



The science behind the report:

# Boost database performance in VMware vSAN environments with Toshiba PX05S SAS SSDs and Dell EMC PowerEdge R740xd 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 [Boost database performance in VMware vSAN environments with Toshiba PX05S SAS SSDs and Dell EMC PowerEdge R740xd servers](#).

On March 22, 2018, we finalized the hardware and software configurations we tested. Updates for current and recently released hardware and software appear often, so unavoidably these configurations may not represent the latest versions available when this report appears. For older systems, we chose configurations representative of typical purchases of those systems. We concluded hands-on testing on April 2, 2018.

## Our results

The tables below present our findings in detail.

18 VMs (R740xd) vs. 18 VMs (legacy)			
	Dell EMC™ PowerEdge™ R740xd cluster	Legacy cluster	
OPM	891,510	592,828	
Average OPM per VM	49,528	32,935	
Average read latency in ms	1.05	2.26	
Average write latency in ms	4.46	14.14	
MB read/sec	327.00	227.56	
MB write/sec	377.87	244.14	

24 VMs (R740xd) vs. 18 VMs (legacy)			
	Dell EMC PowerEdge R740xd cluster	Legacy cluster	
OPM	1,067,868	592,828	
Average OPM per VM	44,495	32,935	
Average read latency in ms	1.62	2.26	
Average write latency in ms	6.95	14.14	
MB read/sec	396.77	227.56	
MB write/sec	444.99	244.14	

## System configuration information

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

Server configuration information	Dell EMC PowerEdge R740xd	Dell EMC PowerEdge R730
BIOS name and version	Dell 1.3.7	Dell 2.7.1
Operating system name and version/build number	ESXi™ 6.5.0	ESXi 6.5.0
Date of last OS updates/patches applied	March 21, 2018	March 21, 2018
Power management policy	Performance	Performance
Processor		
Number of processors	2	2
Vendor and model	Intel® Xeon® Gold 6130	Intel Xeon E5-2690 v4
Core count (per processor)	16	14
Core frequency (GHz)	2.10	2.60
Stepping	H0	M0
Memory module(s)		
Total memory in system (GB)	128	128
Number of memory modules	8	16
Vendor and model	Samsung® M393A2K43BB1-CTD	Samsung M393A1G43DB0-CPB
Size (GB)	16	8
Type	DDR4	DDR4
Speed (MHz)	2,666	2,133
Speed running in the server (MHz)	2,666	2,133
Storage controller		
Vendor and model	Dell PERC H730P	Dell PERC H730P Mini
Cache size (GB)	2	2
Firmware version	25.5.4.0006	25.5.4.0006
Driver version	7.700.50.00	7.700.50.00
Local storage (type A)		
Number of drives	2	2
Drive vendor and model	Intel SSDSCKJB120G7R	Seagate® ST300MM0006
Drive size (GB)	120	300
Drive information (speed, interface, type)	M.2 SSD	10K, 6Gb SAS, HDD
Local storage (type B)		
Number of drives	4	4
Drive vendor and model	Toshiba PX05SMB320Y	Seagate ST600MM0088
Drive size (GB)	3,200	600
Drive information (speed, interface, type)	SAS SSD	10K, 12Gb SAS, HDD

Server configuration information	Dell EMC PowerEdge R740xd	Dell EMC PowerEdge R730
Local storage (type C)		
Number of drives	N/A	2
Drive vendor and model	N/A	Intel DC S3710 SSDSC2BA400G4
Drive size (GB)	N/A	400
Drive information (speed, interface, type)	N/A	SATA SSD
Network adapter 1		
Vendor and model	Broadcom Corporation NetXtreme BCM5720 Gigabit Ethernet	Broadcom Corporation NetXtreme BCM5720 Gigabit Ethernet
Number and type of ports	4 x 1GbE	4 x 1GbE
Network adapter 2		
Vendor and model	Intel Ethernet 10G 2P x520 Adapter	Intel 82599 10 Gigabit Dual Port Network Connection
Number and type of ports	2 x 10GbE	2 x 10GbE
Cooling fans		
Vendor and model	Nidec® UltraFlo™ 4VXP3-X30	NMB 06038DA-12S-EWH
Number of cooling fans	6	6
Power supplies		
Vendor and model	Dell 0CMPGMA00	Dell 0G6W6KX02
Number of power supplies	2	2
Wattage of each (W)	1,100	750

## How we tested

We installed and configured the latest available version of VMware vSphere® 6.5 on both the 14th generation Dell EMC server cluster (with three Dell EMC PowerEdge R740xd servers) and the legacy server cluster (with three PowerEdge R730 servers). On the PowerEdge R740xd servers, we installed the hypervisors using a Dell EMC Boss module. On the legacy servers, we installed the hypervisors on two 300GB HDDs configured on a RAID1 pair.

For the Dell EMC PowerEdge R740xd servers, we created a three-node VMware vSAN™ cluster with two disk groups per server. Two 3.2TB SSD drives made up each disk group. We used the default vSAN storage policy, which had the following settings:

- Number of failures to tolerate = 1
- Number of disk stripes per object = 1
- Object space reservation = 0%
- Flash read cache reservation = 0%
- Force provisioning = NO

We configured the Dell EMC PowerEdge R730 servers to create a three-node vSAN cluster with two disk groups per server. Each disk group contained one 300GB SSD drive as a cache device and two 600GB 10K SAS HDDs as capacity devices.

For each cluster, we configured 18 SQL Server® VMs with Windows Server® 2016 and SQL Server 2017. All the VMs we tested had 4 GB of memory, four vCPUs, a 50GB drive for OS, a 60GB drive for database files, and a 25GB drive for database logs.

We used DVD Store Version 2.1 as a test harness to simulate an online store where customers log in, search for products, and make purchases. DVD Store 2 also performs other actions, such as adding new customers, to exercise a wide range of everyday database functions. Our DVD Store 2 tests consisted of a 30-minute warm-up period followed by a 60-minute test period.

## Installing VMware ESXi 6.5

1. Attach the installation media.
2. Power on 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. Under 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 other servers.

## Deploying the VMware vCenter Server® 6.5

1. On a Windows server or VM, locate the VMware-VCSA installer image.
2. Mount the image, navigate to the VCSA folder, and launch VMware-ClientIntegrationPlugin.exe.
3. In the wizard that appears, click Next.
4. Accept the terms of the license agreement, and click Next.
5. Leave the default installation directory, and click Next.
6. Click Install.
7. Click Finish.
8. In the mounted image's top directory, open vcsa-setup.html.
9. When prompted, click Allow.
10. Click Install.
11. Accept the terms of the license agreement, and click Next.
12. Enter the FQDN or IP address of the host onto which you will be deploying the vCenter Server Appliance.
13. Provide a username and password for the system in question, and click Next.
14. Accept the certificate of the host you chose to connect to by clicking Yes.
15. Select the appropriate datacenter, and click Next.
16. Select the appropriate resource, and click Next.
17. Provide a name and password for the virtual machine, and click Next.
18. Select Install vCenter Server with an Embedded Platform Services Controller, 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. Set an appropriate Appliance Size, and click Next.
23. Select an appropriate datastore, and click Next.
24. Select Use an embedded database (PostgreSQL), and click Next.
25. At the Network Settings page, configure the network settings as appropriate for your environment, and click Next.
26. Review your settings, and click Finish.
27. When installation completes, click Close.
28. Using the vSphere web client, log into the vCenter server with the credentials previously provided.

## Creating a cluster and adding the hosts to VMware vCenter

1. Once logged into the 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 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. Once you have created the cluster, right-click it, and click Add Host.
9. Enter the IP address 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 10 through 15 for the remaining servers.

## 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: 6.5.0, 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, and for the MTU setting, type 9000
12. Click OK.
13. On the left side, right-click the new vSAN port group that was created 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 10Gb 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. Check the VMotion service to enable it, and 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. Check the Virtual SAN service to enable it, and click Next.
44. Enter the desired network information for the new VMkernel, and click Next. Click OK. Select each of the remaining hosts individually, and repeat steps 33 through 44 for each server. Click Next.
45. Analyze the impact, and click Next.
46. Review the settings, and click Next.

## Enabling Virtual SAN on 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 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 SQL Server VMs

We used the following steps to create 18 SQL Server VMs per cluster.

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, complete the following:
  - Set the vCPU count to 4.
  - Set the Memory to 8GB.
  - Add 1 x 50GB VMDK for OS, 1 x 60GB VMDK for database and 1 x 25GB VMDK for database logs. Set database and log VMDKs to Thick provision eager zeroed.
  - 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 and configuring SQL Server VMs

## Installing Microsoft® Windows Server 2016 Datacenter Edition

1. Provide a datastore with the Windows Server 2016 installation media.
2. Attach the Windows Server 2016 ISO to the virtual machine.
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 the 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 (Desktop Experience), 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 automatically begin and restart after completing).
11. When the Settings page appears, complete the Password and Reenter Password fields using the same password.
12. Log in with the password you set up previously.

## Installing 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.
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 Next.
17. At the Error and usage reporting screen, click Next.
18. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
19. At the Ready to Install screen, click Install.
20. Close the installation window.

## Configuring the database

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 on which we ran, Microsoft SQL Server 2017. We ran the Install.pl script on a utility system running Linux®. The Install.pl script also generated 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 2008. We built the database in SQL Server 2008, and performed a full backup, storing the backup file on the C: drive for quick access. We used that backup file to restore the server between test runs.

The only modifications we made to the schema creation scripts were in the specified file sizes for our database. We deliberately 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 schema according to the DVD Store 2 (DS2) documentation. Specifically, we performed the following steps:

1. We generated the data and created the database and file structure using database creation scripts in the DS2 download. We made size modifications specific to our database and the appropriate changes to drive letters.
2. We transferred the files from our Linux data generation system to a Windows system running SQL Server.
3. Using the provided DVD Store scripts, we created database tables, stored procedures, and objects.
4. We set the database recovery model to bulk-logged to prevent excess logging.
5. We loaded the data we generated into the database. For data loading, we used the import wizard in SQL Server Management Studio. Where necessary, we retained options from the original scripts, such as Enable Identity Insert.
6. We created indices, full-text catalogs, primary keys, and foreign keys using the database-creation scripts.
7. We updated statistics on each table according to database-creation scripts, which sample 18 percent of the table data.
8. On the SQL Server instance, we created 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. We set the database recovery model back to full.
10. We created the necessary full text index using SQL Server Management Studio.
11. We created a database user and mapped this user to the SQL Server login.
12. We performed a full backup of the database. This backup allowed us to restore the databases to a pristine state relatively quickly between tests.

## Running the test

### Test start and run times

We ran the workloads with one client per target database, and have included the specific testing parameters we used for the benchmark below.

### 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 2 outputs an orders per minute metric, which is a running average calculated through the test. In this report, we included the aggregate OPM reported by the clients for each run.

Each complete test cycle consisted of the general steps listed below.

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

We used the following DVD Store parameters for testing:

```
ds2sqlserverdriver.exe --target=<target_IP> --ramp_rate=10 --run_time=60
--n_threads=64 --db_size=20GB --think_time=0.005 --detailed_view=Y --warmup_
time=30 --csv_output=<drive_path>
```

Read the report at <http://facts.pt/YGsAaz> ►

This project was commissioned by Dell Technologies.



Facts matter.®

Principled Technologies is a registered trademark of Principled Technologies, Inc.  
All other product names are the trademarks of their respective owners.

#### DISCLAIMER OF WARRANTIES; LIMITATION OF LIABILITY:

Principled Technologies, Inc. has made reasonable efforts to ensure the accuracy and validity of its testing, however, Principled Technologies, Inc. specifically disclaims any warranty, expressed or implied, relating to the test results and analysis, their accuracy, completeness or quality, including any implied warranty of fitness for any particular purpose. All persons or entities relying on the results of any testing do so at their own risk, and agree that Principled Technologies, Inc., its employees and its subcontractors shall have no liability whatsoever from any claim of loss or damage on account of any alleged error or defect in any testing procedure or result.

In no event shall Principled Technologies, Inc. be liable for indirect, special, incidental, or consequential damages in connection with its testing, even if advised of the possibility of such damages. In no event shall Principled Technologies, Inc.'s liability, including for direct damages, exceed the amounts paid in connection with Principled Technologies, Inc.'s testing. Customer's sole and exclusive remedies are as set forth herein.