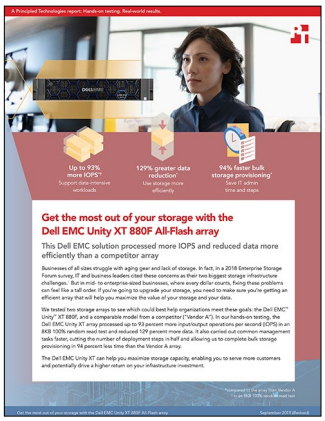

The science behind the report:

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

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report Get the most out of your storage with the Dell EMC Unity XT 880F All-Flash array.

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.

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

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

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
```

Read the report at http://facts.pt/cn5svmk ▶

This project was commissioned by Dell EMC.

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