The science behind the report:

Get significantly better transactional database performance for less from a Dell EMC PowerEdge R740xd server with value SAS and data center NVMe SSDs from KIOXIA

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 significantly better transactional database performance for less from a Dell EMC PowerEdge R740xd server with value SAS and data center NVMe SSDs from KIOXIA.

We concluded our hands-on testing on March 4, 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 January 4, 2019 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Cost analysis results

To calculate the cost of the Dell EMC™ PowerEdge™ R740xd 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. To calculate the TPS-per-dollar metric, we divided the total TPS by the total solution cost of each configuration.

Configuration	Total TPS	Total solution cost	TPS per dollar
Dell EMC PowerEdge R740xd with enterprise SATA SSDs (RAID)	2,779	$41,872.00	0.0663
Dell EMC PowerEdge R740xd with enterprise SATA SSDs (no RAID)	4,453	$41,872.00	0.1063
Dell EMC PowerEdge R740xd with RM5 Series value SAS SSDs (RAID)	4,771	$41,472.00	0.1150
Dell EMC PowerEdge R740xd with RM5 Series value SAS SSDs (no RAID)	5,872	$41,472.00	0.1415
Dell EMC PowerEdge R740xd with CD5 Series data center NVMe SSDs (no RAID)	5,987	$43,072.00	0.1389

Configuration	Percent win
vs. Dell EMC PowerEdge R740xd with enterprise SATA SSDs (RAID)	
Dell EMC PowerEdge R740xd with RM5 Series value SAS SSDs (RAID)	73.45%
Dell EMC PowerEdge R740xd with CD5 Series data center NVMe SSDs (no RAID)	109.50%
vs. Dell EMC PowerEdge R740xd with enterprise SATA SSDs (no RAID)	
Dell EMC PowerEdge R740xd with RM5 Series value SAS SSDs (no RAID)	33.11%
Dell EMC PowerEdge R740xd with CD5 Series data center NVMe SSDs (no RAID)	30.66%

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System configuration information

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

Server configuration information	Dell EMC PowerEdge R740xd
BIOS name and version	Dell 1.6.12
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	01/04/2019
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)	256
Number of memory modules	16
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 H740P
Cache size (MB)	8
Firmware version	50.50-1750
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 (speed, interface, type)	SATA M.2 SSD

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Server configuration information	Dell EMC PowerEdge R740xd
Local storage #2	
Number of drives	4
Drive vendor and model	Intel SSDSC2KB960G8R
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	KIOXIA KRM5XRUG960G
Drive size (GB)	960
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
Local storage #4	
Number of drives	4
Drive vendor and model	KIOXIA KCD5XLUG960G
Drive size (GB)	960
Drive information (speed, interface, type)	PCIe Gen3 x4 2.5" NVMe SSD
Local storage #5	
Number of drives	8
Drive vendor and model	KIOXIA PX05SMB320Y
Drive size (GB)	3.2
Drive information (speed, interface, type)	12Gbps SAS 2.5" SSD
Network adapter #1	
Vendor and model	Broadcom® Corporation NetXtreme® BCM5720 Gigabit Ethernet
Number and type of ports	4 x 1GbE
Network adapter #2	
Vendor and model	Intel Ethernet 10G 2P x520 Adapter
Number and type of ports	2 x 10GbE
Cooling fans	
Vendor and model	Nidec® UltraFlo™ 4VXP3-X30
Number of cooling fans	6
Power supplies	
Vendor and model	Dell 0CMPGMA00
Number of power supplies	2
Wattage of each (W)	1,100

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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. For 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 rest of the servers.

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

Creating a cluster and adding the hosts to VMware vCenter

1. Log into the vCenter, and 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 a name for the new cluster, and click OK.
7. Once the cluster has been created, right-click the cluster, and click Add Host.

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8. Enter the FQDN or IP for the first server, and click Next.
9. Enter the root credentials for the server, and click Next.
10. To accept the server's certificate, click Yes.
11. Review the server details, and click Next.
12. Assign the desired license, and click Next.
13. Disable Lockdown mode, and click Next.
14. Click Finish.
15. Repeat steps 7 through 14 for the remaining servers in the cluster.

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 appropriate 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 24.
   - Set the Memory to 4GB.
   - Add 1 x 40GB VMDK for OS, 1 x 310GB VMDKs for database.1 x100GB VMDK for database logs, and 1x 200GB VMDK for backup. Set OS VMDK to thin provisioning, then set all other VMDKs to thick provision eager zeroed. Note: For our testing, we set up an Offload datastore for all volumes except db and log to isolate those volumes under test.
   - Create three additional VMware Paravirtual SCSI controllers, and assign the VMDKs to the new controllers.
   - Attach the OS ISO to the CD/DVD drive.
9. Click Next.
10. Click Finish.

Installing Microsoft Windows Server® 2016

We used the following steps to install and configure SQL Server VMs:

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 start automatically and 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 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. To accept the license terms, click the checkbox, and click Next.
6. Click Use Microsoft Update to check for updates, and click Next.
7. To install the setup support files, click Install.

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8. If no failures are displayed, click Next.
9. At the Setup Role screen, choose SQL Server Feature Installation, and click Next.
10. At the Feature Selection screen, select Database Engine Services, Full-Text and Semantic Extractions for Search, Client Tools Connectivity, and Client Tools Backwards Compatibility.
11. Click Next.
12. At the Instance Configuration screen, leave the instance default selection, and click Next.
13. At the Database Engine Configuration screen, select the authentication method you prefer. For our testing purposes, we selected Mixed Mode.
14. Enter and confirm a password for the system administrator account.
15. Click Add Current user. This may take several seconds.
16. Click the Data Directories tab.
17. Change the database directory, the database log directory, and the backup directory storage locations to the data, log, and backup volumes.
18. Click the TempDB tab.
19. Change the number of files to 8.
20. Change the initial file size to 1,024 MB.
21. Change the Data Directory to the data volume.
22. Change the initial size of the log to 1,024 MB.
23. Change the Log Directory to the log volume.
24. Click Next.
25. At the Error and usage reporting screen, click Next.
26. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
27. At the Ready to Install screen, click Install.
28. When the install finishes, go to the Installation tab in the Installation Center, and click Install SQL Server Management Tools.
29. In the browser that pops up, click Download SQL Server Management Studio 17.X.
30. Click the download to open the installer.
31. Click Run.
32. Click Install.
33. When the installation is complete, close the installation window.

Enabling Lock pages in memory

1. Click Start, and type `gpedit.msc` and press Enter.
2. In the Local Group Policy Editor, expand Computer Configuration→Windows Settings→Security Settings→Local Policies.
3. Select User Rights Assignment, and scroll down to Lock pages in memory in the right pane.
4. Right-click Lock pages in memory, and click Properties.
5. Click Add User or Group, and add your SQL user account (NT SERVICE\MSSQLSERVER).
6. Click OK.

Setting up the benchmark

We used a client VM running Windows Server 2016 and installed Benchmark Factory for Databases to target our VMs under test.

Creating a database on the VMs under test

1. Open SQL Server Management Studio.
2. Select SQL Server Authentication, type `sa` and `Password1` as your login and password respectively, and click Connect.
3. Right-click Databases→New Database.
4. Name the database. We named ours `tpce`.
5. Click OK.

Installing Benchmark Factory for Databases 8.0.1 on the clients

1. Navigate to the Benchmark Factory for Databases 8.0.1 installation media and launch the installer.
2. At the first screen of the install wizard, click Next.
3. At the License Agreement screen, accept the license terms, and click Next.
4. At the Destination Folder screen, select an installation path, and click Next.
5. At the Ready to Install the Program screen, click Install.
6. After the wizard completes, click Finish.

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Populating the database

1. On the client VM, double-click the Benchmark Factory shortcut to open the program.
2. Select whether you'd like to participate in the Product Improvement Program, and click OK.
3. When the program first opens, a New Job Wizard window appears. To create a connection profile to the VM under test, click Create Connection Profile.
4. From the drop-down menu under Database Type, select Microsoft SQL Server.
5. In the Server name field, type the name or IP address of the server.
6. In the Authentication field, select SQL Server Authentication.
7. Enter the login and password credentials for the VM under test.
8. From the database drop-down menu, select the TPC-E database you created earlier.
9. Enter a connection name.
10. Click Test Connection, and verify that the connection is successful.
11. Click Create Connection.
12. In the Database Under Test section of the New Job Wizard, test the connection again to double-check that it's connected properly. Optionally, you can have the Benchmark Factory wizard detect the environment information.
13. Click Add Workload.
14. From the Test type drop-down menu, select Create/Delete Benchmark Objects Test.
15. From the Benchmark Type drop-down menu, select TPC-E.
16. Click the bubble next to Create/Load objects if objects don't exist (no backup sets created).
17. Click Add Test.
18. Click Test Options.
19. Change the Benchmark Scale to 20.
20. Click Job Setup.
21. Click Agent Setup.
22. Select the Agent that's on the local machine, and click Run Job. Note: This build could take several hours.

Backing up the database

1. Open SQL Server Management Studio.
2. Right-click the tpce database, and click Tasks→Back up…
3. Choose a location to store the backup, and click OK.

Cloning the VMs under test

1. Shut down the gold VM.
2. Right-click the VM and select Clone→Clone to Virtual Machine.
3. Choose a name and your desired Datacenter, and click Next.
4. Choose a compute resource, and click Next.
5. Choose the desired datastore, and click Next.
6. Click Next.
7. Click Finish.
8. Repeat steps 2 through 7 for the remaining VMs.

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Running the test

After cloning the VMs under test, we also cloned out four client VMs, with each VM targeting one of the VMs under test. On the VMs under test, we started perfmon counters and let them run while the system was idle for 10 minutes before starting the test. On the client, we opened Benchmark Factory and created and ran a new TPC-E job, making use of the schedule function so that we could start all of the VMs at the same time. Below are the steps that we took to configure and test the benchmark:

1. On the client VM, open Benchmark Factory for Databases.
2. Click New.
3. From the drop-down menu, select the database on the VM under test.
4. Click Add workload.
5. From the type of test drop-down menu, select Industry Standard Benchmark Test.
6. Select TPC-E, and click Add Test.
7. Click Test Options.
8. Click the bubble next to Create/Load objects if objects don't exist (no backup sets created).
9. Click the TPC-E Transaction Mix in the left menu.
10. Click Test Options.
11. Edit each transaction, and select No delay for the latency.
12. Select the User Load Tab.
13. Click Delete All.
14. Change the user load to 50, and click Add.
15. Select the Timing Tab.
16. Set the Pre-Sampling period to 30 minutes and the Sampling period to 30 minutes.
17. Click Job Setup.
18. Click the Schedule Tab.
19. Enter the time at which you would like the test to start.
20. Click Agent Setup.
21. Select the agent on the local machine, and click Run Job.
22. Repeat the test two more times and report the median of the three runs.

Read the report at http://facts.pt/q7mwkro ▶

This project was commissioned by KIOXIA

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