The science behind the report:

Boost database performance of VMware vSAN clusters by upgrading to Dell EMC PowerEdge R640 servers with 2nd generation Intel Xeon Scalable processors

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 Boost database performance of VMware vSAN clusters by upgrading to Dell EMC PowerEdge R640 servers with 2nd generation Intel Xeon Scalable processors.

We concluded our hands-on testing on August 22, 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 August 21, 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.

Server cluster	Total orders per minute (OPM)
3 x Dell EMC™ PowerEdge™ R640	845,914
3 x Dell EMC PowerEdge R630	330,494
3 x Dell EMC PowerEdge R620	108,643

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System configuration information

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

Server configuration information	Dell EMC PowerEdge R640	Dell EMC PowerEdge R630	Dell PowerEdge R620
BIOS name and version	2.1.8	2.9.1	2.7.0
Non-default BIOS settings	Performance per watt (OS)	Performance per watt (OS)	Performance per watt (OS)
Operating system name and version/build number	VMware® ESXi™ 6.7.0, 13006603	VMware ESXi 6.7.0, 13006603	VMware ESXi 6.0.0, 13635687
Date of last OS updates/patches applied	5/29/2019	5/29/2019	5/24/2019
Power management policy	Performance per watt (OS)	Performance per watt (OS)	Performance per watt (OS)
Processor			
Number of processors	2	2	2
Vendor and model	Intel® Xeon® Gold 6230	Intel Xeon E5-2690 v3	Intel Xeon E5-2690 v2
Core count (per processor)	20	12	10
Core frequency (GHz)	2.10	2.60	3.00
Stepping	6	2	4
Memory module(s)			
Total memory in system (GB)	256	256	256
Number of memory modules	8	16	16
Vendor and model	Micron 36ASF4G72PZ-2G9E2	Samsung® M393A2G40DB0-CPB	Hynix HMT42GR7MFR4C-PB
Size (GB)	32	16	16
Type	PC4-2933	PC4-2133	PC3-12800
Speed (MHz)	2,933	2,133	1,600
Speed running in the server (MHz)	2,933	2,133	1,600
Storage controller			
Vendor and model	PERC H740P Mini	PERC H730 Mini	PERC H710P Mini
Cache size (GB)	8	1	1
Firmware version	50.5.0-1750	25.5.5.0005	21.3.5-0002
Driver version	7.708.07.00	7.708.07.00	7.703.20.00
HDD storage			
Number of drives	N/A	2 (OS)	7: 2 (OS) / 5 (capacity)
Drive vendor and model	N/A	Seagate® ST1200MM0007	Seagate ST9300653SS / ST9900805SS
Drive size	N/A	1.2 TB	300 GB / 900 GB
Drive information (speed, interface, type)	N/A	10K, SAS, HDD	15K, SAS, HDD / 10K, SAS, HDD

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Server configuration information	Dell EMC PowerEdge R640	Dell EMC PowerEdge R630	Dell PowerEdge R620
SATA SSD storage			
Number of drives	8: 2 (OS) / 6 (capacity)	6: 2 (cache) / 4 (capacity)	1 (cache)
Drive vendor and model	Intel SSDSC2KB019T8R	Intel SSDSC2BA40 / Dell 31Y1M	Intel SSDSC2BB80
Drive size	1.92 TB	400 GB / 960 GB	800 GB
Drive information (speed, interface, type)	6Gbps, SATA, SSD	6Gbps, SATA, SSD / 6Gbps, SATA, SSD	6Gbps, SATA, SSD
NVMe SSD storage			
Number of drives	2 (cache)	N/A	N/A
Drive vendor and model	Dell Express Flash NVMe P4610	N/A	N/A
Drive size	1.6 TB	N/A	N/A
Drive information (speed, interface, type)	NVMe PCIe® SSD	N/A	N/A
Network adapter			
Vendor and model	Intel XXV710	QLogic BCM57800	Intel X520-2
Number and type of ports	2 x 25Gb	4 x 10Gb	2 x 10Gb
Driver version	18.8.9	14.10.07	18.5.18
Cooling fans			
Vendor and model	Dell 384-BBQE	Dell TGC4J	Dell 021WNT
Number of cooling fans	8	7	7
Power supplies			
Vendor and model	Dell 0PJMDN	Dell 0Y9VFC	Dell 05NF18
Number of power supplies	2	2	2
Wattage of each (W)	750	750	750

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How we tested

We set BIOS settings to defaults except for the System Profile, which we changed to Performance per Watt (OS) to allow VMware to control the CPU power states. We created a single RAID1 pair on each test server to host the hypervisor. We placed the remaining drives in passthrough mode (or, in the case of the R620s, RAID0 virtual drives). We installed VMware ESXi 6.7 onto the PowerEdge R630 and R640 servers, and installed VMware ESXi 6.0 onto the PowerEdge R620 servers. We used the integrated NICs for management traffic, one 10Gb port for VSAN traffic, and the other 10Gb port for DVD Store 2 client traffic. We used a Dell PowerEdge R730 for our infrastructure / client host.

Installing VMware ESXi 6.7 or 6.0

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. As 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. Log in to the ESXi management console, and navigate to Manage-->Advanced Settings. Apply the following changes to mitigate processor vulnerabilities:
    a. Make no changes to the R640 hosts.
    b. For the R630 hosts, change the following values:
        i.   VMkernel.Boot.hyperthreadingMitigation : true
        ii. VMkernel.Boot.hyperthreadingMitigationIntraVM : false
    c. For the R620 hosts, change the following values:
        i.   VMkernel.Boot.hyperthreadingMitigation : true

Deploying the 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 Center Server with an Embedded Platform Services Controller selected, and click Next.
8. Enter the FQDN or IP address of the host onto which you are deploying the vCenter Server Appliance.
9. Provide the server's username and password, and click Next.
10. To accept the certificate of the host you chose to connect to, click Yes.
11. Provide a name and password for the vCenter Appliance, and click Next.
12. Set an appropriate Appliance Size, and click Next.
13. Select the appropriate datastore, and click Next.
14. At the Configure Network Settings page, configure the network settings as appropriate for your environment, and click Next.
15. Review your settings, and click Finish.
16. When the deployment completes, click Next.
17. At the Introduction page, click Next.
18. At the Appliance configuration page, select the time synchronization mode and SSH access settings, and click Next.
19. Select Create a new SSO domain.
20. Provide a password, and confirm it.
21. Provide an SSO Domain name and SSO Site name, and click Next.
22. At the CEIP page, click Next.
23. At the Ready to complete page, click Finish.

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24. When installation completes, click Close.
25. Using the vSphere web client, log into the vCenter server using the previously provided credentials.

Creating a cluster and adding the hosts to VMware vCenter®

1. After logging into the vCenter environment, navigate to Hosts and Clusters.
2. Select the primary site management vCenter.
3. Right-click the vCenter object, and select New Datacenter...
4. Enter a name for the new datacenter, and click OK.
5. Right-click the new datacenter, and click New Cluster...
6. Enter vSAN as the name for the new cluster.
7. Click OK.
8. After creating 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 9 through 15 for the remaining servers in the cluster.

Configuring the vSAN Networking

1. Log into the vCenter web client, and navigate to Hosts and Clusters.
2. Expand the primary site management vCenter.
3. Select the infrastructure host, and navigate to the Configure tab.
4. Select VMkernel adapters, and click Add Networking.
5. Select Virtual Machine Port Group for a Standard Switch, and click Next.
6. Select New standard switch, change MTU (Bytes) to 9000, and click Next.
7. Click Add adapters, and select your desired physical adapter. We used one of the two 10Gb ports.
8. Choose a network label, and click Next. We labeled our client traffic network `Priv_Net`
9. Click Finish.
10. In the Hosts and Clusters pane, expand the vSAN cluster.
11. Select the first host, and navigate to the Configure tab.
12. Under Networking, select VMkernel adapters, and click Add Networking.
13. Select VMkernel Network Adapter, and click Next.
14. Select New standard switch, change MTU (Bytes) to 9000, and click Next.
15. Click Add adapters, and select your desired physical adapter. We used the remaining 10Gb port.
16. For the Network label, type `vSAN` and select vSAN from the Available services. Click Next.
17. Choose your network settings, and click Next.
18. Click Finish.
19. Click Add Networking.
20. Select VMkernel Network Adapter, and click Next.
21. Choose Select an existing standard switch, browse to the vSwitch created in step 14, click OK, and click Next.
22. For the Network label, type `vMotion` and select vMotion from the Available services. Click Next.
23. Choose your network settings, and click Next.
24. Click Finish.
25. Repeat steps 11 through 24 for the other hosts in your vSAN cluster.

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Enabling three-node virtual SAN

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. Select Configure three host Virtual SAN cluster, and click Next.
5. On the Network validation screen, verify that the correct vmks are selected, and click Next.
6. Select which disks should be claimed for cache and which for capacity in the vSAN cluster, and click Next.
7. On the Ready to complete screen, click Finish.

Creating the Microsoft 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 vSAN datastore to host the VM, and click Next.
7. Select the appropriate guest OS, and click Next.
8. In the Customize Hardware section, use the following settings:

    - Set the vCPU count to 16.
    - Set the Memory to 8GB.
    - Add 1x 80GB VMDK for OS, 1x 100GB VMDKs for database files and 1x 60GB VMDK for database logs.
    - Create two additional VMware Paravirtual SCSI controllers, and assign the data and log VMDKs to the new controllers.
    - Attach the Windows Server 2019 ISO to the CD/DVD drive.

9. Click Next.
10. Click Finish.

Installing Microsoft Windows Server 2019

Use the following steps to install and configure SQL Server VMs:

1. Attach the Windows Server 2019 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 2019 Datacenter Edition (Server with a GUI), and click Next.
8. Check I accept the license terms, and click Next.
9. Click Custom: Install Windows only (advanced).
10. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
11. When the Settings page appears, 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.

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Installing Microsoft SQL Server 2017

1. Attach the installation media ISO for SQL Server 2017 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2017 DVD, and double-click it.
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Specify Evaluation as the edition you are installing, and click Next.
6. To accept the license terms, click the checkbox, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.
8. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
9. Click Next.
10. At the Instance configuration screen, leave the default selection of default instance, and click Next.
11. At the Server Configuration screen, accept defaults, and click Next.
12. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
13. Enter and confirm a password for the system administrator account.
14. Click Add Current user. This may take several seconds.
15. Click Next.
16. At the Ready to Install screen, click Install.
17. Close the installation window.
18. In the SQL Server Installation Center, click on Install SQL Server Management Tools.
19. Click Download SQL Server Management Studio.
20. Click Run.
21. When the Microsoft SQL Server Management Studio screen appears, click Install.
22. When the installation completes, click Close.

Configuring and running the DVD Store 2 benchmark

Data generation overview

We generated the data using the Install.pl script included with DVD Store version 2.1 (DS2), providing the parameters for our 20GB database size and the database platform we used. We ran the Install.pl script on a utility system running Linux® to generate the database schema.

After processing the data generation, we transferred the data files and schema creation files to a Windows-based system running SQL Server 2017. We built the 20GB database in SQL Server, then performed a full backup, storing the backup file remotely for quick access.

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

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 the 20GB database, and make the appropriate changes to drive letters.
2. Transfer the files from the Linux data generation system to a Windows system running SQL Server.
3. Create database tables, stored procedures, and objects using the provided DVD Store scripts.
4. Set the database recovery model to bulk-logged to prevent excess logging.
5. Load the generated data 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
```

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

Cloning additional SQL Server VMs

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

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

Running the DVD Store 2 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 metric, which is a running average calculated through the test. In this report, we report the last OPM that each target reported.

Each complete test cycle consisted of general steps:

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

We used parameters appropriate to the performance ceilings of each server and the commands below for each server group:

Dell EMC PowerEdge R640

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

Dell EMC PowerEdge R630

```
ds2sqlserverdriver.exe --target=<target _ IP> --ramp_rate=10 --run_time=30 --n_threads=16 --db_
size=20GB --think_time=0.00 --detailed_
view=Y --warmup_time=15 --report_rate=1 --pct_newcustomers=20 --csv_output=<drivepath>
```

Dell PowerEdge R620

```
ds2sqlserverdriver.exe --target=<target _ IP> --ramp_rate=10 --run_time=30 --n_threads=8 --db_
size=20GB --think_time=0.001 --detailed_
view=Y --warmup_time=15 --report_rate=1 --pct_newcustomers=20 --csv_output=<drivepath>
```

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Read the report at http://facts.pt/qnuhaw1 ▶

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