB and 32KB 100% random read Vdbench tests at maximum IOPS performance.

```
sd=sd1,lun=/dev/sda,openflags=o_direct
wd=wd_default,sd=*
rd=default,iorate=max,interval=30
rd=wd_rand_8KB_32KB,wd=wd_
default,warmup=60,elapsed=9m,forxfersize=(8k,32k),forrdpct=100,seekpct=100,forthreads=32
```

Testing 8KB and 32KB Vdbench maximum performance with data reduction enabled

For these tests, we enabled data reduction on both arrays, deployed and prefill 60 x 700GB LUNs with compression/dedup 2:1/2:1 data. We ran 8KB and 32KB 100% read random, and, 32KB 70% read/30% write random Vdbench tests at maximum IOPS performance.

```
compratio=2
dedupratio=2
dedupsets=5%
dedupunit=4k (8k for Unity array)
sd=sd1,lun=/dev/sda,openflags=o_direct
wd=wd_default,sd=*
rd=default,iorate=max,interval=30
rd=wd_rand_8KB_32KB,wd=wd_
default,warmup=60,elapsed=9m,forxfersize=(8k,32k),forrdpct=100,seekpct=100,forthreads=32
rd=wd_rand_32KB_mixed,wd=wd_
default,warmup=60,elapsed=9m,forxfersize=32k,forrdpct=70,seekpct=100,forthreads=32
```

Testing data reduction performance at targeted IOPS (70,000 IOPS)

For these tests, we enabled data reduction on both arrays, deployed and prefill 60 x 500GB LUNs with compression/dedup 4:1/3:1 data. We configured Vdbench to generate a 70,000 IOPS workload using 8KB random writes. We performed the data reduction tests immediately after the data reduction prefill completed.

```
compratio=4
dedupunit=4k (8k for Unity array)
dedupratio=3
dedupsets=5%
sd=sd1,lun=/dev/sda,openflags=o_direct
wd=s1w,sd=(sd1),xfersize=8k,seekpct=100,rdpct=0
rd=8k_rand_w_32T,wd=s1w,iorate=1167,interval=10,elapsed=1h,warmup=60,threads=32
```

This project was commissioned by Dell EMC.