



The science behind the report:

Handle 19.7% more SQL Server work and support 25% more VMs with new Dell PowerEdge MX760c servers

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 [Handle 19.7% more SQL Server work and support 25% more VMs with new Dell PowerEdge MX760c servers](#).

We concluded our hands-on testing on February 9, 2023. 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 February 7, 2023 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

To learn more about how we have calculated the wins in this report, go to <http://facts.pt/calculating-and-highlighting-wins>. Unless we state otherwise, we have followed the rules and principles we outline in that document.

Table 1: Results of our testing.

	Dell™ PowerEdge™ MX750c vSAN cluster	Dell PowerEdge MX760c vSAN cluster	% win
Median result comparison (30VM vs. 30VM)			
# of VMs	30	30	-
Core utilization %	97.52	97.13	-
Average latency (ms)	129	113	-
Total orders per minute (OPM)	359,336	404,633	12.61%
Median result comparison (24VM vs. 24VM)			
# of VMs	24	24	-
Core utilization %	92.78	91.56	-
Average latency (ms)	112	100	-
Total OPM	337,977	373,831	10.61%
Median result comparison (matching average ms)			
# of VMs	24	30	-
Core utilization %	92.78	97.13	-
Average latency (ms)	112	113	-
Total OPM	337,977	404,633	19.72%

System configuration information

Table 2: Detailed information on the systems we tested.

System configuration information	3x Dell PowerEdge MX750c	3x Dell PowerEdge MX760c
BIOS name and version	Dell 1.8.2	Dell 1.0.0
Non-default BIOS settings	Performance mode	Performance mode
Operating system name and version/build number	VMware® ESXi™ 8.0.0 (Build 20513097)	VMware ESXi 8.0.0 (Build 20513097)
Date of last OS updates/patches applied	01/05/2023	01/05/2023
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6338	Intel Xeon Gold 6430
Core count (per processor)	32	32
Core frequency (GHz)	2.00	2.10
Stepping	6	6
Memory module(s)		
Total memory in system (GB)	512	512
Number of memory modules	8	8
Vendor and model	Hynix HMAA8GR7AJR4N-XN	Hynix HMCG94AEBRA109N AA
Size (GB)	64	64
Type	DDR-4 3200MHz Dual-Rank	DDR-5 4800MHz Dual-Rank
Speed (MHz)	3,200	4,800
Speed running in the server (MHz)	3,200	4,800
Storage controller (unused)		
Vendor and model	Dell HBA350i MX	Dell HBA350i MX
Cache size (GB)	0	0
Firmware version	22.15.05.00	22.15.05.00
Driver version	23.00.00.00	23.00.00.00
Local storage (OS)		
Number of drives	1	2
Drive vendor and model	Micron MTFDDAV240TDU	Micron MTFDKBA480TDZ
Drive size (GB)	240	480
Drive information	6Gbps SATA M.2 SSD	NVMe® M.2 SSD

System configuration information	3x Dell PowerEdge MX750c	3x Dell PowerEdge MX760c
Local storage (VM storage)		
Number of drives	4	4
Drive vendor and model	Samsung PM1735	Intel D7 P5600
Drive size (GB)	3.2	3.2
Drive information	PCIe® 4 NVMe SSD	PCIe 4 NVMe SSD
Network adapter (type A)		
Vendor and model	Broadcom 25G 4P BCM57504 Mezz	Broadcom 25G 4P Mezz
Number and type of ports	2x 25GbE	2x 25GbE
Driver version	21.80.15.60	22.21.07.80
Network adapter (type B)		
Vendor and model	QLogic QME2742 2x32Gb FC HBA	N/A
Number and type of ports	2x 32GbE	N/A
Driver version	16.10.00	N/A

Table 4: Configuration information for the server enclosure.

Server enclosure configuration information	Dell MX7000
I/O modules	
Vendor and model number	MX9116n Fabric Engine
Occupied bay(s)	1,2
Power supplies	
Number of power supplies	6
Vendor and model number	Dell EMC 0H7TFGA02
Wattage of each (W)	3,000
Cooling fans	
Total number of fan modules	9
Vendor and Dell Part Number (DPN)	4x Dell 09WK4X 5x Dell 0JYT3J

How we tested

We installed and configured the latest available version of VMware vSphere® 8.0.0 build 20513097 on a cluster of three Dell PowerEdge MX750c servers with Intel Xeon Gold 6338 processors, and a cluster of three Dell PowerEdge MX760c servers with Intel Xeon Gold 6430 processors. We installed the hypervisor on internal SSDs. On each cluster, we created a 17.2TB VMware vSAN™ datastore using four NVMe drives on each server: two disk groups each with two 3.2TB drives for cache and two 3.2TB drives for capacity. The vSAN datastore served as a shared datastore for VMware SQL Server deployment.

During the first phase of testing, we deployed 24 VMs (eight per host) in each cluster; during the second, we deployed 30 VMs (10 per host) in each cluster. For both phases of testing, each VM had 32 GB of memory fully reserved, a 50GB OS drive, and a 100GB data drive. We configured the VMs to use all threads in each environment: 16 vCPUs per VM on each cluster. On each VM, we installed Microsoft SQL Server 2019. To test the database performance of each environment, we used the DVD Store 3 (DS3) workload. Each VM had a single MSSQL instance with a 40GB database. We targeted the maximum orders per minute (OPM) each cluster could achieve by increasing the thread count and decreasing the think time until performance degraded. The max thread count was 16 for the both clusters. We deployed a server for DVD Store clients to drive the workload. The client host ran 30 client VMs. We configured each client VM with 4 vCPUs, 8 GB of memory, and 50 GB of OS storage.

We used a Dell Networking 1Gb X1052 switch for the VMware management network. We used the Dell PowerEdge MX chassis' internal 25Gb switch for vMotion®, vSAN, and the VM network. On the 25Gb switch, we configured the following VLANs: 2 for the VM network, 2000 for the vMotion network, 3000 for the vSAN network. We also configured a port channel for each host using the two 25Gb ports from each host. We set the 25Gb switch MTU setting to 9,000. On the Distributed vSwitch, we created vSAN, vMotion, and workload port groups.

The following sections describe the steps we took to configure the test environment and run the test.

Installing vSphere version 8.0.0 build 20513097 on the servers

1. Download ESXi Version 8.0.0 build 20513097 from https://my.vmware.com/group/vmware/evalcenter?p=vsphere-eval-8#tab_download.
2. Open a new browser tab, and connect to the IP address of the MX blade iDRAC.
3. Log in with the iDRAC credentials.
4. In the main screen, click Launch Virtual Console.
5. In the console menu bar, select Virtual Media, and select Virtual Storage.
6. In the Virtual Storage popup window, select ISO from the drop-down menu, and click Open Image. Browse local computers, and select the image you downloaded in step 1.
7. To mount the ISO image, click Plug In, and click OK.
8. On the console menu bar, click the Power Control, and select Power Reset.
9. The system will boot to the mounted image and the Loading ESXi installer screen will appear. When prompted, press Enter to continue.
10. To Accept the EULA and Continue, press F11.
11. Select the storage device to target for installation. We selected the internal SD card. To continue, press Enter.
12. To confirm the storage target, press Enter.
13. Select the keyboard layout, and press Enter.
14. Provide a root password, and confirm the password. To continue, press Enter.
15. To install, press F11.
16. Upon completion, to reboot the server, press Enter.
17. Complete steps 1 through 16 for each server under test.

Installing VMware vCenter Server Appliance version 8.0.0 build 20920323

Note: We deployed the vCenter appliance on one of the client hosts for management of the vSphere environment.

1. Download VMware vCenter version 8.0.0 build 20920323 from the VMware support portal at <https://my.vmware.com>.
2. Mount the image on your local system, and browse to the vcsa-ui-installer folder. Expand the folder for your OS, and launch the installer if it doesn't automatically begin.
3. When the vCenter Server Installer wizard opens, click Install.
4. To begin installation of the new vCenter server appliance, click Next.
5. To accept the license agreement, check the box, and click Next.
6. Enter the IP address of the infrastructure server with VMware ESXi version 8.0. build 20513097. Provide the root password, and click Next.
7. To accept the SHA1 thumbprint of the server's certificate, click Yes.
8. Accept the VM name, and provide and confirm the root password for the VCSA. Click Next.
9. Set the size for environment you're planning to deploy. We selected Medium. Click Next.
10. Select the datastore on which to install vCenter. Accept the datastore defaults, and click Next.

11. Enter the FQDN, IP address information, and DNS servers you want to use for the vCenter server appliance. Click Next.
12. To begin deployment, click Finish.
13. When Stage 1 has completed, click Close. To confirm, click Yes.
14. Open a browser window and connect to [https://\[vcenter.FQDN\]:5480/](https://[vcenter.FQDN]:5480/).
15. On the Getting Started - vCenter Server page, click Set up.
16. Enter the root password, and click Log in.
17. Click Next.
18. Enable SSH access, and click Next.
19. To confirm the changes, click OK.
20. Type `vsphere.local` for the Single Sign-On domain name. Enter a password for the administrator account, confirm it, and click Next.
21. Click Next.
22. Click Finish.

Creating a vSphere cluster in vCenter

1. Open a browser, and enter the address of the vCenter server you deployed. For example: `https://[vcenter.FQDN]/ui`
2. In the left panel, select the vCenter server, right-click, and select New Datacenter.
3. Provide a name for the new data center, and click OK.
4. Select the data center you just created, right-click, and select New Cluster.
5. Give a name to the cluster, and click OK.
6. In the cluster configuration panel, under Add hosts, click Add.
7. Check the box for Use the same credentials for all hosts. Enter the IP address and root credentials for the first host, and enter the IP addresses of all remaining hosts. Click Next.
8. To select all hosts, check the box beside Hostname/IP Address. Click OK.
9. Click Next.
10. Click Finish.

Creating a distributed vSwitch and port group

1. From vSphere client, click Home→Networking.
2. Select your Datacenter.
3. On the right panel, in the Actions drop-down menu, select Distributed Switch→New Distributed Switch.
4. Give your DSwitch a name, or accept the default. Click Next.
5. Select 8.0.0 - ESXi 8.0 and later as the version, and click Next.
6. Select the number of uplinks per ESXi host you'll give to the DSwitch. We selected two. Click Next.
7. Click Finish.
8. Select the new DSwitch, and click Configure.
9. Select Properties, and click Edit.
10. Under Advanced, set MTU (Bytes) to 9000.
11. Click OK.
12. Right-click the new DSwitch, and select Add and Manage Hosts.
13. Leave Add hosts selected, and click Next.
14. To add new hosts, click the +.
15. To select all the hosts in your target cluster, check the box for Host. Click OK, and click Next.
16. Select the NIC you want to use for this DSwitch, and click Assign Uplink.
17. Select the desired Uplink.
18. Check the box for Apply this uplink assignment to the rest of the hosts. Click OK.
19. Complete steps 16 through 18 for the second NIC.
20. Click Next.
21. Do not assign vmkernel adapters. Click Next.
22. Do not migrate any VM networking. Click Next.
23. Click Finish.
24. Right-click the DvSwitch, and select Distributed Port Group→New Distributed Port Group.
25. Name it `Workload Network`, and click Next.
26. Change the VLAN type to VLAN, and set the VLAN ID to VLAN 2. Click Next.
27. Click Finish.
28. Complete steps 17 through 20 two times on each cluster using the following settings:
 - Name: vMotion; VLAN ID 2000
 - Name: vSAN; VLAN ID 3000

Creating a VMkernel adapter

Note: We completed these steps on each server under test for the private network, vSAN network, and vMotion network using the appropriate IPv4 settings for each network and enabling the corresponding service for each VMkernel adapter. We enabled the management service on the private network VMkernel and re-added the hosts to vCenter Server using the private IP.

1. From the vCenter UI in the Hosts and Clusters view, right-click a host, and click Add Networking.
2. Select VMkernel Network Adapter, and click Next.
3. Click Browse, and select existing network.
4. Select the desired Distributed Port Group you created in the previous section.
5. If necessary, assign a different network label.
6. Select the desired service or services for the VMkernel, and click Next.
7. Select use static IPv4 settings, and enter the desired IPv4 address, subnet mask, and default gateway.
8. Click Next.
9. Click Finish.

Configuring the VMware vSAN datastore

1. In the left panel of the vCenter, right-click the test cluster, select vSAN, and select configuration.
2. Select single site cluster, and click Next.
3. In the Services screen, click Next.
4. In the Claim disks screen, click the Group by drop-down menu, and select Host.
5. Select disks for each host. We selected two drives for cache and two drives for capacity. Click Next.
6. In the Review screen, click Finish.
7. Click the test cluster from vCenter, and in the right panel, click the Configure tab.
8. In the vSAN section, select Services.
9. Select I need a local vSAN datastore and Standard vSAN cluster, and click Configure.
10. Look over the Compatibility checks, and if satisfactory, click Next.
11. On the Services page, click Next.
12. On the Claim disks page, split your disks into equal disk groups across each host, and click Next. In our configuration, we claimed two drives per host for capacity, and two drives per host for cache.
13. On the Create fault domains page, click Next.
14. On the Review page, review the details of your configuration, and click Finish.

Creating the gold test VM

1. In vCenter, select a host to create a VM.
2. Right-click, and select New Virtual Machine.
3. Click Create a new virtual machine, and click Next.
4. Enter an appropriate VM name, select Datacenter, and click Next.
5. Select an appropriate host, and click Next.
6. Choose an appropriate datastore, and click Next.
7. Select an appropriate compatibility mode (ESXi 8.0 and later), and click Next.
8. For the Guest OS Family, select Windows, and for the Guest OS Version, select Windows Server 2022 (64-bit). Click Next.
9. In Customize Hardware, select the following:
 - 16 vCPU
 - 32GB memory fully reserved
 - 50GB OS hard drive
 - 100GB data hard drive
 - 20GB log hard drive
 - 70GB backup hard drive
10. Choose the appropriate VM Network, point the DVD drive to the installation media ISO in your datastore, and click Next.
11. Review, and click Finish.

Installing Windows Server 2022 on the gold test VM

1. We used the following steps to install and configure SQL Server VMs.
2. Attach the Windows Server 2022 ISO to the virtual machine.
3. Open the VM console, and start the VM.
4. When the system prompts you to boot from DVD, press any key.
5. When the installation screen appears, leave language, time/currency format, and input method as default, and click Next.
6. Click Install now.
7. When the installation prompts you, enter the product key.
8. Select Windows Server 2022 Datacenter Edition (Server with a GUI), and click Next.
9. Check I accept the license terms, and click Next.
10. Click Custom: Install Windows only (advanced).
11. Select Drive 0 Unallocated Space, and click Next. This starts Windows automatically, and Windows will restart automatically after completing.
12. 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.
13. Install VMware Tools in the VMs hosted on the ESXi servers.
14. From Server Manager, disable Windows Firewall.
15. Run Windows Updates.

Installing Microsoft SQL Server 2019 on gold test VM

1. Attach the installation media ISO for SQL Server 2019 to the VM.
2. Click Run SETUP.EXE. If Autoplay does not begin the installation, navigate to the SQL Server 2019 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.

Creating the gold client VM

1. In vCenter, select a host to create a VM.
2. Right-click, and select New Virtual Machine.
3. Click Create a new virtual machine, and click Next.
4. Enter an appropriate VM name, select Datacenter, and click Next.
5. Select an appropriate host, and click Next.
6. Choose an appropriate datastore, and click Next.
7. Select an appropriate compatibility mode (ESXi 8.0 and later), and click Next.
8. For the Guest OS Family, select Windows, and for the Guest OS Version, select Windows Server 2022 (64-bit). Click Next.
9. In Customize Hardware, select the following:
 - 4 vCPU
 - 8GB Memory fully reserved
 - 50GB OS hard drive
10. Choose appropriate VM Network, point the DVD drive to the installation media ISO in your datastore, and click Next
11. Review, and click Finish.

Installing Windows Server 2022 on the gold client VM

1. Attach the Windows Server 2022 ISO to the virtual machine.
2. Open the VM console, and start the VM.
3. When the system prompts you 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 2022 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.

Configuring and running the DVD Store 3 benchmark

Generating data

We generated the data using the Install.pl script included with DS3, 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 2019. 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 with 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 DS3 download. Make size modifications specific to the 100GB 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. To prevent excess logging, set the database recovery model to bulk-logged.
5. Load the data you 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. To create indices, full-text catalogs, primary keys, and foreign keys, use the database-creation scripts.
7. Update statistics on each table according to database-creation scripts, which sample 18 percent of the table data.

- 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
EXEC master..sp_addsrvrolemember @loginame = N'ds2user',
@rolename = N'sysadmin'
USE [DS3]
CREATE USER [ds3DS3user] FOR LOGIN [ds2user]
EXEC sp_addrolemember N'db_owner', N'ds3DS3user'
USE [master]
CREATE USER [ds3masteruser] FOR LOGIN [ds2user]
EXEC sp_addrolemember N'db_owner', N'ds3masteruser'
```

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

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

Each complete test cycle consisted of general steps:

- Clean up prior outputs from the target system.
- Drop the database from the target.
- Restore the database on the target.
- Reboot the target.
- Wait for a ping response from the server under test and the client system.
- Let the test server idle for 10 minutes.
- Start the DVD Store driver on the clients.

We used the following DVD Store 3 parameters for testing:

```
ds3sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=30 --n_threads=16 --db_size=40GB
--think_time=0 --detailed_view=Y --warmup_time=15 --pct_newcustomers=20 --pct_newmember=1 --pct_
newreviews=5 --pct_newhelpfulness=10 --csv_output=<drivepath>
```

Read the report at <https://facts.pt/2xbW7gM> ▶

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