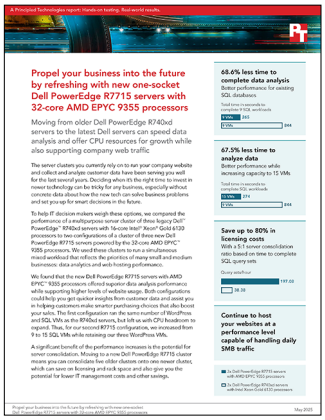

The science behind the report:

Propel your business into the future by refreshing with new one-socket Dell PowerEdge R7715 servers with 32-core AMD EPYC 9355 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 Propel your business into the future by refreshing with new one-socket Dell PowerEdge R7715 servers with 32-core AMD EPYC 9355 processors.

We concluded our hands-on testing on March 20, 2025. 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 10, 2025 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 3: Results of our testing.

	Dell PowerEdge R740xd server cluster with Intel Xeon Gold 6130 processors	Dell PowerEdge R7715 server cluster with AMD EPYC 9355 processors
Data analysis performance (TPROC-H) (Time to complete in seconds)		
9 VMs	844	265
15 VMs	—	274
Data analysis query sets per hour (TPROC-H) (Query sets per hour)		
9 VMs	38.38	122.26
15 VMs	—	197.08
Average WordPress transactions per second (TPS)		
9 VMs	79.13	312.27
15 VMs	—	228.56
Consolidation potential		
	5	1

CPU utilization

In order to gauge that we were fully utilizing the hosts, we used Windows Performance Monitor to track CPU utilization of each host. We used the Hyper-V Hypervisor Logical Processor(_Total) % Total Run Time counter for tracking. Since the database VMs finish the TPROC-H test at different times, we used the CPU% during the full load time of the run to gauge host utilization. The charts below show the average of the three hosts in each cluster during the test. Note: the x-axis differs between the charts below.

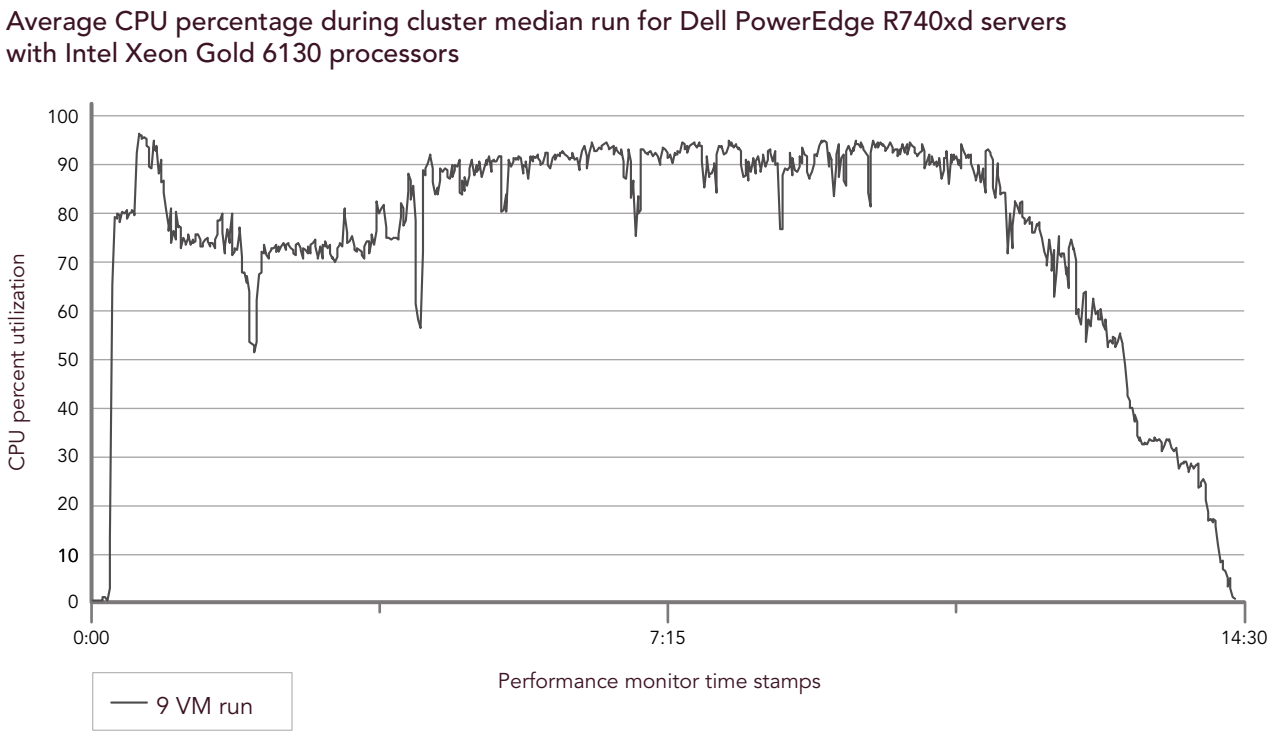

Figure 4: CPU utilization for the Dell PowerEdge R740xd server cluster during testing. Source: Principled Technologies.

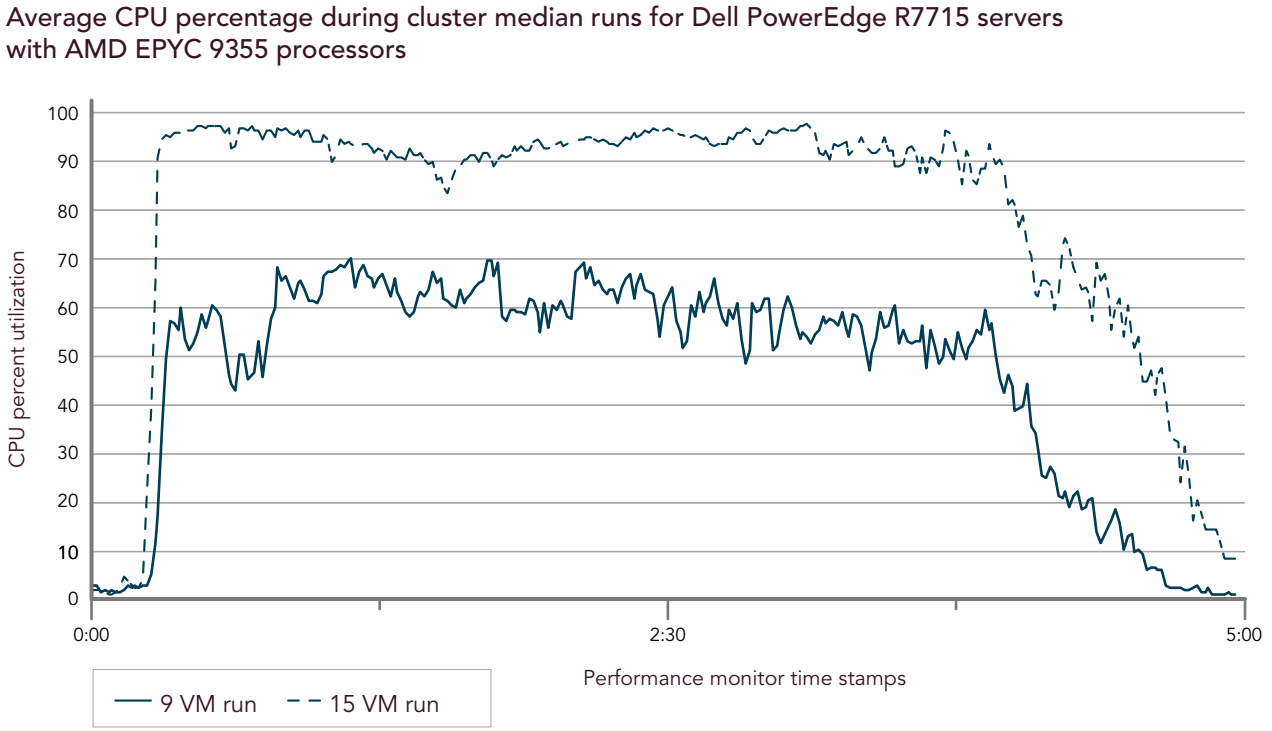

Figure 5: CPU utilization for the Dell PowerEdge R7715 server cluster during testing. Source: Principled Technologies.

System configuration information

Table 4: Detailed information on the systems we tested.

System configuration information	Dell PowerEdge R740xd	Dell PowerEdge R7715
BIOS name and version	2.22.2	1.03
Non-default BIOS settings	N/A	N/A
Operating system name and version/build number	Windows Server 2025	Windows Server 2025
Date of last OS updates/patches applied	12/27/2024	1/10/2025
Power management policy	Default - Performance per Watt (DAPC)	Default - Performance per Watt (OS)
Processor		
Number of processors	2	1
Vendor and model	Intel® Xeon® Gold 6130	AMD EPYC™ 9355
Core count (per processor)	16	32
Core frequency (GHz)	2.10	3.55
Stepping	Model 85 Stepping 4	Model 2 Stepping 1
Memory module(s)		
Total memory in system (GB)	128	384
Number of memory modules	8	12
Vendor and model	Hynix HMA82GR7AFR8N-VK	Samsung M321R4GA3PB2-CCPKC
Size (GB)	16	32
Type	DDR4	DDR5
Speed (MHz)	2,666	6,400
Speed running in the server (MHz)	2,666	5,200
Storage controller (A)		
Vendor and model	BOSS-S1	PERC H965i
Cache size (GB)	N/A	8361Mb
Firmware version	25.13.3024	8.8.0.018-15
Driver version	10.0.26100.1150	3.00.71.90
Storage controller (B)		
Vendor and model	Dell HBA330 Adp	N/A
Cache size (GB)	N/A	N/A
Firmware version	16.17.01.00	N/A
Driver version	2.51.27.80	N/A
Local storage (type A)		
Number of drives	2	2

System configuration information	Dell PowerEdge R740xd	Dell PowerEdge R7715
Drive vendor and model	Intel SSDSCKJB240G7R	KIOXIA KRM6VVUG1T92
Drive size (GB)	240	1,920
Drive information (speed, interface, type)	6Gbps/SATA/M.2	12 Gbps/SAS/SSD
Local storage (type B)		
Number of drives	20	2
Drive vendor and model	Samsung MZILS400HEGR0D3	Dell P5600 MU
Drive size (GB)	400	3,200
Drive information (speed, interface, type)	12Gbps/SAS/SSD	PCI-Express 4.0 x4/U.2SSD
Local storage (type C)		
Number of drives	N/A	2
Drive vendor and model	N/A	Dell Agnostic MU
Drive size (GB)	N/A	3,200
Drive information (speed, interface, type)	N/A	PCIe Gen 4.0 x 4/SSD
Local storage (type D)		
Number of drives	N/A	2
Drive vendor and model	N/A	Dell P5620 MU
Drive size (GB)	N/A	3,200
Drive information (speed, interface, type)	N/A	PCIe Gen 4.0 x 4/SSD
Network adapter		
Vendor and model	Mellanox ConnectX-4 LX 25GbE SFP Adapter	Mellanox ConnectX-6 Lx Adapter
Number and type of ports	2x 25 Gbps ports	2x 25 Gbps ports
Driver version	14.32.20.04	24.7.26520.0
Power supplies		
Vendor and model	Dell PWR SPLY,1100W,RDNT, DELTA/0Y26KXA02	Dell PWR SPLY,1100W,RDNT, LITEON/0D5NDXX30
Number of power supplies	2	2
Wattage of each (W)	1,100	1,100

How we tested

For our tests, we set up two three-node Storage Spaces Direct clusters: one comprising single-socket Dell PowerEdge R7715 servers with AMD EPYC 9355 processors, and the other comprising dual-socket Dell PowerEdge R740xd servers with Intel Xeon Gold 6130 processors. We configured RDMA networking on both clusters and installed Windows Server 2025 Datacenter (WS2025 Datacenter) on each server.

We configured both clusters with two 25GbE network connections: one for VM and management traffic, and the other for disk traffic. We configured Storage Spaces Direct with triple redundancy and created three S2D volumes on each cluster. Each volume was the same size—4TB per volume on the R7715 cluster and 2TB per volume on the R740 cluster—and we labeled each one according to the server responsible for maintaining it. After we created the volumes, we ensured that each host controlled a single volume.

We created our Microsoft SQL VMs by installing Windows Server 2025 Standard, Microsoft SQL Server 2022 Enterprise, and HammerDB v4.12. We created a 100-scale TPROC-H database with the data and log files split and placed them on their own Virtual Hard Drives (VHDs). We stored all VHDs on the same volume controlled by the host storing the VMs.

We created our WordPress VMs by installing Ubuntu 22.04 LTS and WordPress 6.7.1. We used WordPress Dummy Content Generator to build out a store website with a few hundred customer accounts.

We performed exploratory testing to determine the right balance of TPROC-H and Siege performance while trying to utilize as close to 90 percent of the CPU as possible on each cluster. As a result of our exploratory testing, we determined the settings we outline in Table 4 for each cluster VM. We also determined that disabling NUMA Spanning at the VM hardware level improved performance for our test environment.

We simultaneously kicked off TPROC-H testing on all Microsoft SQL Server VMs and Siege on the WordPress VMs. We report how long it took for all SQL VMs to finish their TPROC-H queries. This means that although some VMs finished faster, the final time to finish is the length of time the longest-running VM took to run the query sets. We used five HammerDB streams according to the suggested user count for database size table in the TPC-H documentation (page 96) TPROC-H does not require external client VMs. We used one Siege virtual user (VU), which represents roughly 100 real-world users. We also created one Siege client to run the WordPress testing. We report the transactions per second and throughput in MB/s for each WordPress VM recorded from the duration of the TPROC-H tests.

Table 5: The settings we used for each cluster VM.

	Dell PowerEdge R7715 with AMD EPYC 9355 processors (9 VMs)	Dell PowerEdge R7715 with AMD EPYC 9355 processors (15 VMs)	Dell PowerEdge R740xd with Intel Xeon Gold 6130 processors (9 VMs)	All WordPress VMs
Number of vCPUs	16	16	16	8
Memory (GB)	112	64	32	4
OS disk size (GB)	50	50	50	60
Data disk size (GB)	120	120	140	N/A
Log disk size (GB)	80	80	80	N/A

Installing and configuring the infrastructure

Installing and configuring the Active Directory (AD) server

We installed our AD server on a virtual machine, but so long as your AD server has access to the testing network, you can install it on any system compatible with Windows Server 2025.

Installing Windows Server 2025

1. Launch Virtual Viewer.
2. Click Virtual Media.
3. Under Map CD/DVD, click Browse, navigate to the correct ISO, select it, and click Open.
4. Click Map Device, and click Close.
5. Click Power, and select Warm Boot.
6. To interrupt boot and access the Dell Boot Manager, press the F11 key.
7. Click One-Shot UEFI Manager.
8. Select Virtual Optical Drive.

9. When prompted, press any key to boot into the Windows Server 2025 ISO.
10. On the Windows Setup screen, press Enter.
11. On the Select Language settings screen, leave defaults, and click Next.
12. On the Select keyboard settings screen, leave defaults, and click Next.
13. On the Select setup option screen, choose Install Windows Server, check the box to agree to deleting everything, and click Next.
14. On the Select Image screen, choose Windows Server 2025 Datacenter Evaluation (Desktop Experience), and click Next.
15. On the Select location to install Windows Server screen, choose the OS disk (likely Disk 0), and click Next.
16. On the Ready to install screen, click Install.
17. After the install finishes and the VM reboots, on the Customize settings screen, type an administrator password into the Password and Reenter Password fields. Click Finish.
18. Log into the OS.
19. Open Server Manager.
20. In the menu on the left, click Local Server.
21. Click the IP Address of the primary NIC your system is using.
22. Click IPv4, and click Properties.
23. Change the IP address of the AD server to an appropriate IP, and click OK.

Changing the host name on WS2025

1. On the intended server, open Server Manager.
2. In the menu on the left, click Local Server.
3. Click Computer name, and select Change.
4. Enter the desired computer name, and click OK.
5. When prompted to restart, click Restart Now.

Installing Active Directory Domain Services (ADDS)

1. On the intended server, open Server Manager.
2. Click Add Roles and Features.
3. On the introduction screen, click Next.
4. Select Role-based or feature-based installation, and click Next.
5. Select your local machine, and click Next.
6. In the roles to add page, scroll to Active Directory Domain Services, and check the box.
7. The system will prompt you to add several features to allow ADDS to work. Click Add Features to continue.
8. On the roles page, click Next.
9. On the features to add page, click Next.
10. On the page with a description of ADDS, click Next.
11. On the confirmation page, verify you've added what you want, and click Install.
12. When the installation completes, close the window.
13. In the Server Manager, in the top right corner, click the alert, and choose Promote this server to a domain controller.
14. In the Configuring the deployment screen, select Add a new forest and name your domain, and click Next.
15. Enter a new password for the domain services recovery manager, and click Next.
16. Make sure the DNS options are unchecked, and click Next.
17. Accept the default NetBIOS name for the server, and click Next.
18. Accept the default file locations for ADDS, and click Next.
19. In the Review your choices screen, verify your selections, and click Next.
20. The system will check the deployment. If any errors appear, correct any mistakes. Otherwise, click Install.

Disabling Windows Firewall

1. In the Windows Search bar, type `Firewall`
2. Click Windows Defender Firewall with Advanced Security.
3. Under the Public Profile section, click Windows Defender Firewall Properties.
4. On the Domain profile page, under Firewall State, click the drop-down menu, and select Off.
5. Click Private profile, and under Firewall State, click the drop-down menu, and select Off.
6. Click Public profile, and under Firewall State, click the drop-down menu, and select Off.
7. Click OK.

Enabling Remote Desktop on WS2025

1. In Server Manager, click Local Server.
2. On the Local Server properties page, next to Remote Desktop, click Disabled.
3. In the System Properties menu that appears, select Allow remote connections to this computer.
4. On the warning that appears, click OK.
5. To exit, click OK.

Enabling Remote SSH Access

1. From Server Manager, click Local Server.
2. On the Local Server properties page, scroll down, and next to Remote SSH Access, select Disabled.
3. When prompted, type `Yes` and press Enter.

Running Windows Update on WS2025

1. In the Windows Search bar in the lower left, type Update, and Click on Check for updates.
2. Click Check for Updates.
3. Click Install All.

Installing and configuring the Hyper-V management server

We installed our management server on a virtual machine. However, as long as your management server has access to the testing network, you can install it on any system compatible with Windows Server 2025. System Center Virtual Machine Manager automatically makes the system on which it is installed a virtual machine manager (VMM) library server. As such, ensure that this system has sufficient disk space to host multiple ISOs and, if necessary, any VM templates you wish to create.

Installing Windows Server 2025

1. Launch Virtual Viewer.
2. Click Virtual Media.
3. Under Map CD/DVD, click Browse, navigate to the correct ISO, select it, and click Open.
4. Click Map Device, and click Close.
5. Click Power, and select Warm Boot.
6. To interrupt boot and access the Dell Boot Manager, press the F11 key.
7. Click One-Shot UEFI Manager.
8. Select Virtual Optical Drive.
9. When prompted, press any key to boot into the Windows Server 2025 ISO.
10. On the Windows Setup screen, press Enter.
11. On the Select Language settings screen, leave defaults, and click Next.
12. On the Select keyboard settings screen, leave defaults, and click Next.
13. On the Select setup option screen, choose Install Windows Server, check the box to agree to deleting everything, and click Next.
14. On the Select Image screen, choose Windows Server 2025 Datacenter Evaluation (Desktop Experience), and click Next.
15. On the Select location to install Windows Server screen, choose the OS disk (likely Disk 0), and click Next.
16. On the Ready to install screen, click Install.
17. After the install finishes and the VM reboots, on the Customize settings screen, type an administrator password into the Password and Reenter Password fields. Click Finish.

Changing the host name on WS2025

1. On the intended server, open Server Manager.
2. In the menu on the left, click Local Server.
3. Click Computer name, and select Change.
4. Enter the desired computer name, and click OK.
5. When prompted to restart, click Restart Now.

Joining a domain on WS2025

1. On the intended server, open Server Manager.
2. In the menu on the left, click Local Server.
3. Click Computer name, and select Change.
4. Under Member of, click the domain option.

5. Enter the name of the domain, and click OK.
6. When prompted, enter the login information to join the domain:
   - Domain: `s2d.test`
   - Username: `Administrator@s2d.test`
   - Password: `Password1`
7. Click OK twice.
8. When prompted to restart, click Restart Now.

Disabling Windows Firewall

1. In the Windows Search bar, type `Firewall`
2. Click Windows Defender Firewall with Advanced Security.
3. Under the Public Profile section, click Windows Defender Firewall Properties.
4. On the Domain profile page, under Firewall State, click the drop-down menu, and select Off.
5. Click Private profile, and under Firewall State, click the drop-down menu, and select Off.
6. Click Public profile, and under Firewall State, click the drop-down menu, and select Off.
7. Click OK.

Enabling Remote Desktop on WS2025

1. From Server Manager, click on Local Server.
2. On the Local Server properties page, next to Remote Desktop, click Disabled.
3. In the System Properties menu that appears, select Allow remote connections to this computer.
4. On the warning that appears, click OK.
5. To exit, click OK.

Running Windows Update on WS2025

1. In the Windows Search bar in the lower left, type `Update` and click Check for updates.
2. Click Check for Updates.
3. Click Install All.

Installing MS SQL Server 2022

1. Attach the installation media ISO for SQL Server 2022 to the VM.
2. Double-click the Setup application.
3. In the pane on the left, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Select Evaluation, and click Next.
6. Click the check box to accept the license terms, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.
8. On the Install Rules page, click Next.
9. Check the boxes for the following features, and click Next:
   - Database Engine Services
   - Full-Text and Semantic Extractions for Search
10. Leave the Default instance, and click Next.
11. Leave the default Service Accounts, and click Next.
12. On the Server Configuration tab, choose Mixed Mode, and enter and confirm a password for the SQL Server system administrator (SA) account.
13. Click Add Current User to Specify the SQL Server administrators.
14. On the Data Directories tab, change the data root directory to the database volume.
15. For the User database log directory, choose the log volume.
16. If you plan to have a locally stored backup, change the Backup directory to point to it.
17. Click Next.
18. At the Error and usage reporting screen, click Next.
19. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
20. At the Ready to Install screen, click Install.
21. Close the installation window.
22. Download and install SQL Server Management Studio.

Installing and configuring System Center Virtual Machine Manager (SCVMM)

1. Download the most recent SCVMM installer, and double-click it.
2. When prompted to run as an administrator, click Yes.
3. On the main page, click Install.
4. On the Select features to install page, select VMM management server, and click Next.
5. On the Product registration information page, don't enter a license to start an evaluation period.
6. On the Please read this license agreement page, click the check box acknowledging you have read, understood, and agree with the terms of the license agreement, and click Next.
7. On the Diagnostic and Usage Data page, click Next.
8. On the Microsoft Update page, enable Microsoft Update, and click Next.
9. On the Installation location page, keep defaults, and click Next.
10. On the Database configuration page, enter `localhost` as the name of the target SQL Server, specify that you will use a new database, and click Next.
11. On the Configure service account and distributed key management page, accept the default account for the VMM service and click Next.
12. On the Port configuration page, accept defaults, and click Next.
13. On the Library configuration page, make sure you have selected to create a new library share, and click Next.
14. On the Installation summary page, click Install.
15. When the setup finishes, click Close.

Installing and configuring Windows Admin Center

1. Download the most recent version of Windows Admin Center, and double-click it.
2. In the Welcome to the Windows Admin Center setup wizard window, click Next.
3. In the License Terms and Privacy Statement window, select the check box to accept the terms and privacy statement, and click Next.
4. In Select installation mode, select Express setup, and click Next.
5. In Select TLS certificate, choose to generate a self-signed certificate, and click Next.
6. In Automatic updates, allow updates, and click Next.
7. In Send diagnostic data to Microsoft, select your preference, and click Next.
8. In Ready to install, click Install.

Configuring the switch for the testing

Below are the most important configurations we used on our switch. As every switch has small differences, use the segments as guidelines rather than strict requirements.

Quality of service (QoS) configuration

```
wred wred_ecn
 random-detect color green minimum-threshold 1000 maximum-threshold 2000 drop-probability 100
 random-detect color yellow minimum-threshold 500 maximum-threshold 1000 drop-probability 100
 random-detect color red minimum-threshold 100 maximum-threshold 500 drop-probability 100
 random-detect ecn
!
class-map type application class-iscsi
!
class-map type network-qos pfcdot1p3
 match qos-group 3
!
class-map type queuing Q0
 match queue 0
!
class-map type queuing Q3
 match queue 3
!
class-map type queuing Q7
 match queue 7
!
class-map type network-qos class-map-name
!
class-map type qos .
!
class-map type network-qos class1
```

```
 match qos-group 1-7
!
trust dscp-map rDSCP
 qos-group 7 dscp 48
 qos-group 3 dscp 26
!
qos-map traffic-class 2Q
 queue 0 qos-group 0-2,4-6
 queue 3 qos-group 3
 queue 7 qos-group 7
!
policy-map type network-qos policy_pfcdot1p3
 !
 class pfcdot1p3
  pause
  pfc-cos 3
!
policy-map type queuing policy_2Q
 !
 class Q0
  bandwidth percent 20
 !
 class Q3
  bandwidth percent 80
  random-detect wred_ecn
!
policy-map type network-qos class11
 !
 class class1
!
system qos
  buffer-statistics-tracking
!
```

Interface configuration

We used this configuration on every interface involved in the testing to take advantage of the QoS configuration above:

```
no shutdown
switchport access vlan 1000
mtu 9216
flowcontrol receive off
flowcontrol transmit off
priority-flow-control mode on
service-policy input type network-qos policy_pfcdot1p3
service-policy output type queuing policy_2Q
ets mode on
qos-map traffic-class 2Q
```

Configuring the servers under test

Installing and configuring Windows Server 2025

Installing Windows Server 2025

1. Launch Virtual Viewer.
2. Click Virtual Media.
3. Under Map CD/DVD, click Browse, navigate to the correct ISO, select it, and click Open.
4. Click Map Device, and click Close.
5. Click Power, and select Warm Boot.
6. To interrupt boot and access the Dell Boot Manager, press the F11 key.
7. Click One-Shot UEFI Manager.
8. Select Virtual Optical Drive.
9. When prompted, press any key to boot into the Windows Server 2025 ISO.

10. On the Windows Setup screen, press the Enter key.
11. On the Select Language settings screen, leave defaults, and click Next.
12. On the Select keyboard settings screen, leave defaults, and click Next.
13. On the Select setup option screen, choose Install Windows Server, check the box to agree to deleting everything, and click Next.
14. On the Select Image screen, choose Windows Server 2025 Datacenter Evaluation (Desktop Experience), and click Next.
15. On the Select location to install Windows Server screen, choose the OS disk (likely Disk 0), and click Next.
16. On the Ready to install screen, click Install.
17. After the install finishes and the VM reboots, on the Customize settings screen, type an administrator password into the Password and Reenter Password fields. Click Finish.

Changing the host name on WS2025

1. On the intended server, open Server Manager.
2. In the menu on the left, click Local Server.
3. Click Computer name, and select Change.
4. Enter the desired computer name, and click OK.
5. When prompted to restart, click Restart Now.

Joining a domain on WS2025

1. On the intended server, open Server Manager.
2. In the menu on the left, click Local Server.
3. Click Computer name, and select Change.
4. Under Member of, click the domain option.
5. Enter the name of the domain, and click OK.
6. When prompted, enter the login information to join the domain:
   - Domain: `s2d.test`
   - Username: `Administrator@s2d.test`
   - Password: `Password1`
7. Click OK twice.
8. When prompted to restart, click Restart Now.

Disabling Windows Firewall

1. In the Windows Search bar, type `Firewall`
2. Click Windows Defender Firewall with Advanced Security.
3. Under the Public Profile section, click Windows Defender Firewall Properties.
4. On the Domain profile page, under Firewall State, click the drop-down menu, and select Off.
5. Click Private profile, and under Firewall State, click the drop-down menu, and select Off.
6. Click Public profile, and under Firewall State, click the drop-down menu, and select Off.
7. Click OK.

Enabling Remote Desktop on WS2025

1. In Server Manager, click Local Server.
2. On the Local Server properties page, next to Remote Desktop, click Disabled.
3. In the System Properties menu, select Allow remote connections to this computer.
4. On the warning that appears, click OK.
5. To exit, click OK.

Enabling Remote SSH Access

1. From Server Manager, click Local Server.
2. On the Local Server properties page, scroll down, and next to Remote SSH Access, select Disabled.
3. When prompted, type `Yes` and press Enter.

Enabling Hyper-V on WS2025

1. In Server Manager, in the top right, click Manage, and select Add Roles and Features.
2. On the first page, select Next.
3. Ensure Role-Based or feature-based installation is selected, and click Next.

4. Ensure Select a server from the server pool is selected, and click Next.
5. On the Select server roles menu, select Hyper-V, and click Next.
6. Ensure Include Management tools is checked, and click Add Features.
7. Click Next.
8. On the Select features menu, click Next.
9. On the Hyper-V menu, click Next.
10. Choose the correct port for the virtual switch, and click Next. We chose port 1.
11. Leave Virtual machine migration unchanged, and click Next.
12. Leave Default stores unchanged, and click Next.
13. On the Confirm installation selections screen, check Restart the destinations server automatically if required, and on the prompt that appears, click next.
14. Click install.

Running Windows Update on WS2025

1. In the Windows Search bar in the lower left, type `Update` and click Check for updates.
2. Click Check for Updates.
3. Click Install All.

Deploying and configuring Storage Spaces Direct

Deploying Storage Spaces Direct prerequisites on Windows Server 2025

1. Open PowerShell as an administrator.
2. Deploy prerequisites:

```
Install-WindowsFeature "Failover-Clustering", "Data-Center-Bridging", "RSAT-Clustering-PowerShell",
"Hyper-V-PowerShell", "FS-FileServer"
```

Configuring RDMA networking

While the following are the steps we used for our networking environment, we highly recommend that you consult the Converged NIC configuration document from Microsoft to ensure an accurate setup for your environment: https://github.com/Microsoft/SDN/blob/master/Diagnostics/S2D%20WS2016_ConvergedNIC_Configuration.docx

1. Open PowerShell as an administrator.
2. Retrieve the list of network adapters:

```
Get-NetAdapter
```

3. Rename the desired network adapter (e.g., "NIC in Slot 10 Port 2-1") to the desired name (in our case, S2D):

```
Rename-NetAdapter "NIC in Slot 10 Port 2-1" S2D
```

4. Optionally, test the network connection to a specific IP address (e.g., 172.17.0.31):

```
Test-NetConnection 172.17.0.31
```

5. Install the Data Center Bridging feature:

```
Install-WindowsFeature Data-Center-Bridging
```

Configuring individual port settings

1. Change the maximum transmission unit (MTU) to 9216:

```
Set-NetAdapterAdvancedProperty -Name S2D -RegistryKeyword MTU -RegistryValue 9216
Set-NetAdapterAdvancedProperty -Name S2D -RegistryKeyword FlowControl -RegistryValue Off
Set-NetAdapterAdvancedProperty -Name S2D -RegistryKeyword PriorityFlowControl -RegistryValue On
```

2. Create a new QoS policy for the cluster:

```
New-NetQosPolicy "Cluster" -Cluster -PriorityValue8021Action 7
```

3. Create a new traffic class for the cluster:

```
New-NetQosTrafficClass "Cluster" -Priority 7 -BandwidthPercentage 1 -Algorithm ETS
```

4. Create a new QoS policy for SMB traffic:

```
New-NetQosPolicy "SMB" -NetDirectPortMatchCondition 445 -PriorityValue8021Action 3
```

5. Enable flow control for the specified priority:

```
Enable-NetQosFlowControl -Priority 3
```

6. Create a new traffic class for SMB with specified bandwidth percentage:

```
New-NetQosTrafficClass "SMB" -Priority 3 -BandwidthPercentage 80 -Algorithm ETS
```

7. Enable QoS on the S2D interface:

```
Enable-NetAdapterQos -InterfaceAlias S2D
```

8. Set Data Center Bridging Capability Exchange (DCBX) settings for the S2D interface:

```
Set-NetQosDcbxSetting -InterfaceAlias S2D -Willing $False
```

Creating the Windows cluster

1. Optionally, on one of the S2D servers, verify that the cluster is ready for creation (we recommend this step):

```
Test-Cluster -Node <MachineName1, MachineName2, MachineName3, MachineName4> -Include "Storage Spaces
Direct", "Inventory", "Network", "System Configuration"
```

2. If the validation tool returns no errors, on the same S2D server, create the cluster:

```
New-Cluster -Name <ClusterName> -Node <MachineName1,MachineName2,MachineName3,MachineName4>
-NoStorage -IpAddress <X.X.X.X>
```

3. Open System Center Virtual Machine Manager (SCVMM) on the infrastructure server.
4. In SCVMM, select Fabric → Servers.
5. In the Servers view, select Add group → Add Resources → Hyper-V hosts and Clusters.
6. In the add Resource wizard, under Resource location, click Next.
7. In Credentials, enter your domain username and password, and click Next.

8. In Discovery scope, enter the FQDN of your cluster, and click Next.
9. In Target resources, select all the servers discovered by adding your cluster, and click Next.
10. In Host Group, leave defaults, and click Next.
11. In the Summary page, confirm your settings, and click Finish.
12. Log into Windows Admin Center, and select All Connections → Add.
13. Select Server clusters as the connection type, the FQDN of the cluster, and the credentials, and click Add.

Configuring Storage Spaces Direct

Before performing these steps, ensure that any drives you wish to use for S2D are clear and ready for integration into the cluster. If you are unsure how to do this, you can run the script Microsoft provided to quickly clear any non-boot disks on your S2D cluster.

1. Enable Storage Spaces Direct:

```
Enable-ClusterStorageSpacesDirect -CimSession <ClusterName>
```

2. Log into Windows Admin Center, and navigate to the cluster.
3. On the left pane, click Volumes.
4. In the Volumes page, select the Inventory tab, and click Create.
5. In the Create volume pane, enter the name of the volume (e.g., `Server 1`), the redundancy (Microsoft recommends 3-way mirror, so we selected that), and the size of the disk (we chose 2 TB on the PowerEdge R740xd cluster and 4TB on the PowerEdge R7715 cluster). Click Create.
6. Repeat steps 5 and 6 twice more, assigning one volume per Hyper-V host.
7. To ensure that each host is managing one volume, right-clicking the volume, select Move, and choose an appropriate destination server.

Creating and configuring the Microsoft SQL VMs

Before starting the following steps, upload the Windows Server 2025 ISO to the VMM library. We performed the steps below on the PowerEdge R740xd cluster. Repeat the same steps on the PowerEdge R7715 cluster, being sure to configure the VMs according to Table 4 and cloning a total of 15 VMs with five VMs on each host.

Creating a gold VM

1. On the PowerEdge R740xd cluster, open the System Center Virtual Machine Manager app.
2. Click VMs and Services → Create Virtual Machine → Create Virtual Machine.
3. In the wizard, choose Select Source, and click Create the new virtual machine with a blank virtual hard disk. Click Next.
4. In the Identity screen, give the VM a name, and select Generation 2. Click Next.
5. In the Configure Hardware screen, configure the following:
    a. Correct number of vCPUs and memory according to Table 4.
    b. Under Bus Configuration, click the existing disk, set Type to Static, and set the size for the OS drive according to Table 4.
    c. At the top, click the New button, and add a new disk set to the size for the database disk according to Table 4.
    d. Repeat step 3, but set the size according to the log disk in Table 4.
    e. Under Bus Configuration, click the Virtual DVD drive, choose Existing ISO image, and click Browse.
    f. In the library, choose the Windows Server 2025 ISO image, and click OK.
    g. Under Network Adapters, choose the VM network.
    h. Under Advanced, disable NUMA spanning. Click Next.
6. On the Select Destination screen, leave defaults, and click Next.
7. On the Select Host screen, choose one of the PowerEdge R740xd hosts, and click Next.
8. On the Configure Settings screen, leave defaults, and click Next.
9. On the Add Properties screen, leave defaults, and click Next.
10. On the Summary screen, click Create.

Installing WS2025 on the gold VM

1. In VMM, click the gold VM you created in the last section, and power it on.
2. To open the VM console, click Connect or view → Console.
3. When prompted, press any key to boot into the Windows Server 2025 ISO.
4. On the Select Language settings screen, leave defaults, and click Next.
5. On the Select keyboard settings screen, leave defaults, and click Next.
6. On the Select setup option screen, choose Install Windows Server, check the box to agree to deleting everything, and click Next.

7. On the Select Image screen, choose Windows Server 2025 Standard Evaluation (Desktop Experience), and click Next.
8. On the Select location to install Windows Server screen, choose the OS disk (likely Disk 0), and click Next.
9. On the Ready to install screen, click Install.
10. After the install finishes and the VM reboots, on the Customize settings screen, type an administrator password into the Password and Reenter Password fields. Click Finish.

Configuring WS2025 on the gold VM

Disabling Windows Firewall

1. In the Windows Search bar, type `Firewall`
2. Click Windows Defender Firewall with Advanced Security.
3. Under the Public Profile section, click Windows Defender Firewall Properties.
4. On the Domain profile page, under Firewall State, click the drop-down menu, and select Off.
5. Click Private profile, and under Firewall State, click the drop-down menu, and select Off.
6. Click Public profile, and under Firewall State, click the drop-down menu, and select Off.
7. Click OK.

Enabling Remote Desktop on WS2025

1. In Server Manager, click Local Server.
2. On the Local Server properties page, next to Remote Desktop, click Disabled.
3. In the System Properties menu, select Allow remote connections to this computer.
4. On the warning that appears, click OK.
5. To exit, click OK.

Enabling Remote SSH Access

1. From Server Manager, click Local Server.
2. On the Local Server properties page, scroll down, and next to Remote SSH Access, select Disabled.
3. When prompted, type `Yes` and press Enter.

Setting a static IP address

1. In the Windows Search bar, type `Control Panel`
2. Right-click the Ethernet port, and click Properties.
3. Double-click Internet Protocol Version 4 (TCP/IPv4).
4. Click Use the following IP address, and enter a static IP address for your network.
5. Click Use the following DNS server addresses, enter a static DNS address for your network, and click OK.
6. To close the Ethernet Properties window, click OK.

Running Windows Update

1. In the Windows Search bar, type `Update` and click Check for updates.
2. Click Check for Updates.
3. Click Install All.

Installing and configuring SQL Server 2022 on the gold VM

1. Attach the installation media ISO for SQL Server 2022 to the VM.
2. Double-click the Setup application
3. In the left pane, click Installation.
4. Click New SQL Server stand-alone installation or add features to an existing installation.
5. Select Evaluation, and click Next.
6. Click the check box to accept the license terms, and click Next.
7. Click Use Microsoft Update to check for updates, and click Next.

8. On the Install Rules page, click Next.
9. Check the boxes for the following features, and click Next:
   - Database Engine Services
   - Full-Text and Semantic Extractions for Search
10. Leave the Default instance, and click Next.
11. Leave the default Service Accounts, and click Next.
12. On the Server Configuration tab, choose Mixed Mode, and enter and confirm a password for the SQL Server system administrator account.
13. Click Add Current User to Specify the SQL Server administrators.
14. On the Data Directories tab, change the data root directory to the database volume.
15. Choose the log volume for the User database log directory.
16. If you plan to have a locally stored backup, change the Backup directory to point to it.
17. Click Next.
18. At the Error and usage reporting screen, click Next.
19. At the Installation Configuration Rules screen, check that there are no failures or relevant warnings, and click Next.
20. At the Ready to Install screen, click Install.
21. Close the installation window.
22. Download and install SQL Server Management Studio.

Enabling Lock pages in memory on the gold VM

1. In the Start menu, click Run. In the Open box, type `gpedit.msc`
2. On the Local Group Policy Editor console, expand Computer Configuration, and expand Windows Settings.
3. Expand Security Settings, and expand Local Policies.
4. Select the User Rights Assignment folder.
5. In the details pane, double-click Lock pages in memory.
6. In the dialog box for Local Security Setting - Lock pages in memory, click Add User or Group.
7. In the dialog box for Select Users, Service Accounts, or Groups, select the SQL Server Service account.
8. For this setting to take effect, restart the SQL Server Service.

Installing Microsoft ODBC Driver 18 for SQL Server

1. Download the latest ODBC Driver for SQL Server from https://learn.microsoft.com/en-us/sql/connect/odbc/download-odbc-driver-for-sql-server?view=sql-server-ver16.
2. Double-click the .exe file, and click Next.
3. Check the box to accept the terms, and click Next.
4. Click Next.
5. Click Install.
6. Click Finish.

Configuring the test database

Creating the database

1. Open SQL Server Management Studio.
2. Right-click Databases → New Database.
3. Name the database. We named ours tpch.
4. Navigate to the Filegroups tab, and create a new primary filegroup.
5. Navigate to the Files tab, and to add a data file, click Add.
6. Repeat step 5 until you have eight total data files.
7. Pregrow the database files to 12,500 MB each.
8. Pregrow the log file to 16,584 MB.
9. Rename the database files, and click OK.

Installing HammerDB on the client system

1. Download the latest version of HammerDB from www.hammerdb.com/download.html. We used 4.12.
2. Double-click the .exe file, choose English, and click OK.
3. Click Yes.
4. Click Next.
5. Choose a destination location, and click Next.
6. Click Next.
7. Click Finish.

Populating the database

1. Open HammerDB, and click Options → Benchmark.
2. Choose MSSQL Server and TPROC-H.
3. Expand SQL Server → TPROC-H → Schema Build.
4. Double-click Options.
5. Choose 100 scale, and set the number of virtual users corresponding to the number of vCPUs.
6. Check the box for clustered column store, and click OK.
7. Double-click Build. This build could take a few hours.

Backing up the database

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

Creating and configuring the WordPress VMs

Before starting the following steps, upload the Ubuntu 20.04 LTS ISO to the VMM library. We performed the steps below on the PowerEdge R740xd cluster. Repeat the same steps on the PowerEdge R7715 cluster, being sure to configure the VMs according to Table 4 and cloning a total of three VMs with one VM on each host.

Creating the base WordPress VM

1. On the PowerEdge R740xd cluster, open the System Center Virtual Machine Manager app.
2. Click VMs and Services → Create Virtual Machine → Create Virtual Machine.
3. In the wizard, choose Select Source, and click Create the new virtual machine with a blank virtual hard disk. Click Next.
4. In the Identity screen, give the VM a name, and select Generation 2. Click Next.
5. In the Configure Hardware screen, configure the following:
    a. Correct number of vCPUs and memory according to Table 4.
    b. Under Bus Configuration, click the existing disk, and set the Type to Static and the size for the OS drive according to Table 4.
    c. Under Bus Configuration, click the Virtual DVD drive, choose Existing ISO image, and click Browse.
    d. In the library, choose the Ubuntu ISO image, and click OK.
    e. Under Network Adapters, choose the VM network.
6. In the Select Destination screen, leave defaults, and click Next.
7. In the Select Host screen, choose one of the PowerEdge R740xd hosts, and click Next.
8. On the Configure Settings screen, leave defaults, and click Next.
9. In the Add Properties screen, leave defaults, and click Next.
10. On the Summary screen, click Create.

Installing Ubuntu

1. In VMM, click the gold VM you created, and power it on.
2. To open the VM console, click Connect or view→ Console.
3. In the Select Language settings, leave defaults, and press Enter.
4. On the Keyboard configuration screen, leave defaults, and press Enter.
5. In Choose your install, select Install Ubuntu (minimal configuration), and press Enter.
6. In Network connections, change to a static network configuration, set your IP, highlight Done, and press Enter.

7. In Filesystem setup, highlight Use An Entire Disk, and press Enter.
8. When prompted to select a disk, choose the only disk available, and press Enter.
9. In the Filesystem summary, make any changes you want, highlight Done, and press Enter.
10. In the confirmation window that appears, highlight Continue, and press Enter.
11. In the Profile setup, enter whatever information you need for your Ubuntu user, highlight Done, and press Enter.
12. When Ubuntu is done installing, highlight Reboot Now, and press Enter.

Updating Ubuntu and installing WordPress

1. Run any system updates necessary:

```
sudo apt-get update
sudo apt-get upgrade
```

2. Install utilities you will use later in the installation:

```
sudo apt-get install wget tar vim apache2 ghostscript libapache2-mod-php mysql-server php php-bcmath
php-curl php-imagick php-intl php-json php-mbstring php-mysql php-xml php-zip unzip -y
```

3. Download WordPress, and move it into its installation directory:

```
sudo mkdir -p /srv/www
wget https://wordpress.org/latest.tar.gz
sudo tar -xzvf latest.tar.gz -C /srv/www
```

4. Create a WordPress site in Apache by creating a file at /etc/apache2/sites-available/wordpress.conf and putting the following configuration into it:

```
<VirtualHost *:80>
    DocumentRoot /srv/www/wordpress
    <Directory /srv/www/wordpress>
        Options FollowSymLinks
        AllowOverride Limit Options FileInfo
        DirectoryIndex index.php
        Require all granted
    </Directory>
    <Directory /srv/www/wordpress/wp-content>
        Options FollowSymLinks
        Require all granted
    </Directory>
</VirtualHost>
```

5. Modify the base Apache installation to enable WordPress as the base site:

```
sudo a2ensite wordpress
sudo a2enmod rewrite
sudo a2dissite 000-default
sudo service apache2 reload
```

6. Enter the MySQL console:

```
sudo mysql -u root
```

7. Configure MySQL to work with WordPress:

```
CREATE DATABASE wordpress;
CREATE USER wordpress@localhost IDENTIFIED BY 'Password1';
GRANT SELECT,INSERT,UPDATE,DELETE,CREATE,DROP,ALTER
    -> ON wordpress.*
    -> TO wordpress@localhost;
FLUSH PRIVILEGES;
quit
```

8. Turn MySQL on:

```
sudo service mysql start
```

9. Configure WordPress to connect to MySQL:

```
sudo -u www-data cp /srv/www/wordpress/wp-config-sample.php /srv/www/wordpress/wp-config.php
sudo -u www-data sed -i 's/database_name_here/wordpress/' /srv/www/wordpress/wp-config.php
sudo -u www-data sed -i 's/username_here/wordpress/' /srv/www/wordpress/wp-config.php
sudo -u www-data sed -i 's/password_here/Password1/' /srv/www/wordpress/wp-config.php
```

10. Edit the /srv/www/wordpress/wp-config.php file and replace the security key lines (starting with `AUTH_KEY` and ending with `NONCE_SALT`) with the liens generated at https://api.wordpress.org/secret-key/1.1/salt/. Save the file.
11. Restart Apache to allow WordPress to correctly start:

```
sudo systemctl restart apache2
```

Configuring WordPress

1. On a separate machine, navigate to the IP address of your new WordPress VM, and to finalize the WordPress deployment, fill out the site survey.
2. On the WordPress VM, download and install the WordPress content dummy generator plug-in:

```
cd /srv/www/wordpress/wp-content/plugins
sudo wget https://downloads.wordpress.org/plugin/wp-dummy-content-generator.zip
sudo wget https://downloads.wordpress.org/plugin/woocommerce.9.5.1.zip
sudo unzip wp-dummy-content-generator.zip
sudo unzip woocommerce.9.5.1.zip
```

3. In a web browser, log into your WordPress VM.
4. At the top of the web page, click Plugins.
5. Click the Dummy Content Generator plugin.
6. In the WP Dummy Content Generator plugin page, click Generate Users.
7. In Choose User Role, choose Administrator, and in Number of Users, select 5. Click Generate users.
8. Once the administrators are generated, in User Role, choose Editor, and in Number of Users, select 5. Click Generate Users.
9. Once the editors are generated, in User Role, choose Author, and in Number of Users, select 20. Click Generate Users.
10. Once the authors are generated, in User Role, choose Subscriber, and in Number of Users, enter 200. Click Generate Users.
11. On the left of the web page, Generate Posts.
12. In Posts date range, choose 01/01/2020–02/01/2025, make sure 10 posts will be generated, and click Generate Posts.
13. On the left of the web page, click Generate Products.
14. In the Generate Products page, in the number of products, select 300, and check the Featured Image/Thumbnail check box. Click Generate Products.
15. Once you have finished generating content, shut down the WordPress server.

Creating the WordPress Siege client

To create the Siege client, we followed the Creating the Base WordPress VM and Installing Ubuntu sections above, and then performed the following steps after that point.

1. Run any system updates necessary:

```
sudo apt-get update
sudo apt-get upgrade
```

2. Install utilities you will use later in the installation:

```
sudo apt-get install vim openssl openssl-devel zlib gzip gcc inetutils-ping -y
```

3. Download and extract Siege:

```
wget http://download.joedog.org/siege/siege-latest.tar.gz
tar -xzvf siege-latest.tar.gz
```

4. Navigate to the newly extracted directory, and build Siege:

```
cd siege-4.1.7/
./configure
make
sudo make install
```

Cloning out the test VMs

1. In VMM, right-click the gold VM, and choose Create → Clone.
2. Name the VM, and click Next.
3. In the Configure Hardware screen, leave defaults as they should already match the specs in Table 4, and click Next.
4. In the Select Destination screen, leave defaults, and click Next.
5. In the Select Host screen, choose the second PowerEdge R740xd host, and click Next.
6. In the Select Path screen, choose the storage volume connected to the second PowerEdge R740xd host, and click Next.
7. In the Select Networks screen, leave defaults, and click Next.
8. In the Add Properties screen, leave defaults, and click Next.
9. In the Summary screen, click Create.
10. Repeat steps 1 through 9, placing the VMs on the three PowerEdge R740xd hosts in a round-robin fashion so you end up with 3 VMs on each host for a total of 9 VMs.

Running the tests

We simultaneously started all Microsoft SQL Server VMs and WordPress VMs. We stopped the WordPress VMs when the last TPROC-H VM output its results. We restarted the SQL Service between runs to dump the memory cache.

Starting the HammerDB tests

1. In each SQL VM, open HammerDB.
2. In the popup menu, double-click SQL Server, and double-click TPROC-H.
3. Expand TPROC-H options.
4. Expand Schema.
5. Double-click Options.
6. Change Authentication to SQL Server Authentication.
7. Leave SQL User ID as sa.
8. Change SQL Server User Password to the one you set during SQL creation.
9. Set MAXDOP to 0.

10. Set Scale to 100.
11. Expand Driver Script, and click Load.
12. Expand Virtual User, and open Options.
13. Set Virtual Users to 5.
14. Enable Log Output to Temp, Use Unique Log Name, and Log Timestamps, and click OK.
15. Double-click Create users.
16. When ready, click Start.

Start the WordPress tests

1. Open PowerShell and SSH to your Siege client.
2. To start the test, run the following command against each WordPress client:

```
sudo siege http://<wordpress IP> -c 1 -q 1
```

Read the report at https://facts.pt/NphNSIM ▶

This project was commissioned by Dell Technologies.