The science behind the report:

Discover life after SATA with Dell EMC PowerEdge servers equipped with value SAS SSDs from Toshiba Memory

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 Discover life after SATA with Dell EMC PowerEdge servers equipped with value SAS SSDs from Toshiba Memory.

We concluded our hands-on testing on April 2, 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 March 27, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

The table below presents our findings in detail.

	Dell EMC PowerEdge MX with value SAS SSDs from Toshiba Memory	Dell EMC PowerEdge MX with enterprise SATA SSDs	Percentage win
Total orders per minute (OPM) across 24 VMs	1,334,660	948,294	40.7%
Read latency (ms)	2.1	1.4	-50%*
Write latency (ms)	3.6	9.9	63.6%
Total latency (ms)	5.7	11.3	49.6%

*Because the value SAS SSD-based configuration supported a heavier workload, read latencies for the configuration with value SAS SSDs were higher than the read latencies for the SATA-based configuration.

Cost analysis results

To calculate the cost of the Dell EMC™ PowerEdge™ MX system we tested, we used list pricing information obtained from Dell EMC on April 11, 2019. These numbers, while recent at the time of testing, are subject to change. Note that we used a Dell EMC PowerEdge MX server configured with four compute nodes; a configuration with fewer compute nodes would cost less. To calculate the OPM-per-dollar metric, we divided the total OPM by the total solution cost of each configuration.

Configuration	Total OPM	Total solution cost	OPM per dollar	Percent win
Dell EMC PowerEdge MX with enterprise SATA SSDs	948,294	$278,083.12	3.4101	
Dell EMC PowerEdge MX with RM5 Series value SAS SSDs	1,334,660	$268,483.12	4.9711	45.77%

System configuration information

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

Server configuration information	Dell EMC PowerEdge MX740c
BIOS name and version	Dell 1.6.13
Non-default BIOS settings	N/A
Operating system name and version/build number	ESXI 6.7.0 build-8169922(A01)
Date of last OS updates/patches applied	03/27/2019
Power management policy	Performance
Processor	
Number of processors	2
Vendor and model	Intel® Xeon® Platinum 8164
Core count (per processor)	26
Core frequency (GHz)	2.00
Stepping	H0
Memory module(s)	
Total memory in system (GB)	192
Number of memory modules	12
Vendor and model	Hynix® HMA82GR7AFR8N-VK
Size (GB)	16
Type	DDR4
Speed (MHz)	2,666
Speed running in the server (MHz)	2,666
Storage controller	
Vendor and model	Dell PERC H730P MX
Cache size (GB)	8
Firmware version	25.5.5.0005
Driver version	7.703.18.00
Local storage #1	
Number of drives	2
Drive vendor and model	Intel SSDSCKJB120G7R
Drive size (GB)	120
Drive information (interface, type)	SATA M.2 SSD

Server configuration information	Dell EMC PowerEdge MX740c
Local storage #2	
Number of drives	2
Drive vendor and model	Micron® MTFDDAK960TDN
Drive size (GB)	960
Drive information (speed, interface, type)	6Gbps SATA 2.5" SSD
Local storage #3	
Number of drives	4
Drive vendor and model	Samsung® MZ-7LM3T8N
Drive size (GB)	3.84
Drive information (speed, interface, type)	6Gbps SATA 2.5" SSD
Local storage #4	
Number of drives	2
Drive vendor and model	Toshiba Memory KRM5XVUG960G
Drive size (GB)	960
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
Local storage #5	
Number of drives	4
Drive vendor and model	Toshiba Memory KRM5XRUG3T84
Drive size (GB)	3.84
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
Network adapter #1	
Vendor and model	Intel Ethernet 25G 2P XXV710 Mezz
Number and type of ports	2 x 25GbE
Driver version	18.5.14
Network adapter #2	
Vendor and model	QLogic® 2x25GE QL41232HMKR Adapter
Number and type of ports	2 x 25GbE
Driver version	14.07.07

VMware vSAN™ cluster information	Dell EMC vSAN cluster
Number of servers in the cluster	4
Number of vSAN disk groups per cluster	8
Cache drives #1	
Number of drives per cluster	8
Drive vendor and model	Micron MTFDDAK960TDN
Drive size (GB)	960
Drive information (speed, interface, type)	6Gbps SATA 2.5" SSD
Cache drives #2	
Number of drives per cluster	16
Drive vendor and model	Toshiba Memory KRM5XRUG3T84
Drive size (GB)	3.84
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
Capacity drives #1	
Number of drives per cluster	16
Drive vendor and model	Samsung MZ-7LM3T8N
Drive size (GB)	3.84
Drive information (speed, interface, type)	6Gbps SATA 2.5" SSD
Capacity drives #2	
Number of drives per cluster	16
Drive vendor and model	Toshiba Memory KRM5XRUG3T84
Drive size (GB)	3.84
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
vSAN configuration details	
vSAN storage policy	Default policy
Total storage capacity (TB)	55.89

Server enclosure configuration information	Dell EMC PowerEdge MX7000
First type of I/O module	
Vendor and model number	Dell EMC MX7116n Fabric Expander Module, MX9116n Fabric Engine
Number of modules	2
Occupied bay(s)	1,2
Power supplies	
Vendor	Dell EMC
Number of power supplies	6
Wattage of each (W)	3,000
Cooling fans	
Vendor	Dell EMC
Number of fans	9 (4 front, 5 rear)

How we tested

Installing VMware ESXi 6.7

1. Attach the installation media.
2. Boot the server.
3. At the VMware Installer screen, press Enter.
4. At the EULA screen, to Accept and Continue, press F11.
5. Under Storage Devices, select the appropriate virtual disk, and press Enter.
6. At the keyboard layout select US, and press Enter.
7. Enter the root password twice, and press Enter.
8. To start installation, press F11.
9. After the server reboots, press F2, and enter root credentials.
10. Select Configure Management Network, and press Enter.
11. Select the appropriate network adapter, and select OK.
12. Select IPv4 settings, and enter the desired IP address, subnet mask, and gateway for the server.
13. Select OK, and restart the management network.
14. Repeat steps 1 through 13 on the remaining servers.

Deploying VMware vCenter Server 6.7

1. On a Windows server or VM, locate the VMware-VCSA installer image.
2. Mount the image, navigate to the vcsa-ui-installer folder, and double-click win32.
3. Double-click installer.exe.
4. Click Install.
5. Click Next.
6. Accept the terms of the license agreement, and click Next.
7. Leave the default "vCenter Server with an Embedded Platform Services Controller" selected, and click Next.
8. Enter the FQDN or IP address of the host onto which the vCenter Server Appliance will be deployed.
9. Provide the server's username and password, and click Next.
10. Accept the certificate of the host you chose to connect to by clicking Yes.
11. Provide a name and password for the vCenter Appliance, and click Next.
12. Set an appropriate appliance size, and click Next.
13. Select the appropriate data store, and click Next.
14. At the Configure Network Settings screen, configure the network settings as appropriate for your environment, and click Next.
15. Review your settings, and click Finish.
16. When the deployment completes, click Next.
17. At the Introduction screen, click Next.
18. At the Appliance configuration screen, select the time synchronization mode and SSH access settings, and click Next.
19. Select Create a new SSO domain.
20. Provide a password, and confirm it.
21. Provide an SSO Domain name and SSO Site name, and click Next.
22. At the CEIP page, click Next.
23. At the Ready to complete page, click Finish.
24. When installation completes, click Close.
25. Using the vSphere web client, log into the vCenter server using the credentials previously provided.

Creating a cluster and adding the hosts to VMware vCenter

1. Once you have logged into vCenter, navigate to Hosts and Clusters.
2. Select the primary site management vCenter.
3. Right-click the vCenter object, and select New Datacenter...
4. Enter a name for the new data center, and click OK.
5. Right-click the new data center, and click New Cluster...
6. For the name for the new cluster, enter `vSAN`
7. Click OK.
8. Once you have created the cluster, right-click the cluster, and click Add Host.
9. Enter the FQDN for the first server, and click Next.

10. Enter the root credentials for the server, and click Next.
11. To accept the server's certificate, click Yes.
12. Review the server details, and click Next.
13. Assign the desired license, and click Next.
14. Disable Lockdown mode, and click Next.
15. Click Finish.
16. Repeat steps 8 through 15 for the remaining servers in the cluster.

Configuring the VMware vSphere Distributed Switch for the cluster

1. Navigate to the Networking tab.
2. Expand the vCenter for the cluster.
3. Right-click the datacenter, and click Distributed Switch→Distributed Switch.
4. Enter a name for the vDS, and click Next.
5. Select Distributed switch: 6.7.0, and click Next.
6. Set the number of uplinks to two, and enter a vSAN as the new default port group.
7. Click Next.
8. Review the settings, and click Finish.
9. Select the new vDS, and click the Configure tab.
10. Under Properties, click Edit...
11. Click Advanced. For the MTU setting, type 9000
12. Click OK.
13. On the left side, right-click the new vSAN port group that you created along with the new vDS.
14. Click Edit Settings.
15. Click VLAN, and enter the VLAN for vSAN traffic.
16. Click OK.
17. Right-click the vDS, and click Distributed Port Group→New Distributed Port Group.
18. Enter vMotion as the name of the new port group, and click Next.
19. Under VLAN, set a VLAN for vMotion. Click Next.
20. Review the port group settings, and click Finish.
21. Right-click the vDS, and click Distributed Port Group→New Distributed Port Group.
22. Enter VM_NET as the name of the new port group, and click Next.
23. Under VLAN, set a VLAN for VM_NET. Click Next.
24. Review the port group settings, and click Finish.
25. Right-click the vDS, and click Add and Manage Hosts...
26. Select Add hosts, and click Next.
27. Click + New hosts...
28. Select all the compatible hosts in the vCenter cluster, and click OK.
29. Click Next.
30. Select Manage physical adapters and Manage VMkernel adapters, and click Next.
31. For each host, select each of the two 25Gb ports, click Assign uplink, and assign them to the two uplink ports.
32. Click Next.
33. Select the first host, and click + New adapter.
34. Click an existing network, and click Browse.
35. Select the vMotion port group, and click OK.
36. Click Next.
37. To enable the vMotion service, check it. Click Next.
38. Enter the desired network information for the new VMKernel, and click Next.
39. Click OK.
40. Select the first host, and click + New adapter.
41. Click Select an existing network, and click Browse.
42. Select the vSAN port group, and click OK. Click Next.
43. To enable the Virtual SAN service, check it. Click Next.
44. Enter the desired network information for the new VMKernel, and click Next. Click OK.
45. Select each of the remaining hosts individually, and repeat steps 33 through 44 for each server. Click Next.
46. Review the Analyze the impact screen, and click Next.
47. Review the settings, and click Next.

Enabling Virtual SAN on the server cluster

1. Log into the vCenter web client, and navigate to Hosts and Clusters.
2. Expand the primary site management vCenter, and select the vSAN cluster.
3. Select the Configure tab, and under Virtual SAN, click General➔Configure.
4. On the vSAN capabilities screen, click Next.
5. On the Network validation screen, click Next.
6. Select the disks you wish to assign to cache and capacity in the vSAN cluster, and click Next.
7. On the Ready to complete screen, click Finish.

Creating the SQL Server Master VM

1. In VMware vCenter, navigate to Virtual Machines.
2. To create a new VM, click the icon.
3. Leave Create a new virtual machine selected, and click Next.
4. Enter a name for the virtual machine, and click Next.
5. Place the VM on the desired host with available CPUs, and click Next.
6. Select the appropriate data store to host the VM, and click Next.
7. Select the appropriate guest OS, and click Next.
8. In the Customize Hardware section, use the following settings:

    - Set the vCPU count to 8.
    - Set the Memory to 12GB.
    - Add a 100GB VMDK for OS/Backup, a 300GB VMDK for database files, and a 100GB VMDK for database logs. Set OS VMDK to thin provisioning, then set all other VMDKs to thick provision eager zeroed.
    - Create two additional VMware Paravirtual SCSI controllers, and assign the data and log VMDKs to the new controllers.
    - Attach the OS ISO to the CD/DVD drive.

9. Click Next.
10. Click Finish.

Installing Windows Server 2016

1. Attach the Windows Server 2016 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When prompted to boot from DVD, press any key.
4. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
5. Click Install now.
6. When the installation prompts you, enter the product key.
7. Select Windows Server 2016 Datacenter Edition (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. Windows will restart automatically after completing.
11. When the Settings page appears, fill in the Password and Reenter Password fields with the same password. Log in with the password you set up previously.
12. Install VMware Tools in the VMs hosted on the ESXi servers.
13. From Server Manager, disable Windows Firewall.
14. Run Windows Updates.

Installing and configuring SQL Server 2017

1. Attach the installation media ISO for SQL Server 2017 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2017 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Specify Evaluation as the edition you are installing, and click Next.
6. To accept the license terms, click the checkbox, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.

8. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
9. Click Next.
10. At the Instance configuration screen, leave the default selection of default instance, and click Next.
11. At the Server Configuration screen, accept defaults, and click Next.
12. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
13. Enter and confirm a password for the system administrator account.
14. Click Add Current user. This may take several seconds.
15. Click Next.
16. At the Ready to Install screen, click Install.
17. Close the installation window.
18. In the SQL Server Installation Center, click Install SQL Server Management Tools.
19. Click Download SQL Server Management Studio.
20. Click Run.
21. When the Microsoft SQL Server Management Studio screen appears, click Install.
22. When the installation completes, click Close.

Configuring and running the DVD Store 2 benchmark

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 100GB database size and the database platform we used. We ran the Install.pl script on a utility system running Linux® to generate the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2017. We built the 100GB database in SQL Server, then performed a full backup, storing the backup file remotely for quick access.

We used that backup file to restore the database when necessary.

The only modification we made to the schema creation scripts were the specified file sizes for our database. We explicitly set the file sizes higher than necessary to ensure that no file-growth activity would affect the outputs of the test. Other than this file size modification, we created and loaded the database in accordance to the DVD Store documentation. Specifically, we followed these steps:

1. Generate the data, and create the database and file structure using database creation scripts in the DS2 download. Make size modifications specific to a 100GB database, and make the appropriate changes to drive letters.
2. Transfer the files from your data generation system (we used Linux) to a Windows system running SQL Server.
3. Create database tables, stored procedures, and objects using the provided DVD Store scripts.
4. Set the database recovery model to bulk-logged to prevent excess logging.
5. Load the data generated into the database. For data loading, use the import wizard in SQL Server Management Studio. Where necessary, retain options from the original scripts, such as Enable Identity Insert.
6. Create indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, create a ds2user SQL Server login using the following Transact SQL (TSQL) script:

```
USE [master]
GO
CREATE LOGIN [ds2user] WITH PASSWORD=N'',
DEFAULT_DATABASE=[master],
DEFAULT_LANGUAGE=[us_english],
CHECK_EXPIRATION=OFF,
CHECK_POLICY=OFF
GO
```

9. Set the database recovery model back to full.
10. Create the necessary full text index using SQL Server Management Studio.
11. Create a database user, and map this user to the SQL Server login.
12. Perform a full backup of the database. This backup allows you to restore the databases to a pristine state.

Cloning additional SQL Server VMs

Once you have generated the database, created the ds2user login, and stored the backup on the Master SQL VM, you can clone the rest of your VMs from the Master. For our testing, we created 24 SQL VMs.

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

Running the DVD Store tests

We created a series of batch files, SQL scripts, and shell scripts to automate the complete test cycle. DVD Store outputs an orders-per-minute (OPM) metric, which is a running average calculated through the test. In this report, we give the last OPM that each target reported.

Each complete test cycle consisted of general steps:

1. Clean up prior outputs from the target system.
2. Drop the database from the target.
3. Restore the database on the target.
4. Shut down the target.
5. Reboot the target host.
6. Wait for a ping response from the server under test and the client system.
7. Let the test server idle for 10 minutes.
8. Start the DVD Store driver on the clients.

We used the following DVD Store 2 parameters for testing:

```
ds2sqlserverdriver.exe --target=<target _ IP> --ramp_rate=10 --run_time=30 --n_threads=32 --db_
size=100GB --think_time=0.00 --detailed_
view=Y --warmup_time=15 --report_rate=1 --pct_newcustomers=20 --csv_output=<drivepath>
```

Read the report at http://facts.pt/l3l7pc4 ▶

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